Higher Taxes at the Top: The Role of Entrepreneurs

Bettina Brüggemann*

Goethe University Frankfurt

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COMMENTS ARE WELCOME

Abstract

This paper contributes to the recent and growing literature on optimal top marginal income tax rates. It computes optimal marginal tax rates for top earners in a Bewley-Aiyagari type economy explicitly accounting for entrepreneurs. Entrepreneurs make up more than one third of the highest-earning one percent in the income distribution despite representing less than ten percent of the population. They are thus disproportionately affected by an increase in the top marginal income tax rate. Since entrepreneurs overall also employ half of the private-sector workforce, such policy changes can have important repercussions for aggregate labor demand and productivity. In the model households face an occupational choice between working for the market wage or starting their own business. Borrowing constraints induce entrepreneurs to save in order to grow. Consistent with the data, entrepreneurs significantly influence aggregate productivity, generate 50 percent of total output, and account for 40 percent of taxpayers in the top tax bracket. Nonetheless, the welfare maximizing top marginal tax rate amounts to 82.5 percent, and the revenue maximizing one to 90 percent. A steady state comparison between the benchmark economy featuring the current US tax system and the economy with the welfare maximizing top marginal tax rate illustrates the underlying mechanisms. The substantial increase in taxes leads to a large degree of redistribution, yielding sizable welfare gains for low-income working and entrepreneurial households. The welfare gains decline with income for workers, as middle-income workers are hurt by lower equilibrium wages. These lower wages however benefit medium-sized entrepreneurs and enable them to grow, such that all entrepreneurs except those directly affected by the higher tax experience considerable welfare gains, and the size of the entrepreneurial sector grows.

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1 Introduction

The taxation of top income earners is a controversial topic. In recent years, there have repeatedly been calls to increase the marginal tax rates on top income earners, often with the intention of closing fiscal deficits or decreasing economic inequality. Since Diamond and Saez (2011) recommended imposing high and rising marginal tax rates on top income earners of up to 80 percent, there has been an increasing number of papers analyzing the optimality of top marginal tax rates (TMTRs) in dynamic general equilibrium models. The results differ widely depending on modeling choices: Guner et al. (2015) find relatively low revenue-maximizing top marginal rates of 43 percent in a life-cycle model with idiosyncratic labor productivity. Badel and Huggett (2014) endogenize human capital in an overlapping generations model and find the peak of the Laffer curve at a TMTR of 52 percent. Using an overlapping generations model with ex-ante heterogeneity in education and labor income risk, Kindermann and Krueger (2015) determine a long-run welfare-maximizing TMTR of 95 percent and an even higher revenue-maximizing rate of 98 percent. In a similar setup to theirs, Brüggemann and Yoo (2015) also find large welfare gains after increasing the TMTR to 70 percent.

Although entrepreneurs account for more than one third of top one percent income earners, they have not yet been explicitly included in the aforementioned literature. In this paper I investigate whether the inclusion of entrepreneurs alters the predicted impact of top income taxation on the economy. It is often feared the negative repercussions of an increase in top income tax rates on the aggregate economy are strong because entrepreneurs directly influence the aggregate economy through the role they play for aggregate labor demand, prices, and productivity. Thus, there are many possibly harmful channels through which higher taxes could affect an economy by affecting the entrepreneurial sector.

Surprisingly, the optimal top marginal tax rates that I find in a model with entrepreneurs are still very high: A TMTR of 82.5 percent maximizes long-run welfare, and a TMTR of 90 percent maximizes tax revenue from income taxes. Entrepreneurs are crucial for obtaining the high optimal TMTR in two ways: Unless directly subject to the higher TMTR, they profit from the drop in equilibrium wages after the tax increase (caused by a reduction in the aggregate capital-labor ratio) which enables them to hire cheaper labor and increase production, profits, and ultimately consumption. Moreover, their contribution to the increase in aggregate tax revenue is disproportionately high, facilitating redistribution of additional government funds to households and creating positive welfare effects especially for poor and middle-income households. The optimal marginal tax rates I find are very similar to the findings of Kindermann and Krueger (2015) and Brüggemann and Yoo (2015). However, in their paper the large positive effects on tax revenue and welfare are driven by households with extremely high but risky labor productivity, which which is a feature of their labor productivity process. Labor supply of these households is very inelastic, and they continue to work a lot even when faced with higher tax rates. These households ensure a lot of additional tax revenue and a large degree of redistribution and social insurance. The inclusion of entrepreneurs is a way of endogenizing these mechanisms without relying on extreme realizations of labor productivity and gives a special role to general equilibrium price effects.

Using the 2010 Survey of Consumer Finances (SCF) I document the following facts about entrepreneurs in the U.S.[1] In order to do so, I have to define what an entrepreneur is. I use the same definition as Cagetti and De Nardi (2006): Entrepreneurs are self-employed business owners who actively manage their own business. Using this definition in the SCF 2010, these were 8.0 percent of all U.S. households. 92 percent of their businesses had the legal status of a pass-through entity, meaning that any business income generated by their entrepreneurial activities was taxed according to the ordinary income tax schedule.[2] In my analysis I concentrate on these pass-through entrepreneurs, who account for 7.4 percent of the population.

Despite their small number, entrepreneurs earn 17 percent of total income. They play an especially important role among top income earners: 36 percent of the highest-earning 1 percent in the income distribution in 2010 were entrepreneurs. This over-representation of entrepreneurs among top income earners suggests that they are important to consider when analyzing the effects of higher taxes at the top. But entrepreneurs are not only earning more than working households, they also differ in their asset accumulation behavior. With a ratio of median net worth between entrepreneurs and workers of 7.3, entrepreneurs' median wealth is much higher than that of workers. In total, they own 31 percent of total net worth.

Not only are entrepreneurs on average richer in terms of income and wealth, they are also important participants in the labor market: 66 percent of all pass-through entrepreneurs are employers and therefore play - with on average 29 employees - an essential role for aggregate labor demand and wages. According to the U.S. Census of 2007, pass-through entities employ about half of the private-sector workforce. Opponents of higher top marginal income tax rates often argue that their introduction will lead to less hiring by these firms and therefore be harmful for the economy through its impact for wages and aggregate productivity.

My model features several mechanisms that replicate these empirical facts and shape the reactions to increases in top marginal tax rates. The model is a variant of the standard incomplete-markets model with heterogeneous agents established by Bewley (1986), Huggett (1993), and Aiyagari (1994). It models entrepreneurship in the spirit of Cagetti and De Nardi (2006, 2009): There is a continuum of households which differ in their endowment with labor ability and entrepreneurial ability, both of which follow a persistent, stochastic process. Depending on these endowments, agents choose their occupation: They either work for a wage or they choose to

[1] More details on the data can be found in Appendix A.

[2] The following legal forms classify as pass-through entities: Sole proprietorships, partnerships (including LLCs), and S corporations. Income (or losses) generated by businesses of these types have to be declared on Form 1040 of the U.S. Individual Income Tax Return.

become entrepreneurs and build their own businesses, where they invest part of their wealth, hire labor on the market, and earn net profits. Contrary to the model by Cagetti and De Nardi (2009), household labor supply is endogenous. Both entrepreneurs and workers face borrowing constraints, but the one for workers is tighter. While entrepreneurs are allowed to borrow up to a certain multiple of their wealth, workers cannot borrow at all, and the only way for them to insure against income shocks is through precautionary savings. Labor supply, savings, and consumption are chosen optimally to maximize lifetime utility. There are two sectors of production: a non-corporate sector which comprises all the entrepreneurs and their hired workers, and a corporate sector where the remaining capital and labor are used in a representative firm. Wages and the interest rate are determined in general equilibrium and correspond to the marginal products of labor and capital in the corporate sector. Both wage income and entrepreneurial income are subject to a progressive income tax schedule that closely mimics the U.S. federal tax schedule.

In the model, entrepreneurs save more than workers in order to invest into their businesses and grow. This additional incentive to save, which is absent for workers, helps replicating the large degree of wealth inequality in the data, as well as the large share of wealth held by entrepreneurs. High TMTR distort the incentive to save at the top, which affects entrepreneurial savings, production and income, and thereby aggregate output, prices, and productivity. The latter is due to the fact that the entrepreneurial sector in the model is on average more productive than the non-entrepreneurial sector, and significantly contributes to aggregate output. Second, entrepreneurs employ a large share of the economy's total labor force. Changes in entrepreneurial labor demand after a tax change impact equilibrium prices in addition to changes in aggregate capital. Third, entrepreneurs pay a large share of total taxes, especially since they are overrepresented at the top end of the earnings distribution. Thus, the level of the optimal top marginal tax rate, both in terms of tax revenue and welfare, depends on the degree to which the government can squeeze more tax revenue out of entrepreneurs (and of course other top income earners) and redistribute the additional revenue among the rest of the population while avoiding the partly harmful effects through lower wages and higher interest rates.

I calibrate the model to match a set of empirical moments especially for the distributions of income of workers and entrepreneurs. Next, I determine the top marginal tax rates that maximize (a) welfare in the long run as measured by consumption equivalent variation and (b) revenue from federal income taxes. For the welfare-optimizing tax rate, I analyze the different responses by workers and entrepreneurs when the TMTR is set at its optimal level, and also on how the impact of the tax change differs for households along the earnings distribution. These underlying mechanisms help explain how the optimality results emerge, and are qualitatively the same for the revenue maximizing top marginal rates.

The top marginal tax rate that maximizes welfare amounts to 82.5 percent, whereas the revenue-maximizing rate is with 90 percent slightly higher. The underlying adjustment mechanisms of households are mainly shaped by two channels: First, the tax increase directly lowers the incentive to save, which leads to a reduction in asset holdings especially by wealthy households, resulting in a lower aggregate capital stock. Second, general equilibrium price effects affect household choices: A lower aggregate capital-labor ratio implies a higher equilibrium interest rate and lower equilibrium wages. This makes it less lucrative to work and more attractive to become an entrepreneur. For entrepreneurs, it becomes cheaper to hire employees which increases profitability. The higher interest rate makes borrowing and therefore entrepreneurial investment more expensive. The number of entrepreneurs ultimately increases, but they invest less on average.

