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Higher Taxes at the Top: The Role of Entrepreneurs[†]

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This paper computes optimal top marginal tax rates in Bewley-Huggett-Aiyagari–type economies that include entrepreneurs. Consistent with the data, entrepreneurs are overrepresented at the top of the income distribution and are thus disproportionately affected by an increase in the top marginal income tax rate. The top marginal tax rate that maximizes welfare is 60 percent. While average welfare gains are positive and similar across occupations along the transition, they are larger for entrepreneurs than for workers in the long run, and this occupational gap in welfare gains after the tax increase widens with increasing income. (*JEL* D11, D21, D31, H21, H24, L26)

The taxation of top income earners is a controversial topic. In public debates over recent years, supporters of raising marginal tax rates on top income earners usually have the intention to close fiscal deficits and/or decrease economic inequality. Opponents of this view instead demand lower rates on top incomes as a means of shifting the tax burden away from high-income, high-productivity households and boosting economic activity. An increasing number of academic papers has studied the optimal level of top marginal tax rates (TMTRs). Spurred by Diamond and Saez's (2011) recommendation to impose high marginal tax rates on top income earners of up to 80 percent, a recent wave of quantitative studies, which I discuss in further detail below, uses dynamic general equilibrium models to determine optimal TMTRs. The results differ widely depending on specific modeling choices, especially regarding households' labor income processes and the implied labor supply elasticities among top income earners.

None of these papers features entrepreneurs. This paper closes that gap in the literature by explicitly modeling entrepreneurship based on Cagetti and De Nardi (2006) to evaluate the level and economic impact of optimal top marginal tax rates. Accounting for entrepreneurs is important for several reasons. First, in order to evaluate any increase in top income tax rates in a meaningful way, it is important that the top of the income distribution is replicated well in the model

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economy. Quadrini (2000) and Cagetti and De Nardi (2006) show that including entrepreneurs into incomplete market models with heterogeneous agents helps to endogenously create realistic distributions of income and wealth. Second, entrepreneurs are an empirically important occupational group among top income earners: in the Survey of Consumer Finances (SCF) 2010,[1] more than one-third of households in the top 1 percent of the income distribution are entrepreneurs, while at the same time they represent only 7.4 percent of all households.[2] Despite their small number, entrepreneurs generate 17 percent of total income and own 31 percent of total net worth. Third, since 66 percent of all entrepreneurs are employers and employ on average 29 employees, they play a significant role for aggregate labor demand, overall economic productivity, and wages.[3]

The model is a variant of the standard incomplete markets model with heterogeneous agents established by Bewley (1986), İmrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). Entrepreneurship is introduced into this environment following Cagetti and De Nardi (2006, 2009): there is a continuum of households that are endowed with different abilities for being a worker and an entrepreneur. Depending on these abilities and their assets, agents choose whether to work for the market wage or to become entrepreneurs and run their own businesses. Contrary to the model by Cagetti and De Nardi (2009), workers' labor supply is endogenous. As other quantitative studies on optimal top income taxation like Kindermann and Krueger (forthcoming); Badel and Huggett (2017); or Guner, Lopez-Daneri, and Ventura (2016) have shown, flexible labor supply is essential because the economic impact of a tax increase on top income earners crucially depends on the degree to which workers at the top will adjust their labor supply (for more details, see Section I). Entrepreneurs are collateral constrained and therefore have a higher incentive to save than workers. In addition to the precautionary savings motive, which is common across occupations, entrepreneurs also save because of the need to self-finance their business.[4] There are two sectors of production: a noncorporate sector, which includes all businesses run by entrepreneurs who operate decreasing-returns-to-scale production functions, and a corporate sector that features constant returns to scale. The wage and interest rate correspond to the marginal products of labor and capital in the corporate sector. All forms of income are subject to a progressive income tax schedule that closely mimics the US federal tax schedule.

[1] Data obtained from Board of Governors of the Federal Reserve System (2010a, b). More details on the data can be found in Section A of the Appendix.

[2] The definition of entrepreneurship is similar to the one in Cagetti and De Nardi (2006): entrepreneurs are self-employed owners of pass-through businesses who actively manage their own business. Following that definition, according to the Survey of Consumer Finances, 7.4 percent of all US households were entrepreneurs in 2010. Having the legal status of a pass-through entity means that any business income generated by their entrepreneurial activities is taxed according to the ordinary income tax schedule. The following legal forms classify as such: sole proprietorships, partnerships (including LLCs), and S corporations. Income (or losses) generated by businesses of these kinds have to be declared on Form 1040 of the US Individual Income Tax Return.

[3] According to the US census of 2007, pass-through entities employ about half of the private sector workforce.

[4] Other features often associated with entrepreneurship are its importance for innovation, product variety, trade, and ultimately, economic growth. In this paper, I am first and foremost interested in how differences between workers and entrepreneurs, especially with respect to their savings incentives, shape reactions to higher taxes. I therefore do not include any of these other features in my model but rather leave the analysis of their importance with respect to taxes for future research.

The model is calibrated to replicate a set of empirical moments characterizing the US economy; in particular, the empirical income distributions for workers and entrepreneurs as well as characteristics of the entrepreneurial sector are matched. The additional incentive to save in order to grow helps replicating the large degree of wealth inequality in the data.

After solving the fully calibrated benchmark economy, I obtain the top marginal income tax rates that maximize welfare as measured by consumption equivalent variation (i) in the new long-run steady state and (ii) when taking into account the full transition between steady states. Additional tax revenues raised through higher tax rates are redistributed using a lump-sum transfer. After having obtained the optimal TMTRs, I turn to the main focus of the analysis: the diverging effects of higher taxes on workers and entrepreneurs. Using the TMTR that maximizes welfare for the transition, I compare and contrast the different responses by workers and entrepreneurs at different levels of income to the higher top marginal tax rates. The resulting top marginal tax rate that maximizes welfare when taking into account the transition amounts to 60 percent, whereas the welfare-maximizing rate when comparing steady states only is 57 percent. Implementing the welfare-maximizing tax rate has interesting disparate consequences for workers and entrepreneurs: when considering the whole transition path, both workers and entrepreneurs see large average welfare gains except at the very top of the income distribution. They benefit from the redistributive lump-sum transfer that is paid out after the tax increase, and workers in addition initially profit from a higher wage in the first period of the transition. But when comparing only the two steady states (before and after the tax increase), entrepreneurs experience on average larger gains than workers, and the gap in occupation-specific welfare gains increases with income. While the lump-sum transfer is still beneficial for workers, especially at the low end of the income distribution, the lower wage in the new steady state after the tax increase leads to losses in average consumption and savings for workers with incomes above the median. Instead, high-income entrepreneurs outside the top tax bracket profit from this lower wage in the new steady state as it enables them to hire more employees and thereby grow their firms.

The remainder of the paper is organized as follows. After documenting related literature in Section I, I present the model in Section II. Section III describes the calibration strategy. Section IV then contains the results for the benchmark economy. In Section V, I explain the setup of the policy experiment and present the results, starting with the determination of the optimal top marginal taxes before evaluating the diverging impact that higher taxes have on workers and entrepreneurs. I end the section by exploring the importance of entrepreneurs and the labor earnings process in two robustness checks. Section VI concludes.

I. Related Literature

This paper contributes to the recent and growing literature on optimal top marginal income rates in quantitative dynamic macro models. Most closely related is the recent working paper by İmrohoroğlu, Kumru, and Nakornthab (2018), which has been developed independently and in parallel with my paper. Using a model that is very closely related to the one presented here, they compare the welfare implications of implementing higher taxes on the top 1 percent to increasing overall progressivity and find that the latter is preferable. Their welfare-maximizing top tax rate when only increasing top tax rates is close to the 57 percent found in this paper. İmrohoroğlu, Kumru, and Nakornthab (2018), however, do not share my main focus on disentangling the differential changes in the economic outcomes for entrepreneurs and workers after a tax increase.