The positive welfare effects of an increase in the TMTR are especially concentrated on low and middle-income households and in particular low and middle-income entrepreneurs. While low-income entrepreneurs gain because they can compensate lower average profits with the lump-sum transfer that is paid out to all households and financed by additional tax revenues, high and middle-income households benefit because they can increase production and profits thanks to the lower wage. It is these medium-scale entrepreneurs in particular that contribute heavily to the high CEV of 5.2 percent after increasing the top marginal income tax rate to 82.5 percent. Entrepreneurs also play an essential role in generating additional tax revenues, which in turn enables the government to pay out the pre-tax lump-sum transfer benefitting especially low-income households.

The remainder of the paper is organized as follows. I describe my contribution to the literature in more detail in section 2. In section 3, I present the model. Section 4 describes the calibration strategy. Section 5 then contains the results for the benchmark economy. In section 6, I explain the setup of the policy experiment and present its results, starting with the determination of the optimal top marginal taxes, followed by a discussion of the underlying mechanisms. Section 7 concludes.

2 Literature Review

This paper contributes to the recent and growing literature on optimal top marginal income rates. It is most closely related to papers on optimal tax rates in neoclassical incomplete market economies, which have featured a number of contributions in recent years. Kindermann and Krueger (2015) use an overlapping generations model with ex-ante heterogeneity in education, idiosyncratic labor productivity, and endogenous labor supply to find short- and long-run revenue- and welfare-maximizing top marginal tax rates. They match the empirical distributions of earnings and wealth by calibrating the labor productivity process using a method similar to the one established by Castañeda et al. (2003). The main characteristic of this productivity process is that the wage implied by the highest productivity state and the risk of leaving this state are so large that households will hardly reduce their labor supply even when confronted with very high marginal tax rates. Kindermann and Krueger (2015) find optimal top marginal tax rates of more than 90 percent both during the transition and in the new steady state. Brüggemann and Yoo (2015) use a more detailed system of taxation and focus only on steady state comparisons. They find positive welfare effects after doubling the top marginal tax rate, because low-income households profit from large tax reliefs made possible by large revenue gains from high-productivity households, a mechanism that is similar in Kindermann and Krueger (2015). This role is taken over by entrepreneurs in my setup, relieving me from the need to using the same extreme exogenous labor productivity process.

Badel and Huggett (2014) enlarge the overlapping generations model by endogenizing human capital. In their setup, households are ex-ante heterogeneous in human capital and learning ability, and ex-post heterogeneous due to shocks to human capital. The implied the peak of the Laffer curve in their setup is at a top marginal tax rate of 52 percent. The higher top tax rate leads to lower skill investment and thereby to a large reduction in labor input, leading to a lower optimal TMTR than in other setups that ignore the possibility of skill adjustments. Without endogenous human capital, Badel and Huggett (2014) also find a much higher revenue-maximizing tax rate of 66 percent.

Guner et al. (2015) explore the question whether higher taxes for the rich can be used to close fiscal budget deficits in a life-cycle model with heterogeneous agents and endogenous labor supply. They find that, when increasing taxes on top income households only, the TMTR maximizing revenue from federal income taxes amounts to 43 percent. This is almost twice the effective top marginal benchmark tax rate of approximately 22 percent and raises tax revenues by 8.9 percent. Also related to this literature on the effects of top income taxation is the paper by Kaymak and Poschke (2015), who try to quantify the role of changes in the taxation of top incomes in shaping the evolution of the distributions of wealth, income and consumption in the U.S. over the last decades.

In addition to the literature using neoclassical incomplete market models with heterogeneous agents, the question of how to optimally tax the rich has also been addressed in different frameworks, with a wide range of results. Shourideh (2014) studies how to optimally tax capital income and wealthy individuals in a Mirrleesian environment where households are allowed to invest into businesses and face capital income risk. Ales and Sleet (2015) and Scheuer and Werning (2015) use assignment models to determine optimal tax rates on top incomes where superstar effects exert downward pressure on top marginal rates. Piketty et al. (2014) look at the role of three different elasticities in a static model of optimal labor supply and find high positive optimal top marginal rates. In a very recent contribution, Badel and Huggett (2015) generalize their aforementioned analysis in Badel and Huggett (2014) by using the sufficient statistic approach to derive a formula for the revenue-maximizing tax rate based on three elasticities, which can predict the top of the Laffer curve both in static models and in the steady states of dynamic models.

My paper is the first paper to compute optimal marginal tax rates in an Aiyagari-Bewley-Huggett economy explicitly accounting for entrepreneurs. I carefully illustrate the patterns of entrepreneurial behavior and the role they play for questions of optimal taxation and productivity. My work heavily draws on the extensive literature on entrepreneurship, see Quadrini (2009) for an excellent summary. Among the many papers on entrepreneurship in macroeconomics, I follow Quadrini (2000), Cagetti and De Nardi (2006) and Cagetti and De Nardi (2009). Quadrini (2000) showed that the inclusion of entrepreneurs into a Bewley-Aiyagari type model with idiosyncratic uncertainty in labor income helps to overcome one of the standard model's major deficiencies: its inability to reproduce the right degree of inequality in the wealth distribution. The introduction of entrepreneurs with their different asset accumulation behavior can replicate the main characteristics of the empirical wealth distribution.[3] Cagetti and De Nardi (2006) find the same using a similar model that endogenizes entrepreneurial investment. Their analysis especially focuses on the role of financial frictions for entrepreneurial activity and wealth inequality. I am not the first one to analyze the effects of tax changes in such a model with entrepreneurs. In a follow-up paper, Cagetti and De Nardi (2009) look at the role of estate taxation for the wealth distribution and investigate how abolishing these taxes would affect the savings behavior of households along the wealth distribution and their welfare. De Nardi and Yang (2015) re-address the question of effects of changes in estate taxation, but focus on a different mechanism merging bequest motives and the intergenerational transmission of abilities. Kitao (2008) studies the channels through which fiscal policies affect the economy in a model with occupational choice, and especially examines the role of taxes when the tax differs for different sources of income. Meh (2005) evaluates a tax reform that changes a progressive tax system into a proportional one and assesses the importance of entrepreneurship for aggregate and distributional consequences of such a policy experiment. Boháček and Zubrický (2012) look at the impact of a flat tax reform in a model with heterogeneous agents, occupational choice, and financial frictions that is very similar to mine. There are numerous other papers also looking at the interaction of tax systems and entrepreneurship, albeit in different frameworks. Panousi (2010) analyzes the effects of capital income taxation and is especially interested in the role of investment risk, while abstracting from labor income risk or borrowing constraints. Scheuer (2014) studies the optimal dynamic taxation of business profits when agents can choose between being a worker and becoming an entrepreneur.

[3] De Nardi (2015) provides a survey of the different mechanisms in quantitative dynamic models that generate the right degree of inequality in the wealth distribution. Outside of entrepreneurship paired with borrowing constraints, these can for example be voluntary bequests, heterogeneity in patience, or very high but risky labor productivity.

3 Model

The model is a variant of the standard Bewley-Aiyagari model where households face an occupational choice between being a worker or an entrepreneur. It is similar to the model established by Cagetti and De Nardi (2009), but differs in some crucial elements. While labor supply in their model is inelastic, it is endogenous in my version of the model. This is important, as the effects of top income taxation heavily depend on the elasticity of labor supply especially at the top of the earnings distribution. I also do not allow for entrepreneurship in old age, and abstract from any potential intergenerational correlation of earnings or abilities.

3.1 Demographics and Endowments

The economy is populated by a continuum of households of measure one. Agents go through two life-stages: Young households face a constant probability of aging, $1 - \pi_y$. Old households face a constant probability of dying, $1 - \pi_o$. When a household "dies", he is immediately replaced by a young descendant. Young households derive earnings from supplying labor to the market in return for a wage w or from becoming an entrepreneur, investing into their own company and earning the net profits. This occupational choice depends on the households' idiosyncratic endowments with two different types of ability: labor ability ϵ and entrepreneurial ability θ. Labor ability ϵ can take values in $\mathcal{E} = \{\epsilon_1, ..., \epsilon_{N_\epsilon}\}$ and evolves over time according to a first-order Markov process with transition probabilities $\Gamma(\epsilon'|\epsilon)$. Formally, the entrepreneurial ability process looks very similar: It can take values in $\Theta = \{0, \theta_1, ..., \theta_{N_\theta}\}$ and also follows a first-order Markov process $\Lambda(\theta'|\theta)$. The two abilities are uncorrelated.[4] Knowing its endowment with both labor and entrepreneurial ability, the household decides whether to spend his time working for the market wage or building his own business. Another important determinant for the household's occupational choice is its wealth. A young household starts its life with whatever wealth it inherited from its predecessor. Each young household has a fixed amount of time at its disposal, which it can split up into working time and leisure. When old, all households immediately retire and receive fix retirement benefits from the government.

3.2 Preferences

Each household maximizes its discounted stream of utilities by choosing consumption c and labor supply l. The household's objective is described by:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t), \quad (1)$$

where β is the rate at which the household discounts future utilities. Households are fully altruistic toward their descendants. The utility function is of CRRA type and additively separable in consumption and labor (time indices are dropped for simplicity):

[4] Allub and Erosa (2014) argue that the correlation of skills plays an important role for the distribution of earnings across occupations, but calibrate it to a relatively low value of 0.1 for the Brazilian economy.

$$u(c,l) = \frac{c^{1-\sigma_1}}{1-\sigma_1} - \chi \frac{l^{1+\sigma_2}}{1+\sigma_2}, \tag{2}$$

where σ_1 describes the curvature of consumption, σ_2 the curvature of hours worked (so that $1/\sigma_2$ is the constant Frisch elasticity), and χ is the weight of the disutility of labor.

3.3 Technology

Following Quadrini (2000) as well as Cagetti and De Nardi (2006), I assume that there are two sectors of production. The so-called non-corporate sector consists of many, mostly small businesses run by entrepreneurs according to the following production technology (again dropping subscripts for convenience):

$$f(k,n) = \theta(k^{\gamma}(l^e + n)^{1-\gamma})^{\nu}. \tag{3}$$

In order to produce, entrepreneurs employ n efficiency units of labor in addition to a minimum labor input l^e that has to be provided by the entrepreneur, so that the total labor input amounts to $(l^e + n)$. I assume that all entrepreneurs have to work a predefined amount of hours equal to one third of their total time endowment. Entrepreneurs invest k units of capital into their firm. These inputs, together with entrepreneurial ability θ, determine entrepreneurial production. The production function exhibits decreasing returns to scale since $\nu < 1$. The span-of-control parameter ν captures that the entrepreneur's managerial control gets less efficient as it spreads out over larger projects, a modeling device introduced by Lucas (1978). The entrepreneurial rate of return is endogenous, as it depends on entrepreneurial ability, the size of the implemented project, and the number of people hired in the firm.

Not all firms are owned by entrepreneurs. Production by large, corporate firms in the second "corporate" sector is captured by a standard Cobb-Douglas production function:

$$Y_c = F(K_c, N_c) = A_c K_c^{\alpha} N_c^{1-\alpha} \tag{4}$$

Here, K_c is the capital input and N_c is the input of effective labor (hours worked times ability). The technology parameter A_c is a constant. In both sectors, capital depreciates at rate δ.

3.4 Market Arrangements

Entrepreneurs may borrow to increase their investment into the firm, but only up to a multiple of their wealth: $k \leq \lambda a$. The parameter $\lambda > 1$ specifies the strictness of this exogenous borrowing limit. Workers are not allowed to borrow, but all households can self-insure by saving in form of a riskless bond. Factor markets are competitive so that wage w and interest rate r are in equilibrium given by the marginal products of capital and labor in the corporate sector.

3.5 Government

The government has two sources of revenue: consumption taxes T_c and income taxes T_y. While consumption is subject to a simple proportional tax, $t_c(c) = \tau_c c$, income is taxed according to a progressive income tax schedule approximated by a step-wise tax function with m tax brackets and corresponding marginal tax rates τ^i for $i = 1, \ldots, m$. Taxable income y is the sum of labor and capital income for normal workers and the sum of net profits and capital income for entrepreneurs. Retirees have to pay taxes on their retirement benefits as well as their capital income. For all households, taxable income is reduced by a standard deduction d such that taxable income is defined as $y = y^i - d$ for $i \in \{e, w, r\}$. Formally, the step-wise tax function is expressed as follows:

$$t^F(y) = \begin{cases} \tau_1(y - Y_1) \text{ if } Y_1 < y < Y_2, \\ \tau_1(Y_2 - Y_1) + \tau_2(y - Y_2) \text{ if } Y_2 < Y < Y_3, \\ \vdots \\ \tau_1(Y_2 - Y_1) + \cdots + \tau_m(y - Y_m) \text{ if } Y_m < y. \end{cases} \tag{5}$$

This step-wise tax function intends to represent the progressive, statutory federal income tax schedule. Deductions and exemptions that are not captured by the simple deduction d lead to a wedge between statutory and actually paid, effective tax rates. I therefore introduce a linear adjustment factor τ_{adj} to take these discrepancies into account. The overall tax function is completed by a linear tax component, $\tau^s y$, that reflects state and local taxes:

$$t_y(y) = \tau_{adj} t^F(y) + \tau^s y \tag{6}$$

The government uses its revenues to finance wasteful government spending G and benefits for retired workers B. The government budget balance is characterized by the following equation:

$$G + B = T_c + T_y \tag{7}$$

3.6 The Young Household's Problem

A young household starts the period with assets a, labor ability ϵ, and entrepreneurial ability θ. Based on its endowments with these state variables, it makes its occupational coice between becoming an entrepreneur or a worker. Hence, the value function of a young household is given by

$$V(a, \epsilon, \theta) = \max\left\{V^e(a, \epsilon, \theta), V^w(a, \epsilon, \theta)\right\}, \tag{8}$$

where V^e is the entrepreneur's value function and V^w is the worker's value function. The entrepreneur's value function is defined by the following dynamic program:

$$V^e(a, \epsilon, \theta) = \max_{c,k,n}\left\{u(c, l) + \beta\pi_y EV(a', \epsilon', \theta') + \beta(1 - \pi_y)EP(a')\right\}, \tag{9}$$

subject to

$$y^e = \theta(k^\gamma(1+n)^{1-\gamma})^\nu - \delta k - r(k-a) - wn, \tag{10}$$

$$a' = y^e - T(y^e - d) + a - (1+\tau^c)c \tag{11}$$

$$l = \bar{l},\ a \geq 0,\ n \geq 0,\ k \leq \lambda a. \tag{12}$$

Entrepreneurial earnings are given by business profits and capital income, as defined in equation (10). The entrepreneur not only chooses the optimal level of consumption subject to the budget constraint in equation (11) but also the profit-maximizing inputs into his own firm, subject to the credit constraint in (12). With probabilty π_y, he stays young, but with probability $1-\pi_y$ he becomes an old household and has to retire, in which case his value function will be denoted by P.

The worker maximizes his lifetime value by choosing only consumption and hours worked subject to the budget constraint in equation (15). Income of a worker is simply given by the wage times the productivity-weighted labor input plus capital income (equation (14)):

$$V^w(a,\epsilon,\theta) = \max_{c,l} \left\{ u(c,l) + \beta\pi_y EV(a',\epsilon',\theta') + \beta(1-\pi_y)EP(a') \right\}, \tag{13}$$

subject to

$$y^w = wl\epsilon + ra, \tag{14}$$

$$a' = y^w - T(y^w - d) + a - (1+\tau^c)c \tag{15}$$

$$a \geq 0. \tag{16}$$

Unlike entrepreneurs, workers can decide how much labor to supply to the market whereas entrepreneurs always have to supply a fix amount of time $\bar{l}$.

3.7 The Old Household's Problem

All old households are retired, independent of their occupation when young. Their state when entering a period is only described by their asset holdings. Entrepreneurial and labor ability do not play a role anymore. Retirees are not allowed to work, their labor supply is thus zero. The only remaining uncertainty in the life of a retiree is whether he will survive until the next period with probability π_o or die and be replaced by a descendant. The value function of an old household is thus given by the following dynamic program:

$$P(a) = \max_{c} \left\{ u(c,l) + \beta\pi_o P(a') + \beta(1-\pi_o)V(a',\epsilon',\theta') \right\},$$

subject to

$$y^r = ra + b$$
$$a' = y^r - T(y^r - d) + a - (1 + \tau^c)c$$
$$l = 0,\ a \geq 0.$$

Earnings during retirement consist of retirement benefits b and capital income ra. When a household "dies", it is immediately replaced by a working age descendant who starts his life endowed with labor ability ϵ and entrepreneurial ability θ that have been randomly drawn from the joint distribution of ϵ and θ. The newborn household's two abilities are uncorrelated with the abilities of the parent household. But the descendant inherits the whole estate, abstracting from any kind of estate taxation.[5]

3.8 Equilibrium

Let $x = (a, \epsilon, \theta, z) \in \mathcal{X}$ be the state vector, where z distinguishes young workers, young entrepreneurs, and old retirees. An equilibrium is given by sequences of prices $\{r, w\}$, sequences of public policies $\{\tau^s\}$, decision rules $c(x), l(x), a'(x), n(x), k(x)$ and a distribution of households over the state variables x: $m(x)$, such that, given prices and government tax and transfer schedules:

- the functions c, l, a', n, k solve the maximization problems described above,
- capital and labor markets clear,
- the marginal product of labor and capital in the corporate sector are equal to w and r,
- the government budget is satisfied, and
- the distribution of people m is induced by the transition matrix of the system as follows: $m' = M(x, \cdot)'m'$.

In the steady state, $m = m^*$ is the invariant distribution for the economy; prices, and government policies are constant; and the individual's decision rules are time-independent.

4 Calibration

The calibration of the model parameters follows a threefold strategy: Parameters describing the income tax schedule directly correspond to what is fixed in tax laws. Some parameter values are taken from the literature and in particular Cagetti and De Nardi (2009). Lastly, I calibrate the remaining set of parameters to match a set of empirical targets that I calculate using the

[5] Cagetti and De Nardi (2009) look at the role of estate taxation in a model with entrepreneurs that is closely related to mine. They find that an estate tax mimicking the actual American tax has only small effects on savings and investment of small businesses, but affects larger firms so that they produce less than in a world without estate taxes.

Table 1: Fixed Parameters

Parameter	**Symbol**	**Value**	**Source**
Preferences, technology, demographics, and labor ability			
Risk Aversion	σ_1	1.500	Attanasio et al. (1999)
Labor Supply Elasticity	σ_2	1.700	Frisch elasticity = 0.59
Time endowment	ℓ	3.000	$1/3\ell = 1.0$
Capital Share in Corp. Sec.	α	0.330	Gollin (2002)
Depreciation Rate	δ	0.060	Stokey and Rebelo (1995)
Technology Parameter	A_c	1.000	Normalization
Span-of-Control Parameter	ν	0.880	Cagetti and De Nardi (2009)
Borrowing Limit	λ	1.500	Kitao (2008)
Entrepreneurs' Labor Input	l^e	1.000	$l^e = \bar{l} = 1/3\ell$
Probability of Retiring	π_y	0.978	Ave. Working life = 45 years
Probability of Survival in Ret.	π_o	0.911	Ave. Retirement = 11 years
Government budget			
Government Spending	G	0.187	Cagetti and De Nardi (2009)
Retirement benefits	b	0.400	Kotlikoff et al. (1999)
Consumption Tax	τ_c	0.110	Altig et al. (2001)
Income Tax Deduction	d	$0.35y^{med}$	Krueger and Ludwig (2013)
Tax Rate Adjustment	τ_{adj}	0.70	$\text{TMTR}^{eff} = 0.246$
U.S. statutory federal income tax code 2010:			
	τ_i	$\{0.1, 0.15, 0.25, 0.28, 0.33, 0.35\}$	
	Y_i	$\{0.0, 0.214\bar{y}, 0.868\bar{y}, 1.753\bar{y}, 2.672\bar{y}, 4.771\bar{y}\}$	

Survey of Consumer Finance in 2010. In the subsequent sections, I follow the structure of the model section to describe the calibration of each parameter. All exogenously fixed parameters are collected in Table 1, the endogenously calibrated parameters in Table 2.

4.1 Demographics and Endowments

I set the probability of ageing and retiring at $\pi_y = 0.978$ and the probability of surviving in retirement at $\pi_o = 0.911$. These two probabilities imply an average duration of working life of 45 years and an average retirement of 11 years. Households are endowed with $\ell = 3$ units of time, which is calibrated such that average hours worked are equal to $1/3\ell = 1.0$.