Another paper that is closely related to mine is Kindermann and Krueger (forthcoming). Using an overlapping generations model with ex ante heterogeneity in education and labor income risk, they determine a long-run welfare-maximizing TMTR on labor income of 82 percent. Taking into account the transition, which in their OLG setup means all current and future generations' lifetime utility, yields a welfare-maximizing TMTR of 79 percent. Their high rates are partly due to the underlying labor productivity process, which is based on Castañeda, Díaz-Giménez, and Ríos-Rull (2003) and features very high, very risky productivity states in order to capture the high dispersion of income and wealth. Households that are endowed with these high productivity realizations hardly adjust their labor supply after a tax increase in order to accumulate as much wealth as possible and smooth lifetime consumption, creating room for large increases in tax revenue and in the degree of social insurance in the economy. In a complementary contribution, Brüggemann and Yoo (2015) rely on a similar labor productivity process but focus only on steady state comparisons. They also find large positive welfare effects after doubling the top marginal tax rate: low-income households profit from large tax reliefs made possible by large revenue gains from high-productivity households. In the paper at hand, while following a similar calibration strategy as the two aforementioned papers, the highest productivity state is much less extreme because the inclusion of entrepreneurs goes a long way in endogenously generating the large dispersion in wealth and income that can be found in the data. This partly explains the resulting lower optimal tax rates.

Badel, Huggett, and Luo (2020) extend the overlapping generations model by letting households be ex ante heterogeneous in human capital and learning ability and ex post heterogeneous due to shocks to human capital. The implied peak of the Laffer curve in their setup is at a top marginal tax rate of 49 percent. The higher top tax rate leads to lower skill investment and thereby to a large reduction in the labor input, leading to a lower optimal TMTR than in other setups that ignore the possibility of skill adjustments.[5] Guner, Lopez-Daneri, and Ventura (2016) also explore top marginal tax rates but find that a top marginal tax rate of only 42 percent maximizes revenue. This lower rate can be explained by the fact that productivity realizations in their setup are much more permanent than, for example, in Kindermann and Krueger (forthcoming). Another paper contributing to the quantitative literature on the effects of top income taxation is the paper by Kaymak and Poschke (2016), who quantify the role of changes in the taxation of top incomes in shaping

[5] In a more recent contribution, Badel and Huggett (2017) generalize their analysis 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.

the evolution of the distributions of wealth, income, and consumption in the United States over the last decades.

My paper heavily draws on the extensive literature on entrepreneurship in macroeconomics; see Quadrini (2009) for an excellent summary. I am not the first one to analyze the effects of tax changes in such a model with entrepreneurs. Cagetti and De Nardi (2009) look at the role of estate taxation for the wealth distribution. Kitao (2008) examines the role of taxes in a model with occupational choice when taxes vary 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.

II. Model

The model is a variant of the standard neoclassical model with heterogeneous agents established by Bewley (1986), İmrohoroğlu (1989), Huggett (1993), and Aiyagari (1994), where households face an occupational choice between being a worker or an entrepreneur. I adopt the model from Cagetti and De Nardi (2009) but change some crucial elements. First, while labor supply in their model is inelastic, it is flexible for workers 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. Second, I do not allow for entrepreneurship in old age and abstract from any potential intergenerational correlation of earnings or abilities.[6]

A. *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 retiring, $1 - \pi_y$. Old households face a constant probability of dying, $1 - \pi_o$. When a household "dies," he is immediately replaced by a young (working-age) descendant who inherits the full estate. Young households derive earnings either from supplying labor to the market in return for a wage w or from becoming an entrepreneur, investing into their own firm and receiving the net profits in earnings. 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 $\mathcal{E} = \left\{\epsilon_1, \ldots, \epsilon_{N_\epsilon}\right\}$ and evolves over time according to a first-order Markov process with transition probabilities $\Gamma\left(\epsilon' | \epsilon\right)$. Formally, the entrepreneurial ability process looks very similar: it can take values in $\Theta = \left\{0, \theta_1, \ldots, \theta_{N_\theta}\right\}$ and also follows a first-order Markov process $\Lambda\left(\theta' | \theta\right)$. The two abilities are uncorrelated.[7]

[6] This does not mean that there are no intergenerational linkages between parents and children regarding the choice of becoming an entrepreneur. In the model, one of those links is through wealth: the level of wealth inherited from entrepreneurial parents is four times as high as from non-entrepreneurial parents, leading to a higher likelihood of their children also becoming entrepreneurs.

[7] This assumption is also made by Cagetti and De Nardi (2006). Allub and Erosa (2019) argue that the correlation of skills plays an important role for the distribution of earnings across occupations but calibrate it to a relatively

Knowing its endowment with both labor and entrepreneurial ability, the household decides whether to spend his time working for the market wage or running 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 fixed retirement benefits from the government.

B. *Preferences*

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

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

where β is the rate at which the household discounts future utilities. Households are fully altruistic toward their descendants.

C. *Technology*

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

$$f(k,n) \;=\; \theta\left(k^{\gamma}\left(l^e + n\right)^{1-\gamma}\right)^{\nu}. \tag{2}$$

In order to produce, entrepreneurs employ n efficiency units of labor in addition to a fixed work time input l^e that has to be provided by the entrepreneur, so that the total labor input amounts to $\left(l^e + n\right)$. Entrepreneurs invest k units of capital into their firm. These inputs weighted by entrepreneurial ability θ determine entrepreneurial production. The production function exhibits decreasing returns to scale captured by the span-of-control parameter $\nu < 1$. This parameter captures the notion that the entrepreneur's managerial control becomes less efficient as it spreads out over larger and larger projects, a modeling device introduced by Lucas (1978). Entrepreneurial profits depend on the level of entrepreneurial ability, the size of the implemented project, the number of people hired by the entrepreneur, and the prices of capital and labor.

Not all firms are owned by entrepreneurs. Production by large corporate firms that are owned by the public takes place in the second sector of the economy, the so-called corporate sector, which is perfectly competitive and is captured by a standard Cobb-Douglas production function:

$$Y_c \;=\; F\left(K_c, N_c\right) \;=\; A_c K_c^{\alpha} N_c^{1-\alpha}. \tag{3}$$

low value of 0.145 for the Brazilian economy.

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

D. *Market Arrangements*

Entrepreneurs may borrow to increase investment into their 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 the form of a riskless bond. The corporate sector operates under perfect competition such that the equilibrium wage w and interest rate r are given by the marginal products of capital and labor in the corporate sector.

E. *Government*

The government has two sources of revenue: consumption taxes T_c and income taxes T_y.[8] 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 stepwise 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 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 stepwise tax function is expressed as follows:

$$(4) \qquad t^F(y) = \begin{cases} \tau_1(y - Y_1) & \text{if } Y_1 < y < Y_2, \\ \tau_1(Y_2 - Y_1) + \tau_2(y - Y_2) & \text{if } Y_2 < y < Y_3, \\ \vdots & \\ \tau_1(Y_2 - Y_1) + \cdots + \tau_m(y - Y_m) & \text{if } Y_m < y. \end{cases}$$

This stepwise tax function is intended to mirror the progressive, statutory federal income tax schedule in the United States. Tax credits 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 account for these discrepancies. The overall tax function is completed by a linear tax component, $\tau^s y$, that reflects state and local taxes:

$$(5) \qquad t_y(y) = \tau_{adj} t^F(y) + \tau^s y.$$

[8] I abstract from other forms of taxation, especially corporate taxes, which are of less importance for the question at hand. This is in line with the relevant literature, such as Kitao (2008) or Meh (2005).