Endowments with entrepreneurial ability can take on four different values, $\theta \in \{\theta_1, ...\theta_4\}$. I fix $\theta_1 = 0$, so that agents with this level of entrepreneurial ability will always choose to be a worker. The remaining three levels will be pinned down by two parameters, $\bar{\theta}$ and $\hat{\theta}$, such that $\{\theta_2, \theta_3, \theta_4\} = \bar{\theta} * \{(1 - \hat{\theta}), 1, (1 + \hat{\theta})\}$. In this and in the calibration of the transition matrix $\Lambda(\theta'|\theta)$, I follow Kitao (2008). For the transition matrix, I assume that a household can only make the transition into the neighboring ability states, and that transition probabilities are the same for θ_2 and θ_3. This leaves me with four parameters to calibrate for the transition probability matrix:

$$\Lambda = \begin{pmatrix} \pi_1^\theta & 1-\pi_1^\theta & 0.00 & 0.00 \\ \pi_2^\theta & \pi_3^\theta & 1-\pi_2^\theta-\pi_3^\theta & 0.00 \\ 0.00 & \pi_2^\theta & \pi_3^\theta & 1-\pi_2^\theta-\pi_3^\theta \\ 0.00 & 0.00 & 1-\pi_4^\theta & \pi_4^\theta \end{pmatrix} \tag{17}$$

The six parameters characterizing the entrepreneurial ability process will be calibrated to match six empirical targets that describe the entrepreneurial sector: The fraction of entrepreneurs in the economy (7.4 percent, SCF 2010), the annual entry rate into entrepreneurship of 2.3 percent, the exit rate from entrepreneurship of 22 percent (Cagetti and De Nardi, 2009), the share of income earned by entrepreneurs amounting to 16.8 percent (SCF 2010), the Gini coefficient of entrepreneurs' earnings of 0.650 (SCF 2010), and the share of entrepreneurs that are also employers (66.1 percent, SCF 2010).

Labor ability ϵ can take on six different values, $\epsilon \in \{\epsilon_1, ..., \epsilon_6\}$. I take the values for the first five levels of the labor ability process from Cagetti and De Nardi (2009), as well as the estimated transition probabilities for these five states. In the spirit of Kindermann and Krueger (2015) I introduce a high sixth level of labor ability, ϵ_6. A household can reach this from every other labor ability level with the same probability π_6^ϵ. This high ability is quite risky, with a probability π_{63}^ϵ of falling back to the medium ability level, ϵ_3. I introduce this additional income state to achieve the right ratio of entrepreneurs and workers in the top 1 percent income earners: 35.5 percent in this percentile of the earnings distribution are entrepreneurs. Since I want to evaluate the role of entrepreneurs when increasing taxes on top income earners, it is important that the right fraction of households subject to the higher tax are entrepreneurs. Without the high level of labor ability, all households at the top of the earnings distribution would be entrepreneurs. At the same time, the additional level of labor ability will help me to match the empirical distribution of workers' earnings (Gini coefficient: 0.514, SCF 2010) as well as share of earnings of top 1 percent earners in the overall earnings distribution (17.1 percent, SCF 2010). For the labor ability process, I am thus left with three parameters to calibrate: ϵ_6, π_6^ϵ, and π_{63}^ϵ.

4.2 Preferences

For the CRRA utility function in equation 2, I need to find values for three parameters. I set the curvature of consumption $\sigma_1 = 1.5$, which is a standard value used in papers from the macroeconomic literature such as Attanasio et al. (1999). The inverse of the curvature of hours worked, $1/\sigma_2$, is the Frisch elasticity of labor. Choosing a value for $\sigma_2 = 1.7$ yields a Frisch elasticity of 0.59, which lies in the standard range of values in the literature. The last remaining preference parameter is the weight of the disutility of labor χ, which will be calibrated such that average hours worked are equal to one third of the time endowment.

Table 2: Calibrated Parameters

Parameter	Symbol	Value
Entrepreneurial Ability Process		
Entrepreneurial Ability Levels	θ_1	0.000
	θ_2	0.743
	θ_3	1.770
	θ_4	2.798
Transition Probabilities	$\Lambda = \begin{pmatrix} 0.97 & 0.03 & 0.00 & 0.00 \\ 0.26 & 0.57 & 0.17 & 0.00 \\ 0.00 & 0.26 & 0.57 & 0.17 \\ 0.00 & 0.00 & 0.31 & 0.69 \end{pmatrix}$	
Labor Ability Process		
Highest Labor Ability Level	ϵ_6	21.950
Probability of Reaching ϵ_6	$\Gamma(\epsilon_6)$	0.002
Probability of Leaving ϵ_6	$\Gamma(\epsilon_3 \vert \epsilon_6)$	0.068
Remaining Calibrated Parameters		
Discount factor	β	0.914
Utility weight of labor	χ	0.722
Capital share in ent. sector	γ	0.300

4.3 Technology

Entrepreneurial production is characterized by two parameters in addition to entrepreneurial ability. I adopt the value for the span-of-control parameter $\nu = 0.88$ from Cagetti and De Nardi (2009). The value determining the income share of capital, γ, will be endogenously calibrated. The minimum labor input provided by the entrepreneur is equal to his hours worked, which amount to one third of the time endowment.

The capital share in the corporate sector will be 0.33, which is standard and for example found in Gollin (2002). Productivity in the corporate sector, A_c, is normalized to one. The depreciation rate for both sectors $\delta = 0.06$ is also standard, e.g. in Stokey and Rebelo (1995).

4.4 Market Arrangements

Entrepreneurs can borrow up to 50 percent of their assets, such that their maximum investment amounts to $\lambda = 1.5$ times their assets. I adopt this borrowing limit from Kitao (2008). In Appendix D I illustrate how results of the policy experiment change when I tighten or loosen this borrowing limit.

4.5 Government

The expenditure side of the government budget consists of wasteful government spending G and total retirement benefits B paid out to retirees. I fix wasteful government spending at 18.7 percent of GDP following Cagetti and De Nardi (2009). The retirement benefit b will amount to 40 percent of average income just as in Kotlikoff et al. (1999).

On the revenue side, there is a number of parameters pinning down the federal income tax schedule. The six statutory tax brackets and the pertaining marginal tax rates are taken directly from the U.S. tax law for 2010 and are stated in Table 1 relative to average income household income (U.S.$ 78,332 in the SCF 2010). I fix the deduction d at 35 percent of median income as argued by Krueger and Ludwig (2013). The adjustment factor τ_{adj} intended to close the gap between effective and statutory tax rates is set to 0.7, such that the highest effective marginal tax rate is equal to 0.246 which is the value estimated by Guner et al. (2014). The linear income tax rate τ^s will be endogenous and balancing the budget. The consumption tax rate is fixed at 0.11 following Altig et al. (2001).
All parameters can be found in Table 1 (for the exogenously fixed parameters) and 2 (endogenously calibrated). In the end, I have to endogenously calibrate 12 parameters to match 12 targets.

5 Benchmark Economy

In this section, I present the empirical fit of the benchmark economy. I show how well the calibrated benchmark economy matches the empirical targets. Afterwards, I demonstrate that the model also does a good job in replicating empirical moments that have not been directly targeted.

Table 3 compares targeted moments in the data to those in my benchmark calibration. All moments are hit closely. Especially for the central features of the entrepreneurial sector like the fraction of entrepreneurs, the entry rate to entrepreneurship and the exit rate from it are hit perfectly. For the validity of the quantitative exercise that I do in the following it is also very important that I get a close fit for the share of entrepreneurs among top 1 percent earners.

I underestimate the degree of earnings inequality among entrepreneurs. I do however match both the share of earnings earned by the top 1 percent of the overall population, which is of particular importance for my tax experiment, and the Gini coefficient of the wealth distribution. When looking at the shape of the Lorenz curves of the earnings and wealth distributions for the whole population, as well as workers, retirees, and entrepreneurs, in Figure 1, the overall fit of the different distributions is satisfactory, especially considering the low number of distributional targets.

While the distributions of earnings and wealth are partly targeted, the distribution of firm sizes in the entrepreneurial sector is untargeted. When looking at the firm size measured by the number of employees, the model matches the empirical distribution rather well, see Table 5. The firm size distribution in the benchmark economy preserves the general shape of its empirical counterpart, but underestimates the number of small firms in the economy. Still, the average of 11 employees per employer is much lower than the value that can be found in the SCF 2010 (on average 29 employees) because the maximum number of employees per firm is much lower in my model economy.

Table 3: Targets: Data and Model

	Data	**Model**
Overall Economy		
Capital-Output Ratio	2.65	2.65
Wealth Gini	0.85	0.84
Top 1% Earnings Share	0.17	0.16
Entrepreneurs		
Fraction of Entrepreneurs	0.07	0.07
Entry Rate	0.02	0.02
Exit Rate	0.22	0.22
Entrepreneurs' Share of Total Earnings	0.17	0.22
Entrepreneurs' Earnings Gini	0.65	0.60
Share of Entrepreneurs among Top 1% Earners	0.35	0.37
Share of Hiring Entrepreneurs	0.66	0.68
Workers		
Average Working Time	1.00	1.00
Workers' Income Gini	0.51	0.52

Pass-through entrepreneurs hire approximately one half of the total private sector workforce. This is also true in my model with 49 percent of total labor supply in efficiency units employed in the entrepreneurial sector.

Table 4: Firm Size Distribution: Data and Model

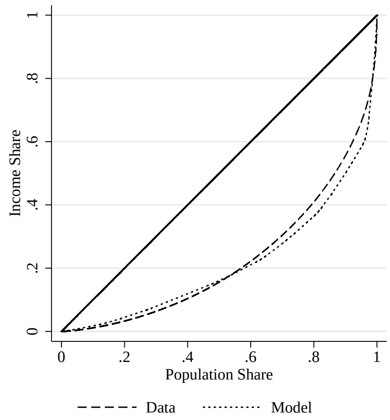
	Data	**Model**
Fraction of Hiring Firms	0.661	0.681
1-5 Employees	0.692	0.545
6-10 Employees	0.119	0.181
11-20 Employees	0.065	0.114
More than 20 Employees	0.125	0.161

Another important aspect of the benchmark economy are the shares of entrepreneurs along the distributions of earnings and wealth. I target the share of entrepreneurs among the top 1 percent earners and am able to closely match it. When looking at the entire distribution of earnings, I also match the shares of entrepreneurs in the two lowest earnings quintiles, but underestimate the share of entrepreneurs in the third and fourth quintile. This is due to the coarse discretization of the entrepreneurial ability process. The share of entrepreneurs is too high in the highest quintile, but the share of entrepreneurs in the highest earnings bracket (top 3.2 percent) is with 40 percent still reasonable. Although entirely untargeted, the shares of entrepreneurs along the wealth distribution are matched rather closely, except with in the top 10 percent.

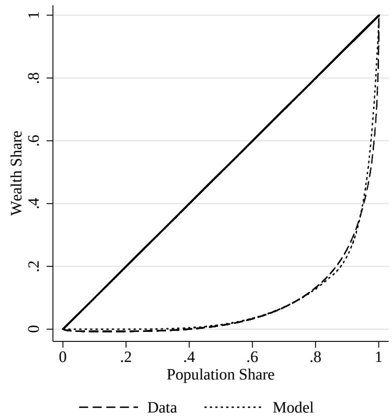
Figure 1: The Distributions of Earnings and Wealth

(a) All Households

Earnings

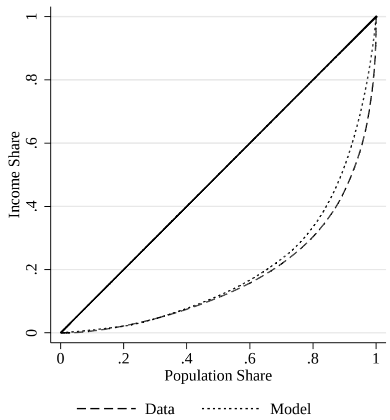


Wealth

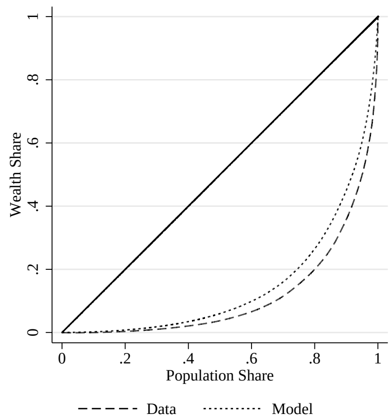


(b) Entrepreneurs

Earnings

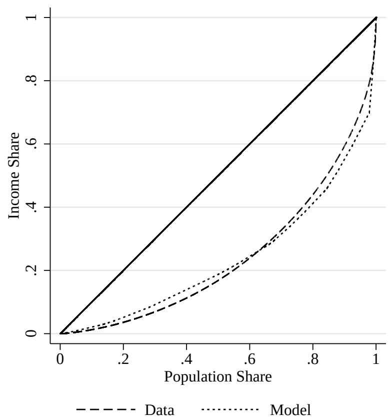


Wealth



(c) Workers and Retirees

Earnings



Wealth

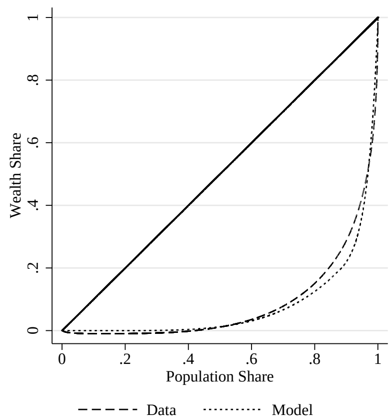


Table 5: Share of Entrepreneurs Along the Earnings Distribution: Data and Model

	Quintiles					Top (%)		
	1st	2nd	3rd	4th	5th	90-95	95-99	99-100
	Fraction of Entrepreneurs in Income Distribution							
Data	3.4	4.2	6.5	8.2	14.5	11.8	25.0	35.6
Model	3.6	4.0	0.2	5.6	24.3	4.4	63.0	37.5*
	Fraction of Entrepreneurs in Wealth Distribution							
Data	1.5	1.9	5.6	8.8	19.1	18.6	32.7	44.4
Model	0.0	2.0	8.1	8.3	19.3	27.8	16.2	19.3

Note: * Targeted

6 Policy Experiment

After having established that my model economy provides a good description of the empirical distributions of earnings and wealth as well as sufficiently capturing the role of entrepreneurs, I now proceed to implement the policy experiment of increasing taxes on top income earners and analyze how entrepreneurs shape the economy's reaction to this change.

In the policy experiment, I increase the statutory marginal tax rate pertaining to the highest income bracket in the federal income tax schedule. The federal income tax function then becomes:

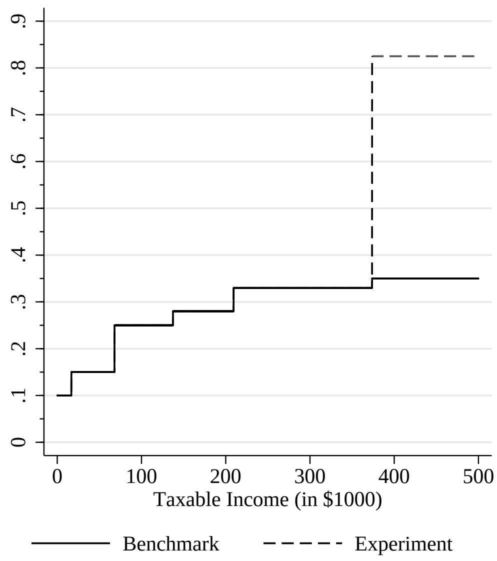
$$T^F_{exp}(y) = \begin{cases} \tau_{adj} T^F(y) & \text{if } y \leq \bar{Y} \\ \tau_{adj} \left[T^F(\bar{Y}) + \tau^{rich}(y - \bar{Y}) \right] & \text{if } y > \bar{Y} \end{cases} \tag{18}$$

$\bar{Y}$ stands for the level of taxable income above which housholds belong to the highest income tax bracket and therefore have to pay the highest marginal tax rate. In 2010, this threshold was U.S.$ 373,651, or 4.8 times average household income, and the corresponding tax rate was 35 percent. In the benchmark economy, 3.2 percent of all households belong to this tax bracket, 39 percent of whom are entrepreneurs.[6] These households are directly affected by the tax increase. Any additional tax revenue generated by the tax increase is redistributed through a lump-sum transfer to all households, keeping the level of government spending constant. The transfer is paid out before households have to pay taxes and fully adds to their taxable income. Figure 2 shows how the tax function is altered if the TMTR is changed from 35 to 50 percent as an example.

I use this experimental setup to analyze several aspects of increasing the top marginal tax rate. First, I do a simple grid search over potential TMTRs and determine the tax rates that maximize tax revenue and overall welfare in the economy. I then pick the welfare-maximizing

[6] In the following, I will look at this group when talking about top earners. I decided against calibrating the tax schedule such that only the top 1 percent would be subject to the highest tax rate in order to stay as close as possible to the actual U.S. tax schedule.

Figure 2: Tax Experiment: Increase of MTR for Highest Tax Bracket



tax rate and look at the underlying adjustment mechanisms. Here, I am especially interested in how workers and entrepreneurs are affected differently, and how households at different positions in the earnings distribution differ in their reactions to the tax change. I highlight the most important channels through which the tax change impacts household behavior and aggregate economic performance.

6.1 Optimality

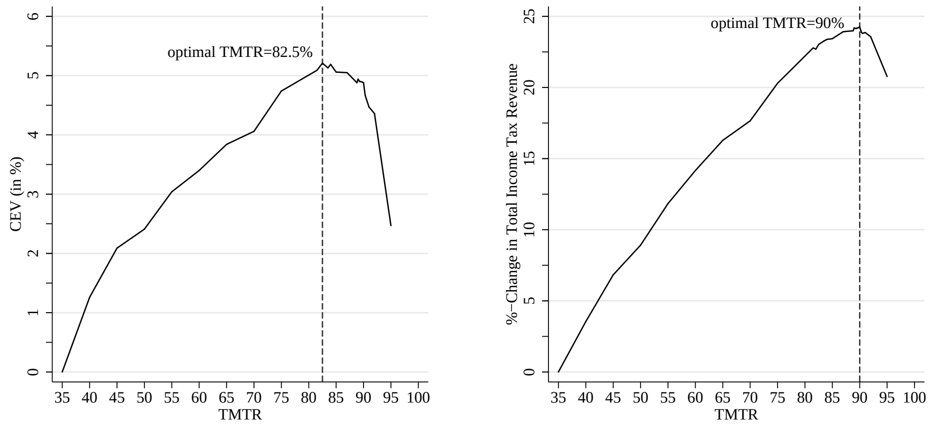
The search for the optimal top marginal tax rates is a grid search over potential top marginal tax rates. After solving for the steady state of the benchmark economy, I confront households with a higher top marginal tax rate. I solve the model for the new steady state and compare welfare and tax revenues with those of the benchmark economy.[7]

To find the welfare-maximizing tax rate, I calculate the consumption-equivalent variation (CEV) for the new steady states after the experiment. Following McGrattan (1994), the CEV is defined as the percentage Δ^{CEV} by which every household's per-period consumption has to be changed in order to make the household indifferent between the old and the new steady state, keeping everything else constant. If the CEV is positive, this means that welfare is higher in the new steady state and households would only be willing to remain in the old steady state if one increases their consumption. The algebraic derivation of the CEV can be found in Appendix B. In order to determine the optimal top marginal tax rate in terms of tax revenue, I calculate and compare total tax revenue from income taxes in the benchmark steady state and for all

[7]The inclusion of the transition between the two steady states is important when analyzing welfare effects in heterogeneous agent models with endogenous distributions of income and wealth. I plan to implement the transition analysis for my policy experiment in the near future.

Figure 3: Optimal TMTRs

(a) Welfare (b) Income Tax Revenue



potential TMTRs.