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:

$$G + B = T_c + T_y. \tag{6}$$

F. *The Young Household's Problem*

A young household starts the period knowing its assets a, labor ability ϵ, and entrepreneurial ability θ. Based on these endowments, it makes its occupational choice between becoming an entrepreneur or a worker depending on which offers the highest level of expected lifetime utility. Hence, the value function of a young household is given by

$$V(a,\epsilon,\theta) = \max\{V^e(a,\epsilon,\theta), V^w(a,\epsilon,\theta)\}, \tag{7}$$

where V^e is the entrepreneur's value function and V^w is the worker's value function. Note, V^w is given by the following set of equations:

$$V^w(a,\epsilon,\theta) = \max_{c,l}\{u(c,l) + \beta\pi_y EV(a',\epsilon',\theta') + \beta(1-\pi_y)EP(a')\}, \tag{8}$$

subject to

$$y^w = wl\epsilon + ra, \tag{9}$$

$$a' = y^w - t_y(y^w - d) + a - (1+\tau^c)c, \tag{10}$$

$$a \geq 0. \tag{11}$$

The worker maximizes his lifetime value by choosing consumption c and hours worked l subject to the budget constraint in equation (10). With probability π_y, workers stay young, but with probability $1-\pi_y$, they become old households and have to retire, in which case their value function will be denoted by P. Gross income for a worker is simply given by the wage times the productivity-weighted labor input plus capital income (equation (9)). The zero borrowing constraint faced by the worker enters in equation (11).

The entrepreneur's value function is defined by the following dynamic program:

$$V^e(a,\epsilon,\theta) = \max_{c,k,n}\{u(c,l) + \beta\pi_y EV(a',\epsilon',\theta') + \beta(1-\pi_y)EP(a')\}, \tag{12}$$

subject to

$$y^e = \theta\left(k^\gamma(l^e+n)^{1-\gamma}\right)^\nu - \delta k - r(k-a) - wn, \tag{13}$$

$$a' = y^e - t_y(y^e - d) + a - (1+\tau^c)c, \tag{14}$$

$$l^e = \bar{l}, \quad a \geq 0, \quad n \geq 0, \quad k \leq \lambda a. \tag{15}$$

The entrepreneur not only chooses the optimal level of consumption subject to the budget constraint in equation (14) but also the profit-maximizing inputs into his own firm, subject to the credit constraint in (15). Unlike workers, entrepreneurs cannot decide how much labor to supply to the market but always have to supply a fixed amount of time $\bar{l}$. Entrepreneurial earnings are given by business profits and capital income, as defined in equation (13).

G. *The Old Household's Problem*

All old households are retired, independent of their occupation when young. Their state when starting a period is fully 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

$$\begin{aligned} y^r &= ra + b, \\ a' &= y^r - t_y(y^r - d) + a - (1+\tau^c)c, \\ l &= 0, \quad a \geq 0. \end{aligned}$$

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.[9]

H. *Stationary Equilibrium*

Let $\mathbf{x} = (a,\epsilon,\theta,z) \in \mathcal{X}$ 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

[9] Cagetti and De Nardi (2009) look at the role of estate taxation in their model with entrepreneurs, which this paper is based on. They find that an estate tax mimicking the actual US 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.

$c(\mathbf{x}), l(\mathbf{x}), a'(\mathbf{x}), n(\mathbf{x}), k(\mathbf{x})$, and a distribution of households over the state variables $\mathbf{x}$: $m(\mathbf{x})$, such that, given prices and government tax and transfer schedules:

- the policy functions $c(\mathbf{x}), l(\mathbf{x}), a'(\mathbf{x}), n(\mathbf{x})$, and $k(\mathbf{x})$ solve the maximization problems described above;
- capital and labor markets clear:

$$\int a(\mathbf{x})dm(\mathbf{x}) = K_c + \int k(\mathbf{x})\,\mathbf{I}_e(\mathbf{x})dm(\mathbf{x}),$$

$$\int l(\mathbf{x})\epsilon(\mathbf{x})\,\mathbf{I}_w(\mathbf{x})dm(\mathbf{x}) = L_c + \int n(\mathbf{x})\,\mathbf{I}_e(\mathbf{x})dm(\mathbf{x}),$$

  where $\mathbf{I}_w(\mathbf{x}) = 1$ if the agent is a worker and $\mathbf{I}_e(\mathbf{x}) = 1$ if the agent is an entrepreneur;

- the marginal product of labor and capital in the corporate sector are equal to w and r:

$$w = (1-\alpha)A_c\left(\frac{K_c}{L_c}\right)^{\alpha},$$

$$r = \alpha A_c\left(\frac{K_c}{L_c}\right)^{\alpha-1} - \delta;$$

- the government budget is satisfied:

$$G + \int b\,\mathbf{I}_r(\mathbf{x})dm(\mathbf{x}) = \int\left[t_y\big(y(\mathbf{x})\big) + t_c\big(c(\mathbf{x})\big)\right]dm(\mathbf{x}),$$

  where $\mathbf{I}_r(\mathbf{x}) = 1$ if the agent is a retiree;

- the stationary distribution of people m is time-invariant and satisfies

$$m = \mathbf{M}(m),$$

  where $\mathbf{M}(\cdot)$ is a one-period-ahead transition operator such that $m' = \mathbf{M}(m)$.

III. Calibration

The calibration of the model parameters follows a threefold strategy: Parameters describing the statutory income tax schedule directly correspond to what is fixed in tax laws. Some parameter values are taken from the literature, 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 Survey of Consumer Finance in 2010 (Board of Governors of the Federal Reserve System 2010a, b) as well as data from the Internal Revenue Service (Statistics of Income SOI Tax Stats 2001–2017). 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.

Table 1—Fixed Parameters

	Parameter	Value	Source
Preferences			
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	$1/3\ell = 1.0$
Production sector			
Capital share in corporate sector	α	0.330	Gollin (2002)
Technology parameter	A_c	1.000	Normalization
Depreciation rate	δ	0.060	Stokey and Rebelo (1995)
Borrowing limit	λ	1.500	Kitao (2008)
Entrepreneurs' labor input	l^e	1.000	$l^e = \bar{l} = 1/3\ell$
Demographics			
Probability of retiring	π_y	0.978	Average working life = 45 years
Probability of survival in retirement	π_o	0.911	Average retirement = 11 years
Government budget			
Government spending	G/y	0.146	United States President, and Council of Economic Advisers (2014)
Retirement benefits	b/y	0.400	Kotlikoff, Smetters, and Walliser (1999)
Taxes			
Consumption tax	τ_c	0.110	Altig et al. (2001)
Income tax deduction	d	$0.2385\bar{y}$	Tax Policy Center (2020)
US statutory federal income tax code 2010:			
	τ_i	{0.1, 0.15, 0.25, 0.28, 0.33, 0.35}	
	Y_i	$\{0.0, 0.214\bar{y}, 0.868\bar{y}, 1.753\bar{y}, 2.672\bar{y}, 4.771\bar{y}\}$	

Table 2—Calibrated Parameters

	Parameter	Value
Entrepreneurial ability process		
Entrepreneurial ability levels	θ_1	0.000
	θ_2	0.682
	θ_3	1.750
	θ_4	2.818
Transition probabilities	$\Lambda = \begin{pmatrix} 0.963 & 0.037 & 0.000 & 0.000 \\ 0.275 & 0.581 & 0.144 & 0.000 \\ 0.000 & 0.275 & 0.581 & 0.144 \\ 0.000 & 0.000 & 0.304 & 0.696 \end{pmatrix}$	
Labor ability process		
Highest labor ability level	ϵ_6	26.0
Probability of reaching ϵ_6	$\Gamma(\epsilon_6)$	0.002
Probability of leaving ϵ_6	$\Gamma(\epsilon_3 \mid \epsilon_6)$	0.071
Remaining calibrated parameters		
Discount factor	β	0.900
Utility weight of labor	χ	0.716
Capital share in ent. sector	γ	0.359
Span-of-control	ν	0.864
Tax adjustment factor	τ_{adj}	0.669

A. *Demographics and Endowments*

I set the probability of aging and retiring at $\pi_y = 0.978$ and the probability of surviving in retirement at $\pi_o = 0.911$. In line with the data, 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 chosen such that average hours worked are equal to $1/3\ell = 1.0$.

Endowments with entrepreneurial ability can take on four different values, $\theta \in \{\theta_1, \ldots, \theta_4\}$. I fix $\theta_1 = 0$ such 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 $\{\theta_2, \theta_3, \theta_4\} = \bar{\theta} \times \{(1-\hat{\theta}), 1, (1+\hat{\theta})\}$. 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 to the next higher and next lower ability level are the same for θ_2 and θ_3. This leaves me with four parameters to calibrate in the transition probability matrix:

$$\Lambda = \begin{pmatrix} \pi_1^\theta & 1-\pi_1^\theta & 0.00 & 0.00 \\ \pi_2^\theta & \pi_3^\theta & 1-\pi_2^\theta-\pi_3^\theta & 0.00 \\ 0.00 & \pi_2^\theta & \pi_3^\theta & 1-\pi_2^\theta-\pi_3^\theta \\ 0.00 & 0.00 & 1-\pi_4^\theta & \pi_4^\theta \end{pmatrix}. \tag{16}$$

The 6 parameters characterizing the entrepreneurial ability process are calibrated to match 6 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 (16.8 percent) (SCF 2010), the Gini coefficient of entrepreneurs' income of 0.650 (SCF 2010), and the share of entrepreneurs who are also employers (66.1 percent) (SCF 2010).

Labor ability ϵ can take on six different values, $\epsilon \in \{\epsilon_1, \ldots, \epsilon_6\}$. 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. Similar to Kindermann and Krueger (forthcoming), 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 income 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, almost all households at the top of the income distribution would be entrepreneurs. At the same time, the additional level of labor ability will help me to match the empirical distribution of workers' income (Gini coefficient: 0.514) (SCF 2010) as well as share of income of top 1 percent earners in the overall income 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. The fully calibrated process can be found in Section B of the Appendix.

B. *Preferences*

The utility function is of CRRA type and additively separable in consumption and labor (time indices are dropped for simplicity):

$$u(c,l) = \frac{c^{1-\sigma_1}}{1-\sigma_1} - \chi \frac{l^{1+\sigma_2}}{1+\sigma_2}. \tag{17}$$

The parameter σ_1 describes the curvature of consumption and is set to $\sigma_1 = 1.5$, 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 is similar to values picked by others in the relevant literature.[10] The last remaining preference parameter is the weight of the disutility of labor χ, which is calibrated within the model such that average hours worked are equal to one-third of the time endowment.

C. *Technology*

Entrepreneurial production is characterized by two parameters in addition to entrepreneurial ability: the span-of-control parameter ν and the income share of capital, γ. Both are calibrated internally and help matching wealth-related targets, namely the wealth Gini of 0.84 and the ratio of median net worth between entrepreneurs and workers of 7.24, as well as the targets describing the entrepreneurial sector listed above.

The capital share in the corporate sector is set to 0.33, which is a value commonly used in the macroeconomic literature 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 standard, e.g., in Stokey and Rebelo (1995).

D. *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).

E. *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 14.6 percent of GDP, which corresponds to total federal receipts

[10] The cross-sectional variation in income and hours choices allows me to estimate the uncompensated labor supply elasticity on the micro level. The obtained value is close to zero, which is in line with common estimates for male workers.

Table 3—Targets: Data and Model

	Target	Model
Overall economy		
Capital-output ratio	2.65	2.65
Top 1 percent income share	0.17	0.17
Ratio of median net worth E/W	7.26	7.69
Wealth Gini	0.85	0.84
Average federal income tax rate	0.12	0.12
Entrepreneurs		
Fraction of entrepreneurs	0.07	0.07
Entry rate	0.02	0.02
Exit rate	0.22	0.22
Entrepreneurs' share of total income	0.17	0.22
Entrepreneurs' income Gini	0.65	0.62
Share of entrepreneurs among top 1 percent income	0.35	0.35
Share of hiring entrepreneurs	0.66	0.64
Workers		
Average working time	1.00	1.00
Workers' income Gini	0.51	0.52

over GDP in 2010.[11] The retirement benefit b amounts to 40 percent of average income just as in Kotlikoff, Smetters, and Walliser (1999).

On the revenue side, there are 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 US tax law for 2010 and are stated in Table 1 relative to average household income (US$78,332 in the SCF 2010). I fix the deduction d at 23.9 percent of average income, which corresponds to a personal exemption of \$7,300 and a standard deduction of \$11,400, both of which were available to married couples in 2010. The adjustment factor τ_{adj} intended to close the gap between effective and statutory tax rates is calibrated to match the average effective federal income tax rate paid by US taxpayers in 2010 (defined as total income tax raised divided by total taxable income) of 11.8 percent (Statistics of Income SOI Tax Stats 2001–2017). The linear income tax rate τ^s is endogenous and balancing the budget. The consumption tax rate is fixed at 0.11 following Altig et al. (2001).

All parameter values can also be found in Table 1 for the exogenously fixed parameters and Table 2 for the endogenously calibrated ones. In the end, I have to endogenously calibrate 14 parameters to match 14 targets.

IV. Benchmark Economy

In this section, I evaluate the performance of the benchmark economy in the initial steady state against the empirical targets. A good fit of the model-generated data with respect to empirical facts, especially regarding the entrepreneurial sector and right tail of the income distribution, is an important requirement for the subsequent policy experiment to be meaningful. I therefore also assess the performance of the model against some data moments that were not explicitly targeted in the

[11] Obtained from the 2014 Economic Report of the President, table B-20 (United States President, and Council of Economic Advisers 2014).

Table 4—Distributions of Income and Wealth

	Income				Wealth			
	Gini	Top 1%	Top 5%	Top 10%	Gini	Top 1%	Top 5%	Top 10%
All households								
Data	0.549	17.2	33.7	44.4	0.846	34.1	60.9	74.4
Model	0.572	17.0 [a]	42.2	49.8	0.842 [a]	21.6	60.9	77.7
Entrepreneurs								
Data	0.650	21.1	42.2	55.1	0.771	25.5	50.1	64.1
Model	0.621 [a]	9.7	32.4	49.1	0.709	14.6	39.9	55.3
Workers and retirees								
Data	0.518	14.5	29.7	40.6	0.832	31.4	57.3	71.3
Model	0.519 [a]	17.4	35.5	44.2	0.850	22.6	64.2	78.9

[a] Targeted.

Source: Data on income and wealth distributions are obtained from the Survey of Consumer Finances 2010 (Board of Governors of the Federal Reserve System 2010a, b).

calibration, like detailed characteristics of the firm size distribution as well as the income and wealth distribution.

Table 3 shows the close fit of targeted moments in the data to those that are the result of the calibrated initial steady state. The model moments successfully match central features of the entrepreneurial sector like the fraction of entrepreneurs, the entry rate to entrepreneurship, and the exit rate from it. The share of entrepreneurs among the top 1 percent earners resulting from the model matches its empirical counterpart.

Table 4 compares the Gini coefficients and the top percentiles for the income and wealth distributions of all households and separately for entrepreneurs and everyone else. The numbers targeted directly in the calibration are marked by "a." Despite only targeting very few characteristics directly, the overall fit of the income and wealth distribution generated by the model is satisfying and comparable to the fit achieved by, e.g., Kitao (2008). As in Cagetti and De Nardi (2006), the explicit modeling of entrepreneurs helps generating the large degree of inequality in wealth because the borrowing constraint that entrepreneurs face means that they have to rely on their own wealth to invest into their businesses and thereby provides an additional incentive to save.

The calibration matches the average federal income tax rate in the United States. But since we are especially interested in taxes at the top of the distribution, it is also worthwhile comparing the distribution of taxes in the model against the distribution of taxes in the data. This is done in Table 5. The model only slightly underestimates taxes paid by the very top of the distribution but otherwise does a very good job at replicating the tax burden that rich households face in the data.