Figure 3 shows the CEV and the change in total income tax revenue for top marginal tax rates up to 95 percent.[8] Income tax revenues steadily increase until they are maximized at a TMTR of 90 percent. The graph for welfare shows a similar increase before flattening out for rates between 80 and 87 percent. The maximum CEV identified by the grid search lies at a TMTR of 82.5 percent. In the following, I explain these optimality results by illustrating the underlying mechanisms and reactions in the economy when increasing the tax rate to its welfare-maximizing level of 82.5 percent. For the revenue-maximizing tax rate, the adjustments look very similar, I therefore refrain from discussing them in detail.

6.2 Aggregate Effects

Increasing the top marginal tax rate to its welfare-maximizing level decreases the aggregate capital stock, labor and output. Two channels mainly shape this response: The direct effects of the tax increase on the incentives to work and save, and the indirect effects through adjustments in general equilibrium prices.

The first line of Table 6 shows the aggregate effects of raising the top marginal tax rate from 35 to 82.5 percent. In the benchmark economy, 3.2 percent of households are subject to the TMTR, 39 percent of these being entrepreneurs. After the tax increase, this fraction increases slightly to 3.3 percent driven by new entry of entrepreneurs, who now account for 41 percent of households in the top tax bracket.

The most obvious aggregate change is in aggregate capital K: Households in the post-experiment economy save 25 percent less than their benchmark counterparts. Effective labor supply N also decreases, albeit with 4.3 percent less than capital. The substantial reduction in factor supplies

[8]The small spikes in the optimality curves are due to numerical inaccuracies and a certain degree of non-smoothness in the adjustment of workers and entrepreneurs to the new tax regime.

decreases aggregate production Y by 9 percent. Tax revenues from both income and consumption taxes, T, increase by 14 percent. This additional revenue is redistributed through a large lump-sum transfer of 4.3 percent of average household income.

Table 6: Aggregate Effects of the Increase in TMTR to 82.5% (in %)

	Y	K	N	T	r	w	TFP
τ^{rich}=82.5%, GE	−9.4%	−25.3%	−4.3%	14.4%	68.5	−6.2	2.8%
τ^{rich}=82.5%, PE	−14.1%	−37.4%	−2.7%	11.1%	0.0	0.0	2.5%

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

Table 6 allows to deduce the two channels that are most important in shaping the economy's adjustment to the tax increase. First, there is the direct effect of the tax change. This effect is captured particularly well when keeping wages and interest rates constant at their benchmark level as shown in line 2 of Table 6. Higher taxes at the top diminish the incentive to save especially at the upper end of the wealth distribution, where most of the economy's capital is held. This leads to a large reduction in the supply of capital. Capital decreases more than effective labor, making it scarcer. Going from the second to the first line of Table 6, I allow prices to adjust and reflect the relative appreciation of capital: The interest rate increases by 68.5 percent (from 1.5 to 2.6 percent), while the wage goes down by 6 percent. This change in equilibrium prices constitutes the second important channel that shapes the adjustment of the economy to the new tax system. In the following chapters, I look more closely at both channels and how they affect the different occupational groups in the economy.

Before getting to that, Table 6 shows one more important effect of the tax increase on top income earners. Surprisingly, total factor productivity (TFP) increases by 2.8 percent. The total economy thus becomes more efficient after an increase in the TMTR. This is due to a reallocation of factors across sectors as can be seen in Table 7. Relatively more capital and labor is used in the more productive entrepreneurial sector. Hence, the drop in output that we see in the first column of Table 6 has been dampened by a more efficient use of input factors.

Table 7: Relative Factor Allocation in Corporate and Non-Corporate Sector (in %)

	Capital		**Labor**	
	Corporate	Non-Corporate	Corporate	Non-Corporate
Benchmark	76.3%	23.7%	50.9%	49.1%
τ^{rich}=82.5%, GE	72.8%	27.2%	46.0%	54.0%

Underlying these aggregate results and movements in input factors across sectors are the reactions of households in the economy to the tax increase itself but also to the changes in equilibrium prices. These reactions differ by age, income, and especially occupation, leading to a large degree of heterogeneity in welfare gains as I show in the following section.

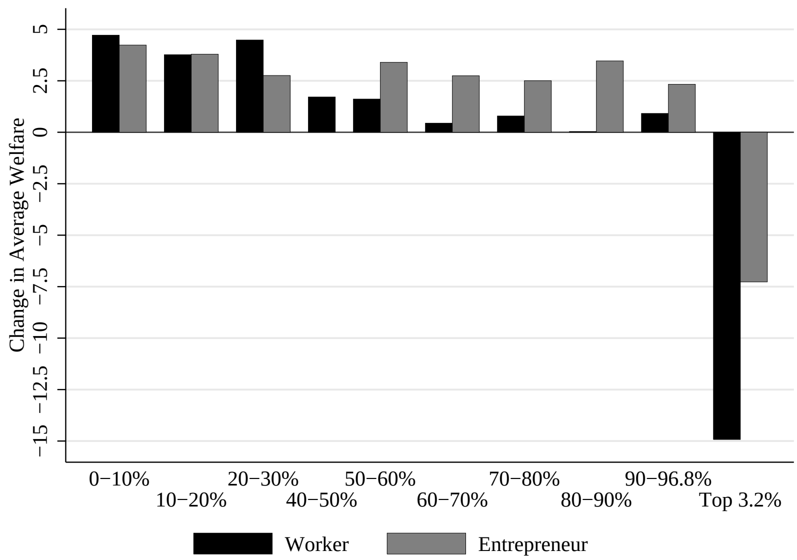
6.3 Disaggregate Effects

6.3.1 Heterogeneous Welfare Effects

Figure 4 shows the average change in welfare for workers and entrepreneurs along the distribution of gross earnings, where changes in welfare are measured by changes in a household's expected lifetime utility.[9] Overall, there is an almost universal increase in welfare, it is therefore not surprising that the overall welfare gain measured by the CEV is also large: 5.2 percent.

Additionally, the graph shows three important heterogeneous effects of the tax increase: (1) Households subject to the top marginal tax rate (top 3.2 percent) experience large welfare losses, but workers much more so than entrepreneurs. (2) Both workers and entrepreneurs at the low end of the earnings distribution gain from the tax increase, their average welfare increases the most. (3) Welfare gains for middle and high-earning entrepreneurs below the highest tax bracket are positive, constant in earnings, and consistently larger than for workers whose gains decrease with earnings.

Figure 4: Welfare Gains by Earnings Deciles for Workers and Entrepreneurs



Facts (1) and (2) confirm basic intuition and are largely explained by the direct consequences of the tax increase. Households at the top of the distribution are directly confronted with the higher tax rate and are also directly suffering from its consequences for net earnings, consumption and savings. Additional tax revenues are redistributed lump-sum to all households, which is particularly beneficial for households with low earnings. Hence, they see the largest increases in welfare.

[9] Note that there are no entrepreneurs in the fourth decile of the earnings distribution. However, there are workers in the eighth decile, but their lifetime utility increases only barely.

The effects on households in the middle segment of the distribution and especially the differences between workers and entrepreneurs are less straightforward to explain. They are mainly due to changes in general equilibrium prices, as I explain in the following sections.

6.3.2 Workers

First, I look at the effects of the tax change on earnings and choices of households that are workers. Highest-earning workers in the top tax bracket experience a welfare loss. All other working households gain, but middle and high-income households much less than their low-income counterparts. This is because these richer households suffer from the tax increase's negative consequences for wages, while low-income households profit from the relatively large redistributive transfer financed by the higher TMTR: They manage to increase their utility through higher consumption and lower hours worked.

In Table 8, I show the changes in average choices of working households in these different segments of the earnings distribution. Workers in the highest tax bracket (top 3.2 percent) are directly confronted with the higher tax rate of 82.5 percent and react by reducing their savings and hours worked, also bringing down consumption. While the direct consequences of the tax increase in partial equilibrium are mostly responsible for these negative effects (third line in Table 8a), the price adjustments in general equilibrium further worsen their situation (second line): The lower wage reduces the incentive to work even further and thereby also lowers the ability to save and consume. The large welfare losses for workers in this highest tax bracket that I show in Figure 4 are the direct consequences of this reduction in consumption and savings.

Low-income workers whose earnings lie below the median experience large welfare gains as seen in Figure 4. Table 8c shows that these households mainly profit from the redistributive transfer that the government pays out to every household and is financed by the increase in tax revenues. The transfer amounts to one sixth of their benchmark net earnings and enables them to reduce their hours worked without suffering an income loss, which raises their utility. Wages decrease in the new equilibrium, which induces low-income households to further reduce their labor supply. But the higher interest rate incentivizes these workers to save more, leading to more capital income and higher consumption.

Workers with earnings above the median but below the highest earnings bracket also react to the low wage by reducing their labor supply, leading to lower net earnings and lower consumption. The higher interest rate partly compensates the savings disincentive of the tax rate increase, but average wealth still shrinks by more than thirty percent. While welfare on average still increases for this group of households, Figure 4 shows that welfare gains are much smaller than for low-income households, for whom the lump-sum transfer was much higher relative to their benchmark earnings and therefore also more beneficial.

Table 8: Changes in Workers' Choices and Income Shares by Earnings Level

	l	a	c	y^w_{net}	Earnings Shares ϵ l w	ra	ρ
(a) Highest Earnings Bracket (Top 3.2%)							
Benchmark	0.8	78.0	10.9	18.6	95.9%	4.1%	0.0%
τ^{rich}=82.5%, GE	−9.1%	−42.8%	−29.9%	−34.9%	−0.9%p	0.5%p	0.4%p
τ^{rich}=82.5%, PE	−8.6%	−41.8%	−28.6%	−33.3%	1.1%p	−1.4%p	0.3%p
(b) Earnings Levels between Median and Top 3.2%							
Benchmark	1.0	6.0	1.8	1.8	95.6%	4.4%	0.0%
τ^{rich}=82.5%, GE	−0.5%	−32.1%	−8.0%	−0.3%	−5.1%p	0.6%p	4.5%p
τ^{rich}=82.5%, PE	0.7%	−43.5%	−7.8%	2.1%	−1.2%p	−2.1%p	3.3%p
(c) Below Median Earnings							
Benchmark	1.0	2.4	0.9	0.6	93.0%	7.0%	0.0%
τ^{rich}=82.5%, GE	−8.3%	16.2%	1.4%	9.9%	−19.1%p	5.0%p	14.0%p
τ^{rich}=82.5%, PE	−4.6%	−18.2%	−1.1%	6.1%	−9.4%p	−1.5%p	10.9%p
(d) Averages							
Benchmark	1.0	6.5	1.7	1.7	95.4%	4.6%	0.0%
τ^{rich}=82.5%, GE	−4.1%	−27.9%	−10.0%	−9.3%	−5.9%p	1.2%p	4.6%p
τ^{rich}=82.5%, PE	−1.8%	−38.7%	−9.8%	−7.5%	−1.6%p	−1.8%p	3.3%p

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

6.3.3 Entrepreneurs

According to Figure 4, low-income entrepreneurs experience similar welfare gains as low-income workers. But there are large differences in welfare between workers and entrepreneurs in the middle and top segments of the distribution: Entrepreneurs in the top tax bracket experience lower welfare losses than workers, and medium to high-income entrepreneurs outside the highest tax bracket enjoy sizable gains in welfare that are evenly distributed across income levels. In this section, I show that these more favorable outcomes of the tax experiment for entrepreneurs are mainly due to the fact that the general equilibrium price effects have more advantageous consequences for entrepreneurs.