Another aspect of the benchmark economy that is not directly targeted is the distribution of firm sizes in the entrepreneurial sector. When looking at the firm size measured by the number of employees, the firm size distribution generated by the model matches the empirical distribution rather well for the benchmark economy; see Table 6. It preserves the general shape of its empirical counterpart but underestimates the number of small firms in the economy. Still, the average of 9

Table 5—Average Tax Rates for Top Percentiles of the Income Distribution

	Top 1%	Top 3%	Top 5%	Top 10%
Data	23.4	21.9	20.6	18.5
Model	21.6	20.9	20.0	18.5

Note: Average tax rates are computed by dividing total income tax by taxable income.

Source: Data are obtained from the Internal Revenue Service (Statistics of Income SOI Tax Stats 2001–2017).

Table 6—Firm Size Distribution: Data and Model

	Data	Model
Share of hiring entrepreneurs	0.661	0.636[a]
1–5 employees	0.692	0.588
6–10 employees	0.119	0.179
11–20 employees	0.065	0.102
More than 20 employees	0.125	0.131

[a] Targeted.

Source: Data on firm size distribution are obtained from the SCF 2010.

employees per employer is much lower than the value that can be found in the SCF 2010 (on average 29 employees) because the number of employees per firm has an upper bound that is much lower in the model economy than in the data. Empirically, pass-through entrepreneurs hire approximately one-half of the total private sector workforce. In the model, this fraction is a little lower, with 40 percent of total labor supply in efficiency units employed in the entrepreneurial sector.

V. Policy Experiment

After demonstrating that the model economy replicates the empirical distributions of income and wealth well and sufficiently captures the entrepreneurial sector, I analyze next how entrepreneurs shape the economy's reaction to an increase in the marginal tax rate imposed on the highest-earning households in the economy.

In order to implement this policy experiment, I simply raise the marginal tax rate pertaining to the highest income bracket in the federal income tax schedule. The federal income tax function with a variable top marginal tax rate $\tau^{\max}$ can be written as

$$t_{exp}^F(y) = \begin{cases} \tau_{adj} t^F(y) & \text{if } y \leq y^{\max} \\ \tau_{adj} t^F(y^{\max}) + \tau^{\max}(y - y^{\max}) & \text{if } y > y^{\max}, \end{cases} \tag{18}$$

where $y^{\max}$ represents the level of taxable income above which households belong to the highest income tax bracket and therefore have to pay the highest marginal tax rate. In 2010, this threshold is US\$373,651, or 4.8 times average household income. When taking into account the adjustment factor $\tau_{adj} = 0.67$, the effective top marginal tax rate pertaining to that tax bracket in the benchmark model is $\tau^{\max} = 23.5$ percent. Approximately 2.9 percent of all households belong to this tax bracket, 40 percent of whom are entrepreneurs. In the following, I refer to this group as the top income earners. The tax increase affects these households directly. When increasing the effective TMTR, I keep the level of government spending (including transfers to retirees) as well as other tax parameters such as the tax brackets and standard deductions at their benchmark level. Any additional tax revenue generated by the tax increase is redistributed through a tax-free lump-sum transfer to all households.

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 between the benchmark level of 23.5 percent and a maximum rate of 70 percent and determine the tax rates that maximize welfare in the economy for the full transition path and when comparing steady states only. I then pick the welfare-maximizing tax rate for the transition and compare and contrast the behavior of workers and entrepreneurs as well as equilibrium prices to the higher-tax steady state and along the transition. Here, I am especially interested in how workers and entrepreneurs are affected differently and how households at different positions in the income distribution differ in their reactions to the tax change. I highlight the important channels through which the tax change impacts household behavior and aggregate economic performance and describe how outcomes change along the transition path. Last, I examine how the optimality results would change if I change some key components of the model.

A. *Optimality*

The optimal top marginal tax rates are determined through a grid search over potential top marginal tax rates. Starting from the calibrated initial steady state of the benchmark economy, I increase the top marginal tax rate. I then solve the model for the new steady state as well as for the transition path between the old and new steady state. Next, I compare the gain in welfare for the whole transition path and when comparing steady states only. To find the welfare-maximizing tax rates, I calculate the consumption-equivalent variation (CEV). Following McGrattan (1994), the CEV is defined as the percentage Δ^{CEV} by which every household's steady state per-period consumption c^* has to be changed in order to make the household indifferent on average between the initial and the new steady state, keeping everything else constant. Put differently, aggregate welfare in the new, higher-tax steady state, $\tilde{W}(\tau^{\max})$, has to be equal to aggregate welfare in the initial steady state (W) with an effective TMTR of 23.5 percent, where optimal consumption has been changed by Δ^{CEV} percent:

$$\tilde{W}(\tau^{\max}) = W(\tau^{\max} = 23.5\%, \Delta^{CEV}), \tag{19}$$

$$\int_{\mathbf{x}} E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{\left(\tilde{c}_t(\mathbf{x})\right)^{1-\sigma_1}}{1-\sigma_1} - \chi\frac{\left(\tilde{l}_t(\mathbf{x})\right)^{1+\sigma_2}}{1+\sigma_2}\right)\right]d\tilde{m}(\mathbf{x})$$

$$= \int_{\mathbf{x}} E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{\left(\left(1+\Delta^{CEV}\right)c_t^*(\mathbf{x})\right)^{1-\sigma_1}}{1-\sigma_1} - \chi\frac{\left(l_t^*(\mathbf{x})\right)^{1+\sigma_2}}{1+\sigma_2}\right)\right]dm^*(\mathbf{x}).$$

This is an ex ante welfare comparison, i.e., before the household is born and knows its type. If the CEV is positive, this means that average welfare is higher in

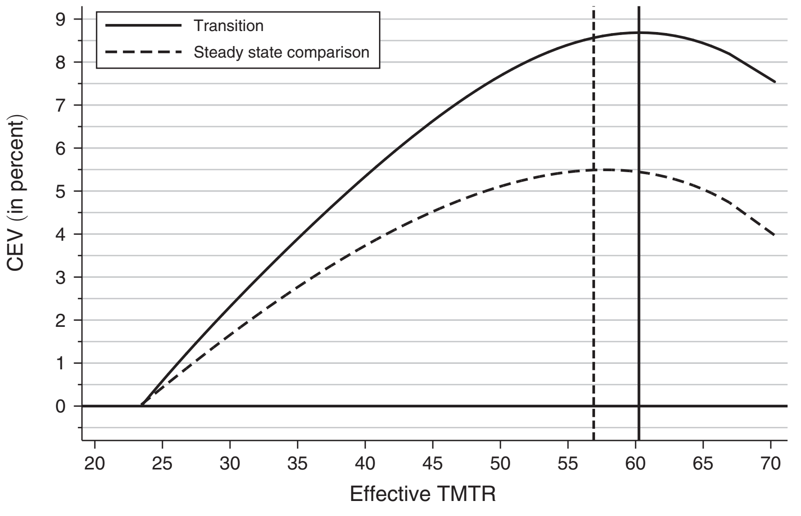

Figure 1. Welfare-Maximizing Top Marginal Tax Rate

Notes: The solid line shows the CEVs (in percent) associated with increasing the top marginal tax rate to the levels indicated on the x-axis, taking into account the whole transition path. The dashed line shows the CEVs (in percent) when comparing steady states.

the new steady state and households would only be willing to remain in the initial steady state if they are compensated by a higher level of consumption.

The procedure for including the transition is similar, only I calculate the CEV using aggregate welfare in the first period of the transition $(\tilde{W}_1(\tau^{\max}))$, where the household's value function takes into account the full transition path between the two steady states:

(20) $$\tilde{W}_1(\tau^{\max}) = W(\tau^{\max} = 23.5\%, \Delta^{CEV}).$$

Again, the CEV is capturing the percentage by which benchmark consumption would have to be changed for households to be indifferent between the initial steady state and the first period of the transition to a new, higher-tax steady state. More details of the formal derivation of the CEV can be found in Section C of the Appendix.

The welfare-maximizing top marginal tax rate $(\tau^{\max})^*$ is then found by maximizing Δ^{CEV}:

(21) $$(\tau^{\max})^* = \operatorname{argmax}(\Delta^{CEV}).$$

Figure 1 shows the CEV for effective top marginal tax rates between 23.5 and 70 percent.[12] Welfare gains along the transition increase steadily before flattening out for rates between 55 and 65 percent. The maximum CEV identified by the grid

[12] Revenue-maximizing tax rates can be found in Section E of the Appendix. They are with 60 percent in the first period of the transition and 62 percent in the steady state, very similar to the welfare-maximizing rates.

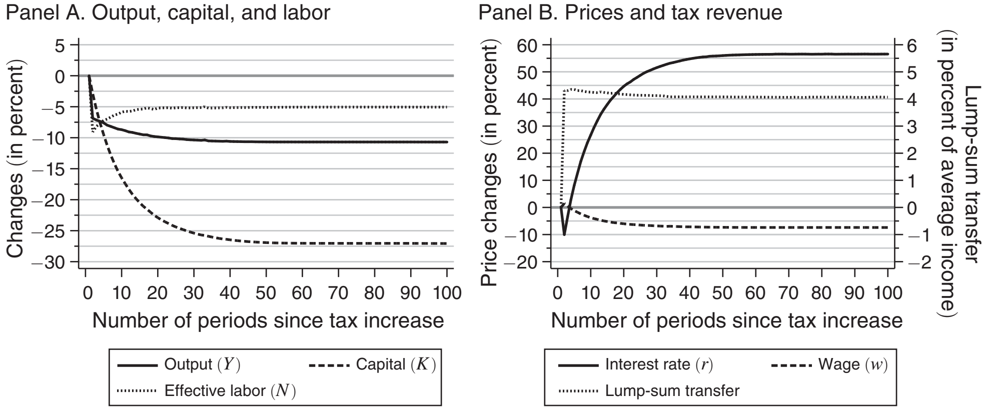

Figure 2. Changes in Aggregate Variables along the Transition

Notes: The solid, dashed, and dotted lines in panel A show percentage changes in output, capital, and effective labor, respectively, along the transition between the initial steady state (period 0) and the higher-tax equilibrium. The solid and dashed lines in panel B show percentage changes in interest rate and wage, respectively, along the transition. The dotted line in panel B shows the lump-sum transfer paid out along the transition in percent of average income.

search lies at a TMTR of approximately 60 percent. Welfare gains when comparing only steady states are very similar and result in a maximum CEV at 57 percent. When implementing a similar experiment where I lower the consumption tax rate instead of paying out a lump-sum transfer to balance the budget, the welfare-optimizing TMTR is the same, as Section G of the Appendix describes.

In the following sections, I illustrate the changes in aggregate and disaggregate occupation-specific outcomes after increasing the effective tax rate to its welfare-maximizing level when taking into account the whole transition path, 60 percent.

B. *Aggregate Outcomes after the Tax Increase*

Increasing the top marginal tax rate to its welfare-maximizing level decreases the aggregate capital stock, labor, and output along the transition to the new steady states. In this section, I highlight two channels that are important in shaping this response: the direct effects of the tax increase on the incentives to work and save as well as the indirect effects through adjustments in general equilibrium prices.

Figure 2 shows the adjustment paths for aggregate output, capital, and effective labor (panel A of Figure 2) as well as those for prices (interest and wages) and tax revenue (captured by the universal lump-sum transfer, panel B of Figure 2). The exact values of these adjustments between the old and new steady state after the tax change can be found in the first line of Table 7. In the benchmark economy, 2.9 percent of households are subject to the TMTR, 40 percent of which are entrepreneurs. After the tax increase from 23.5 to 60 percent, this fraction increases slightly to 3 percent, with entrepreneurs accounting for 42 percent of households in the top tax bracket.

Table 7—Aggregate Changes between Steady States after Increasing the Effective TMTR to 60 Percent

	Y	K	N	T	r	w
$\tau^{\max} = 60\%$, GE (percent)	−10.7	−27.1	−5.1	19.6	56.6	−7.4
$\tau^{\max} = 60\%$, PE (percent)	−15.4	−38.8	−3.4	15.5	0.0	0.0

Note: PE stands for partial equilibrium (prices at benchmark level), GE for general equilibrium (prices adjust).

Panel A of Figure 2 shows that output drops instantaneously after the tax increase. This is mostly driven by the fact that households sharply decrease their labor supply in the first period of the transition in direct response to the tax increase and thanks to the immediate benefit of the redistributive lump-sum transfer of 4.3 percent of average income (dotted line in panel B of Figure 2). After that initial drop, effective labor supply slightly recovers for the remaining transition path before reaching the new steady state, which is about 5.1 percent below its benchmark level. Output continues to fall after the initial drop, but the decrease is then mainly driven by the slow but large downward adjustment of the aggregate capital stock. In the new steady state, capital is 27.1 percent lower than in the benchmark, and the fall in output amounts to 10.7 percent.

Capital drops to a much larger degree than labor does, and this increased relative scarcity is reflected in the sharp increase in the interest rate after the first period of the transition, which ultimately ends up at a level that is 56.6 percent higher than in the benchmark (4.0 instead of 2.5 percent). Wages behave in the opposite way, briefly increasing in the first period of the transition before falling to a level that is 7.4 percent lower than before the increase in the TMTR. Tax revenues from both income and consumption taxes, T, increase by almost 20 percent. This additional revenue is redistributed through a large lump-sum transfer that, after being slightly higher in the early periods of the transition, eventually converges to 4 percent of average household income.

In addition to quantifying the final steady state deviations from the benchmark, Table 7 also sheds light on another important mechanism shaping the economy's adjustment to the tax increase. In its second row, it shows the changes in the aggregate variables when taxes increase but prices stay at their benchmark level.[13] Comparing this partial equilibrium (PE) to the general equilibrium case (i.e., the final steady state) captures an important channel of the tax increase: price adjustments (higher interest rates, lower wages) have a mitigating effect on the drop in capital and thereby, on output. Without these adjustments, capital and output fall more, and the increase in tax revenue is lower than we ultimately see.

While these "positive" effects of the price adjustments exist for the aggregate economy, they are not universal across sectors. Table 8 compares the changes in output, capital, and labor in the corporate and the entrepreneurial sector between steady states both before and after prices adjust to the new tax regime. While the drop in

[13] The government balances its budget, and there is a positive lump-sum transfer of about 3.4 percent of average household income.

Table 8—Aggregate Changes between Steady States after Increasing the Effective TMTR to 60 Percent: By Sector

	Y	K	N	# Ent.
Corporate sector				
$\tau^{\max} = 60\%$, GE (percent)	−19.5	−31.1	−13.0	
$\tau^{\max} = 60\%$, PE (percent)	−12.5	−43.3	+8.4	
Entrepreneurial sector				
$\tau^{\max} = 60\%$, GE (percent)	−0.9	−13.8	+7.1	+4.1
$\tau^{\max} = 60\%$, PE (percent)	−18.7	−23.9	−21.5	+1.5

Note: PE stands for partial equilibrium (prices at benchmark level), GE for general equilibrium (prices adjust).