When looking at Table 9a, the first impression is that the effect of the tax increase on entrepreneurial households in the highest tax bracket is the same as for workers: All choice variables decrease heavily. But while the initial negative effect on average choices in partial equilibrium is almost the same as for workers (third line of Table 9a), general equilibrium price adjustments affect entrepreneurs in the opposite way (second line). The lower wage and higher

Table 9: Changes in Entrepreneurs' Choices and Income Shares by Earnings Level

	a	c	y^e_{net}	Earnings Shares: Profits	ra	ρ
(a) Highest Earnings Bracket (Top 3.2%)						
Benchmark	61.0	6.9	17.0	100.0	0.0%	0.0%
τ^{rich}=82.5%, GE	−31.4%	−21.1%	−29.4%	−0.4%	0.0%p	0.4%p
τ^{rich}=82.5%, PE	−38.8%	−25.0%	−36.4%	−0.4%	0.0%p	0.4%p
(b) Earnings Levels between Median and Top 3.2%						
Benchmark	8.4	2.0	3.0	100.0	0.0%	0.0%
τ^{rich}=82.5%, GE	7.9%	7.1%	7.2%	−2.3%	0.0%p	2.3%p
τ^{rich}=82.5%, PE	−2.6%	4.0%	1.9%	−1.8%	0.0%p	1.8%p
(c) Below Median Earnings						
Benchmark	1.3	0.8	0.6	99.7	0.3%	0.0%
τ^{rich}=82.5%, GE	−4.9%	5.7%	12.3%	−12.5%	0.2%p	12.2%p
τ^{rich}=82.5%, PE	−5.9%	5.2%	9.0%	−9.3%	−0.1%p	9.4%p
(d) Averages						
Benchmark	15.8	2.6	4.9	100.0	0.0%	0.0%
τ^{rich}=82.5%, GE	−18.2%	−6.1%	−14.5%	−1.5%	0.0%p	1.5%p
τ^{rich}=82.5%, PE	−29.6%	−11.5%	−23.3%	−1.3%	0.0%p	1.3%p

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

interest rate have a compensatory effect on entrepreneurial choices and reduce the negative impact of the tax increase. Price developments are thus more beneficial for entrepreneurs than for workers, which is reflected by the lower welfare loss for entrepreneurs in the highest tax bracket shown in Figure 4.

Outcomes for low-income entrepreneurs largely follow the same rule as for workers. Changes in average choices of entrepreneurs in Table 9c and for workers in Table 8c are very similar: The increase in entrepreneurial earnings and consumption is mainly due to the lump-sum transfer that all households receive from the government after the tax increase. This similarity of effects on workers and entrepreneurs can also be observed in Figure 4, where welfare gains for workers and entrepreneurs are comparably high at the low end of the earnings distribution.

For middle and high-income households outside the highest tax bracket, this is very different. In this earnings segment, entrepreneurs are much more positively affected by the tax change than workers, as Table 9b shows. Here, it becomes very obvious that entrepreneurs benefit heavily from favorable changes in equilibrium prices and in particular the drop in wages.

Table 10: Changes in Characteristics of Entrepreneurial Sector by Earnings Level

	Fraction (%)	Entry (%)	Exit (%)	Investment	Employees	Profits
(a) Highest Earnings Bracket (Top 3.2%)						
Benchmark	39.0	4.8	1.8	77.9	31.5	24.4
τ^{rich}=82.5%, GE	0.3%	−33.2%	−41.6%	−30.4%	−4.9%	−7.1%
τ^{rich}=82.5%, PE	−6.8%	−34.6%	−35.2%	−37.6%	−25.4%	−20.5%
(b) Earnings Levels between Median and Top 3.2%						
Benchmark	10.2	2.6	16.4	11.4	2.8	3.8
τ^{rich}=82.5%, GE	5.2%	3.7%	−4.3%	7.8%	25.4%	5.5%
τ^{rich}=82.5%, PE	4.8%	3.2%	−4.2%	−2.5%	−0.1%	0.3%
(c) Below Median Earnings						
Benchmark	3.0	2.0	48.1	1.8	0.0	0.7
τ^{rich}=82.5%, GE	2.9%	1.6%	−1.4%	−11.1%	–	−1.4%
τ^{rich}=82.5%, PE	2.6%	1.1%	−1.7%	−3.5%	–	−0.8%
(d) Averages						
Benchmark	7.5	2.4	21.7	20.6	7.0	6.6
τ^{rich}=82.5%, GE	3.4%	0.6%	−3.4%	−17.2%	1.8	−3.1%
τ^{rich}=82.5%, PE	1.6%	0.3%	−1.6%	−28.2%	−24.5	−16.9%

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

In order to understand why these price effects are more advantageous for entrepreneurs than they are for workers, it is useful to look at changes in variables characterizing entrepreneurial activity and earnings.

The variables in Table 10 describe the composition of the entrepreneurial sector and its adjustment to the new tax rate. Table 10b refers to middle- and high-income entrepreneurs below the highest tax bracket. In this segment, the benefits of the price effects, in particular the lower wage, are most obvious. If it were not for the drop in wages, average investment and the number of employees would decrease. But since wages go down, entrepreneurs are able to hire more workers and even increase investment although borrowing has become more expensive because of the higher interest rate. This leads to higher profits, which in turn imply higher consumption and welfare. For some of the highest-earning entrepreneurs in this segment, it is even profitable to increase production in a way that pushes their earnings across the highest tax threshold. These households account for the higher fraction of entrepreneurs in the highest tax bracket that I briefly mentioned in Section 6.2.

Favorable general equilibrium effects on middle-income entrepreneurs especially come from the lower wage. However, the lower wage does not help small, low-income entrepreneurs since they are too small to even have employees. These entrepreneurs suffer from the higher interest rate, which can be seen from the large decrease in average investment: Borrowing is much more expensive than in the benchmark, so average investment goes down, and so do average profits. Welfare gains for these entrepreneurs only stem from the redistributive transfer. The lower wage can however account for the increase in the entry rate for entrepreneurs: The outside option of being a worker becomes less attractive and more households decide to enter entrepreneurship. At the upper end of the earnings distribution, the lower wage dampens the negative effects of the tax increase on hiring and investment, but does not compensate for all the negative consequences. Investment and hiring still decrease on average, and consequentially, so do profits. This explains the large drop in consumption for the richest entrepreneurs that Table 9a shows.

6.3.4 Retirees

For completeness, I want to also show the changes in retirees' choices and earnings. Largely as a reaction to the higher top marginal tax rate and the ensuing lump-sum transfer, retirees save a lot less than they did in the benchmark economy, which is only partially counteracted by the higher interest rate. They also consume less on average. This average outcome is driven by a large reduction in consumption by rich retirees, as becomes obvious in Table 11a. Low-income households profit from the higher interest rate and transfer and manage to increase net earnings, consumption, and savings (cf. Table 11b). Almost all retirees except for the richest experience welfare gains after the tax increase, as Figure C.1 shows.

6.4 Summing Up the Role of Entrepreneurs

It has been long understood that the inclusion of entrepreneurs into incomplete market models with heterogeneous agents helps to generate a realistic distributions of earnings and wealth. This is mainly due to the additional savings motive provided by the borrowing constraint and the large degree to which entrepreneurs rely on their own wealth as investment into their businesses. That is also the case for my model and analysis.

Other papers circumvent the problem of too little asset accumulation especially at high wealth levels using a different strategy. Following the method established by Castañeda et al. (2003), they calibrate their labor ability processes to include an extremely high, low-probability labor ability realization. While very lucrative, this labor ability realization is also very risky and therefore induces the lucky households to save a lot. This generates a large degree of wealth inequality.

When searching for the optimal top marginal tax rate in economies that are shaped by such a labor ability process, like Kindermann and Krueger (2015) and Brüggemann and Yoo (2015), the resulting optimal rates are very high. This is mainly caused by households that are endowed with the highest realization of labor ability: Even when confronted with very high tax

Table 11: Changes in Retirees' Choices and Earnings Shares

	a	c	y^r_{net}	Earnings Shares ra	ρ
(a) Above Median Earnings					
Benchmark	29.2	3.3	1.2	34.7%	65.3%
τ^{rich}=82.5%, GE	−28.3%	−21.5%	12.2%	2.2%p	−2.2%p
τ^{rich}=82.5%, PE	−35.0%	−20.7%	−5.9%	−10.3%p	10.3%p
(b) Below Median Earnings					
Benchmark	0.4	0.9	0.8	1.0%	99.0%
τ^{rich}=82.5%, GE	22.5%	7.4%	9.3%	0.8%p	−0.8%p
τ^{rich}=82.5%, PE	−6.2%	5.9%	7.4%	−0.1%p	0.1%p
(d) Averages					
Benchmark	3.3	1.1	0.9	5.8%	94.2%
τ^{rich}=82.5%, GE	−22.7%	−1.4%	9.7%	1.0%p	−1.0%p
τ^{rich}=82.5%, PE	−44.1%	−5.6%	4.9%	−2.6%p	2.6%p

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

rates, they will continue to work a lot in order to save for worse times, generating large gains in tax revenues for the government and guaranteeing redistribution to lower-earning households.