Table 9—Relative Factor Allocation in Corporate and Entrepreneurial Sector in the Benchmark Steady State and after Increasing Effective TMTR to 60 Percent

	Capital		Labor	
	Corporate	Entrepreneurial	Corporate	Entrepreneurial
Benchmark (percent)	76.7	23.3	60.5	39.5
$\tau^{\max} = 60\%$, GE (percent)	72.5	27.5	55.4	44.6

capital is still dampened in both sectors after prices adjust, in the corporate sector, the mitigating effect on output disappears. Instead, the drop in wages is associated with a further drop in effective labor (N) used in the corporate sector. This drop is caused by two adjustments: first, lower wages encourage hiring as well as entry into entrepreneurship, which means that less labor is available to the corporate sector. Second, total effective labor supply falls overall (as panel A of Figure 2 and Table 7 show) in response to lower wages, higher taxes at the top, and the income effect associated with the redistributive transfer.[14] Taken together, these two effects lead to the large drop in corporate labor and contribute to the amplification of the decrease in corporate output after prices adjust. In the entrepreneurial sector, on the other hand, the same increase in hiring and entry because of lower wages dampens the negative effects of the tax increase on entrepreneurial output. The diverging implications of the price changes in the corporate and entrepreneurial sector and especially the increase in hiring by entrepreneurs lead to a shift in the factor allocation across sectors. Table 9 shows that after the tax increase, relatively more capital and labor are used in the more productive entrepreneurial sector.

Underlying these aggregate results and movements in input factors across sectors are the reactions of households in the economy in response to the tax increase and the ensuing change in general 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.

[14] Wages fall despite the drop in aggregate labor supply because the large decrease in capital leads to an overall decrease in the capital-labor ratio.

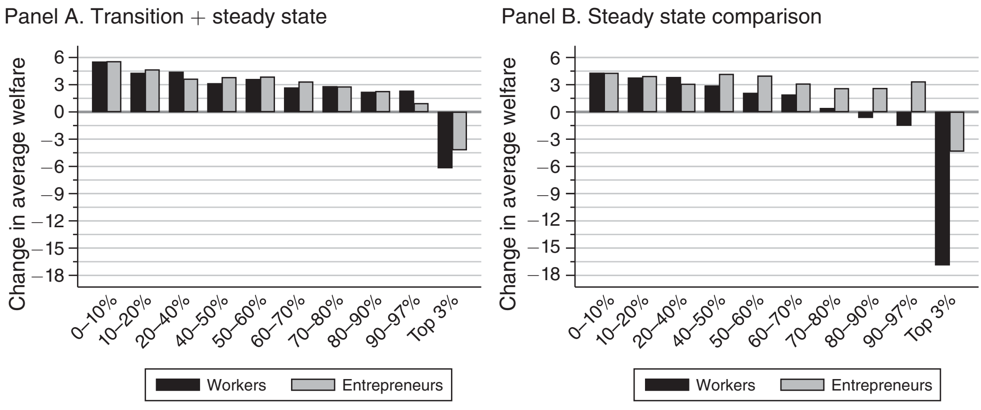

Figure 3. Welfare Gains by Income Deciles for Workers and Entrepreneurs

Notes: The black bars show the average changes in welfare for workers as measured by changes in households' expected lifetime utility for each decile of the distribution of gross income. The gray bars show the same for entrepreneurs. Panel A shows the welfare changes when taking into account the transition path to the new steady state. Panel B compares the two steady states only. A household is characterized by its occupation, age, and endowments with wealth, labor, and entrepreneurial ability.

C. *Disaggregate Changes*

Heterogeneous Welfare Gains.—Figure 3 shows the average change in welfare for workers and entrepreneurs along the distribution of gross income, where changes in welfare are measured by changes in households' expected lifetime utility. Panel A shows the welfare gains when taking into account the transition path, and panel B compares the two steady states.

In order to calculate these values, I first identify the income decile that each household type falls into in the benchmark economy. A household type is characterized by its occupation, age, and endowments with wealth, labor, and entrepreneurial ability.[15] For each decile, I then calculate average expected lifetime utility separately for entrepreneurs and workers, splitting the top decile into the share of households in the top tax bracket (top 3 percent) and the remaining 7 percent.[16] For the same household types, I compute average expected lifetime utility in the first period of the transition (thus taking into account the transition path and the new steady state) and in the new steady state after increasing the effective TMTR to 60 percent, again separately for workers and entrepreneurs. The change in welfare depicted in Figure 3 is the percentage difference in average occupation-specific welfare between the benchmark and the experiment economy, where each household type has been categorized

[15] Please note that I only include households that do not switch occupations after taxes are increased. This excludes 0.17 percent of the overall population. Welfare results for occupation switchers can be found in Section F of the Appendix along with the results for retirees.

[16] Please note that I lump together the third and fourth decile because of jumps in the cumulative distribution of income that do not allow for a clean separation between the two deciles.

according to their income level in the benchmark economy. In the first period of the transition, these welfare gains take into account the whole transition path.[17]

Overall, Figure 3 shows that there is an almost universal increase in welfare both in the long run as well as along the transition. It is therefore not surprising that the aggregate welfare gain measured by the CEV is also large: approximately 8 percent along the transition and 5 percent in the new steady state. Additionally, the graph shows four interesting heterogeneous effects of the tax increase: (i) Households subject to the top marginal tax rate (top 3 percent) experience large welfare losses, both along the transition and in the steady state. (ii) Average welfare increases the most at the low end of the income distribution. (iii) In the long run, welfare gains for middle- and high-income entrepreneurs below the highest tax bracket are positive and fairly constant in income. (iv) Workers' welfare gains are larger when taking into account the transition than when only comparing steady states, but entrepreneurial gains are very similar for both timelines. Average welfare gains across occupations are thus larger along the transition, which was also reflected in the aggregate welfare gains that were shown in Figure 1.

Facts (i) and (ii) are not surprising 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 income, consumption, and savings. Additional tax revenues are redistributed lump-sum to all households, which is particularly beneficial for households with low incomes. Hence, they see the largest increases in welfare.

The effects on households in the middle segment of the distribution and especially the large differences between workers and entrepreneurs in the long run are less straightforward to explain. Here, differences in the reaction to changes in general equilibrium prices can help explain why the gap in welfare gains for workers and entrepreneurs widens with increasing income.

Heterogeneous Changes in Consumption, Savings, and Hours Worked.—The changes to welfare in the long run and along the transition are reflections of the changed economic circumstances and households' adjustments to them. In the following sections, I want to disentangle these adjustments and take a closer look at how they differ by income and occupation in the first period of the transition and also in the new steady state. To start, Figure 4 shows the diverging changes in the choice variables that workers and entrepreneurs have in common, i.e., consumption (panel A of Figure 4) and savings (panel B of Figure 4), as well as workers' adjustments of hours worked. Remember that entrepreneurs supply a fixed amount of hours to their business, so panel C of Figure 4 does not show any changes in the hours worked by entrepreneurs.

[17] Note that the weight of each household type may change from one steady state to the next. That is, the weight of each working (entrepreneurial) household type in the calculation of the average might have changed. I chose this form of comparing welfare across steady states because it allows for clean comparisons across occupational groups while at the same time also allowing me to take into account changing distributions from one steady state to the next. Also note that this is not a problem in the first period of the transition as the distribution has not yet adjusted after the tax change.