In my model which includes entrepreneurs and thereby endogenously creates a large degree of wealth inequality, I get similarly high optimal top marginal rates. But while the papers mentioned above rely on exogenous ability processes with arguably unrealistically high ability realizations, the high optimal rates of up to 82.5 percent in my model are the result of endogenous mechanisms shaped by the reactions of the different occupational groups in the economy. Admittedly, I also introduce an additional high ability level into my labor ability process which is almost 10 times as large as the second-highest. However, the idea behind its introduction is not a failure in achieving the right degree of wealth inequality, but the goal of having the right shares of workers and entrepreneurs among high-earning households. Without this high productivity realization, all high-earning households would have been entrepreneurs. Also, the level of this high ability is less than 1/10 of the highest ability realization used by Kindermann and Krueger (2015).

In my analysis, entrepreneurs play an especially important role. The majority of entrepreneurs actually gain from the tax increase: Low-income entrepreneurs because they can compensate lower average profits with the lump-sum transfer, and high and middle-income entrepreneurs because they can increase production and profits thanks to the lower wage. Especially these middle-income entrepreneurs contribute heavily to the overall increase in welfare and the high CEV of 5.2 percent, since they benefit evenly across all income levels while welfare gains phase out for workers with similar earnings. Only the highest-earning entrepreneurs in the top tax bracket are negatively affected by the tax increase.

Entrepreneurs also contribute heavily to the increase in tax revenue. The absolute amount of taxes raised from entrepreneurs increases by 40 percent, while taxes raised from workers and retirees only increase by 17 percent after the TMTR is raised to 82.5 percent. Entrepreneurs thus play an essential role in generating additional tax revenue, which in turn enables the government to pay out a large pre-tax lump-sum transfer. This transfer then benefits low-income households, guaranteeing large welfare gains also for that segment of the earnings distribution.

7 Conclusion

The greatest fear of many opponents of higher top income taxation is that disproportionately many entrepreneurs will be hit by the tax increase and consequentially avoid growing and hire less labor. In my analysis, while this is true for entrepreneurs directly confronted with the tax increase, the effect on lower-earning entrepreneurs is the opposite: Lower wages induce these entrepreneurs to actually increase their number of employees, and through that, production, profits and ultimately consumption.

Raising the top marginal tax rate is thus beneficial for entrepreneurs outside the highest tax bracket, and these benefits are crucial in generating the high welfare-maximizing top marginal tax rate of 82.5 percent. But also workers largely profit from the higher tax rate: Since additional tax revenues are redistributed lump-sum among all households, low-income workers do not suffer the earnings loss from lower wages but can actually increase their consumption thanks to the lump-sum transfer. The resulting positive welfare effects for low and middle-income households outweigh the welfare losses incurred by the rich, leading to an aggregate welfare gain measured by the CEV of 5.2 percent.

These results are all based on long-run steady state comparisons. During the transition from one state to the next, welfare and revenue effects could look very different. Therefore, the transition dynamics should be taken into account in order to increase soundness of the analysis. Filling this gap is one necessary next step in my further analysis.

Another interesting aspect of the interplay of higher top income taxation and entrepreneurship is its relevance for innovation and growth. Entrepreneurs are the main innovators in an economy, and are often called the “engines of growth”. Analyzing the impact of higher top marginal tax rates on entrepreneurial innovation would be a fascinating extension and could potentially alter the optimality results of my analysis.

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A SCF Data

I obtained data for the distributions of income and wealth, as well as income and wealth statistics for entrepreneurs, from the Survey of Consumer Finances 2010. *Household wealth* is defined as net worth of a household, that is the difference between assets and debt. Assets include financial assets and nonfinancial assets, such as liquid assets, certificates of deposit, directly held pooled investment funds, stocks, bonds, quasi-liquid assets, savings bonds, whole life insurance, other managed assets, and other financial assets, and also vehicles, value of primary residence, value of other residential real estate, net equity in nonresidential real estate, and value of business interests. *Household income* includes wages, self-employment and business income, taxable and tax-exempt interest, dividends, realized capital gains, food stamps and other support programs provided by the government, pension income and withdrawals from retirement accounts, Social Security income, alimony and other support payments, and miscellaneous sources of income. I follow Cagetti and De Nardi (2006) in defining entrepreneurs as self-employed business owners. Additionally, I require that these entrepreneurs have the legal form of a pass-through entity (S corporation, partnership, or sole-propietorship), which is the case for 92 percent of all entrepreneurs.

B Consumption Equivalent Variation (CEV)

Similar as in Heer and Trede (2003), aggregate welfare W is defined as the integral over all households' life-time utility:

$$W(\text{TMTR} = 35\%) = \int_{\mathcal{X}} V(a, \epsilon, \theta) dm^* \tag{B.1}$$

$$= \int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \right] dm^* \tag{B.2}$$

$$= \int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^*)^{1-\sigma_1}}{1-\sigma_1} - \chi \frac{(l_t^*)^{1+\sigma_2}}{1+\sigma_2} \right) \right] dm^* \tag{B.3}$$

The steady state policy functions are marked with an asterisk, and so is the benchmark distribution m^*. Welfare in the new tax system is defined in the same way but denoted by $W(\text{TMTR} = \tau^{rich})$. The CEV Δ^{CEV} is defined as the percentage by which benchmark consumption c^* has to be increased in order to make a household indifferent between the two tax systems, i.e. $W(\text{TMTR} = 35\%) = W(\text{TMTR} = \tau^{rich})$. Thus,

$$W(\text{TMTR} = \tau^{rich}) = \int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{\left((1+\Delta^{CEV}) c_t^*\right)^{1-\sigma_1}}{1-\sigma_1} - \chi \frac{(l_t^*)^{1+\sigma_2}}{1+\sigma_2} \right) \right] dm^* \tag{B.4}$$

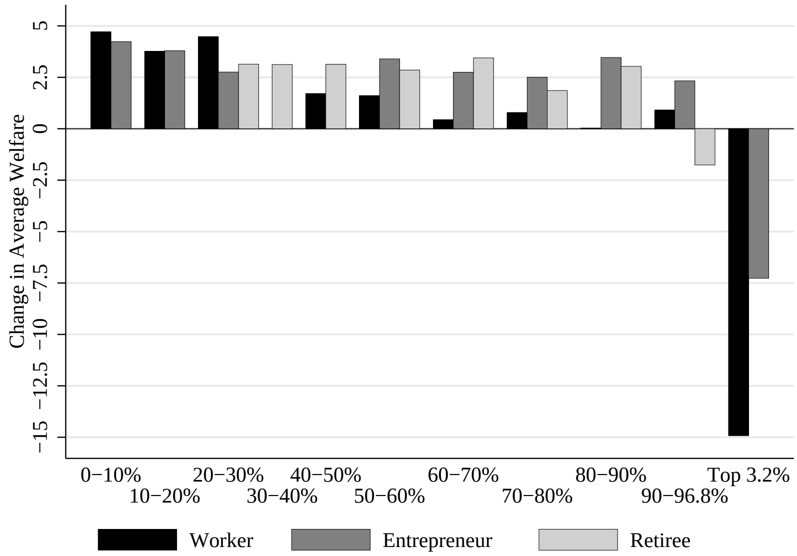
This equation can be rearranged to yield an expression for the CEV that looks as follows:

$$\Delta^{CEV} = \left[\frac{W(\text{TMTR} = \tau^{rich}) - W(\text{TMTR} = 35\%)}{\int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^*)^{1-\sigma_1}}{1-\sigma_1} \right) \right] dm^*} + 1 \right]^{\frac{1}{1-\sigma_1}} - 1 \tag{B.5}$$

This can be easily solved using the value functions in the two steady state as well as the consumption policy function from the benchmark economy.

C Welfare Effects for Retirees

Figure C.1: Welfare Gains by Earnings Deciles for Workers, Entrepreneurs, and Retirees



D The Role of the Financial Friction

The financial friction in form of the borrowing constraint provides a large incentive to save for entrepreneurs: They need to increase their asset holdings in order to be able to increase their business investment. The borrowing constraint is the main reason for the fact that entrepreneurs have a higher savings rate than workers and cause a large degree of wealth inequality in the economy. The tighter the borrowing constraint, the greater the incentive to save.

Raising the top marginal tax rate has the opposite effect on asset accumulation: It lowers the incentive to save since it diminishes the marginal return to capital. Additionally, redistribution of extra tax revenue through a lump-sum transfer has an insurance effect which further decreases the need to accumulate savings.

In Table D.1 I present the aggregate effects of increasing the TMTR to 82.5 percent for different degrees of tightness of the borrowing constraint. In order to arrive at these results I change the value of λ in the benchmark calibration, but leave all other parameters unchanged. Then I solve the model for the steady states of the benchmark as well as the experiment economy and compare the outcomes, just as I did in the previous sections.

The first panel contains the effects of the tax increase when tightening the borrowing constraint. The incentive to save is stronger than in the original economy since the entire amount of entrepreneurial investment has to be backed by household savings. Consequently, the savings effect of the tax increase is less pronounced: Aggregate capital only decreases by 23 instead of 25 percent, leading to a smaller drop in output and a smaller increase in the interest rate.

In the second panel, I present the results of the tax increase in a world where the borrowing constraint is loosened: Instead of being allowed to borrow up to 50 percent of their asset

Table D.1: Role of the Financial Friction for Aggregate Effects of Tax Increase

	Y	K	N	T	r	w	TFP
Tighter Borrowing Constraint: No Borrowing ($\lambda = 1$)							
τ^{rich}=82.5%, GE	−8.8	−23.2	−4.9	13.1	38.5	−5.1	2.7
τ^{rich}=82.5%, PE	−12.5	−33.5	−3.2	10.9	0.0	0.0	2.4
Relaxed Borrowing Constraint ($\lambda = 2$)							
τ^{rich}=82.5%, GE	−10.3	−30.1	−4.3	16.2	134.1	−7.3	4.0
τ^{rich}=82.5%, PE	−15.7	−40.6	−2.6	11.4	0.0	0.0	2.4

PE stands for partial equilibrium (constant prices), GE for general equilibrium (flexible prices).

holdings, households are now allowed to borrow up to a 100 percent of their savings. As one would expect, aggregate effects change in the opposite direction. The savings motive is weaker in this economy, so the tax increase has a larger negative effect on aggregate savings and output. Also the price effects are more extreme in this setup.