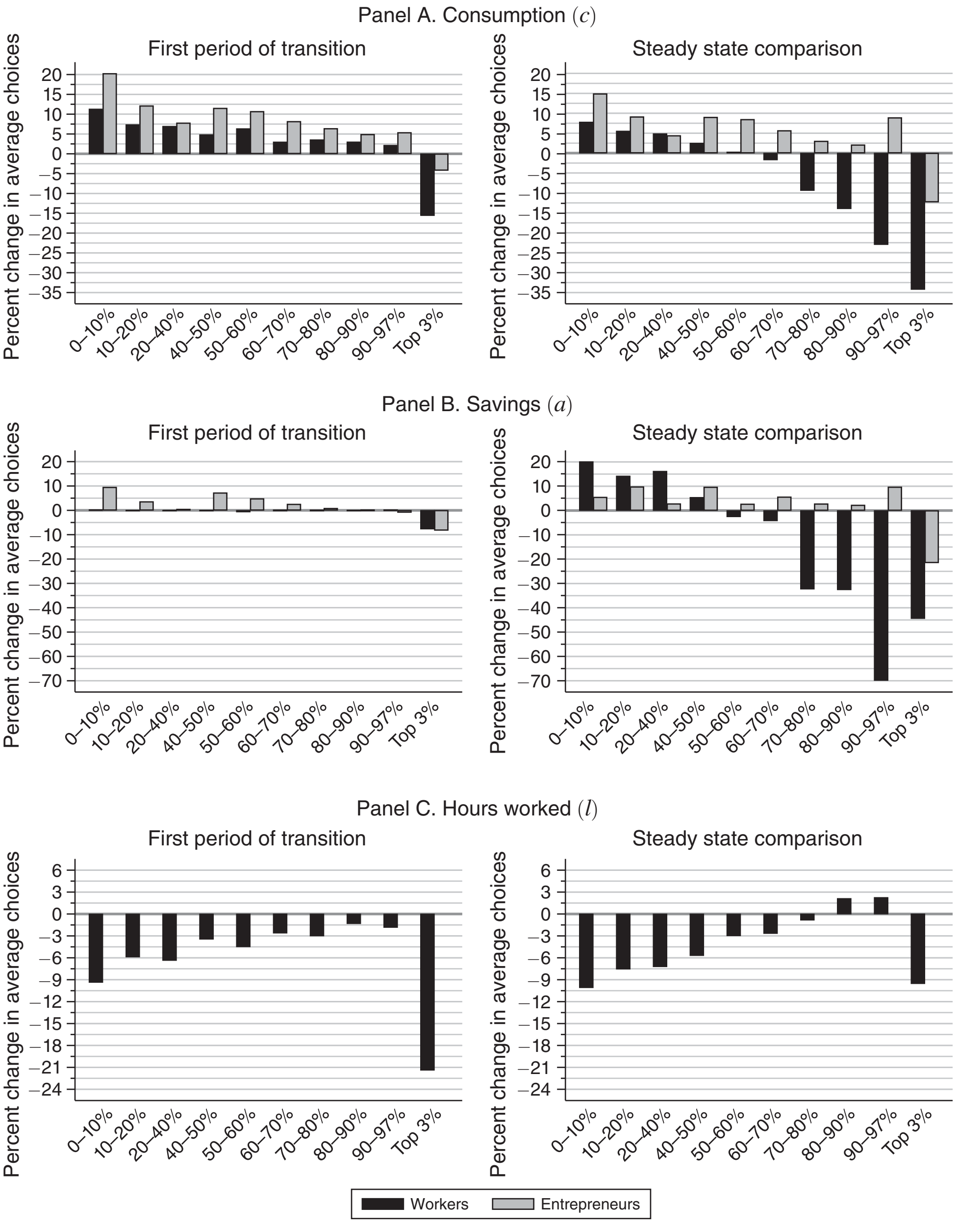

FIGURE 4. CHANGES IN AVERAGE CHOICES BY OCCUPATION AND INCOME LEVEL

Notes: The black bars show the average changes in workers' consumption (panel A), savings (panel B), and hours worked (panel C) for each decile of the distribution of gross income after the TMTR was increased to 60 percent. The gray bars show the same for entrepreneurs. The left panels in each subfigure depict changes in the first period of the transition; the right panels show changes between steady states.

The values are obtained using the same computation strategy as for the calculation of welfare changes in the previous section. The black bars show how average choices for workers in a given decile change directly after increasing the TMTR to 60 percent (first period of the transition; left panels) and the new steady state (right panels). The gray bars depict the same changes for entrepreneurs. Note that in the first period of the transition, the distribution of households is still the same as in the benchmark,[18] so these graphs capture the pure behavioral adjustments of households to the tax increase. The graphs for the new steady state also include distributional changes.

In the first period of the transition, the similar welfare gains below the top tax bracket across occupations stem from large increases in consumption among entrepreneurs as well as workers. Workers' consumption increases less than entrepreneurs', but welfare gains are nevertheless similar because workers also work lower hours and therefore enjoy more leisure in the short run. This is largely driven by a strong income effect associated with the lump-sum transfer households receive after the tax increase. Workers do not adjust their savings directly after the tax increase, but entrepreneurs save slightly more, especially among low- and medium-income households. Given that entrepreneurs cannot reduce their labor supply after receiving the lump-sum transfer (except when they switch occupations, which very few do), they instead use the additional income to save more. Only entrepreneurs at the very top of the distribution immediately reduce their savings in response to the tax increase.

Panel B of Figure 3 showed that welfare gains for workers and entrepreneurs diverge in the long run. Comparing the short and long run in the left and right panels of Figure 4 shows that this divergence is mainly due to further changes that workers make to their behavior in the new steady state. The negative correlation between welfare gains and income as shown in panel B of Figure 3 is mirrored in the changes to workers' average consumption and savings depicted by the black bars in the right panels of panels A and B in Figure 4. For income levels below the median, the impact of the tax increase on consumption and savings is positive in the long run. Together with the large reduction in hours worked (right side of panel C of Figure 4) in response to the lower wage as well as the redistributive transfer, adjustments in these variables account for the continued large welfare gains for working households with incomes below the median. But above the median, working households choose much lower levels of consumption and savings than they did early in the transition. The income effect caused by the drop in wages outweighs that of the redistributive transfer for households with high income and high labor productivity, causing households to not reduce labor as much as they did in the short run, or even increase it. The additional welfare gain from lower hours worked is thus lost in the new steady state. Working households in the top income tax bracket (the top 3 percent) experience the largest reduction in consumption of about -34 percent.

While the changes in consumption and savings for workers feature a strong negative correlation with income in the long run, the patterns of adjustment among entrepreneurs vary less systematically with income and are more similar across the two time horizons. After the tax increase on top income earners, all entrepreneurs except those in the top tax bracket end up with higher levels of consumption and savings than in the benchmark steady state, as shown by the gray bars in panels A

[18] This is because individuals adjust their savings in response to the tax change that takes place at the beginning of period 1, which then leads to changes in the distribution over assets and abilities in period 2 of the transition.

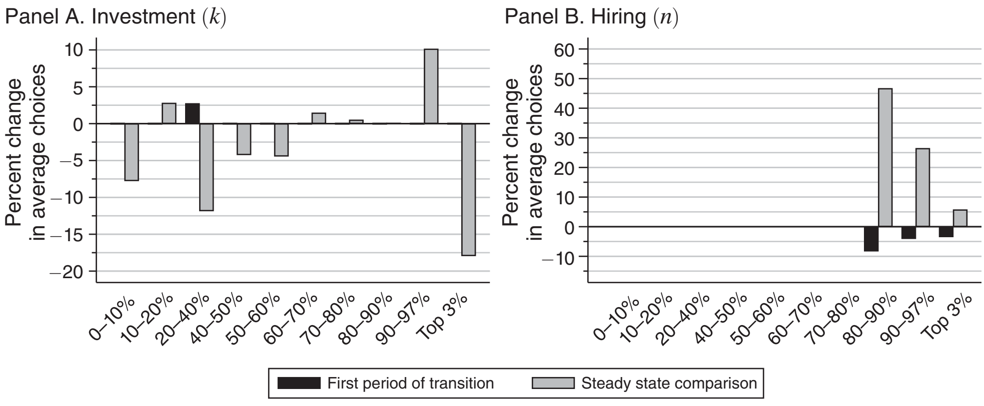

Figure 5. Changes to Entrepreneurs' Average Choices by Income Level

Notes: Panel A shows percentage changes in entrepreneurs' investment for each decile of the distribution of gross income after the TMTR was increased to 60 percent; panel B shows changes in hiring. The black bars depict changes in the first period of the transition; the gray bars show changes between steady states.

and B of Figure 4. Especially for entrepreneurs above the median, this is in contrast to workers' lowering of consumption. This gap between workers and entrepreneurs widens as incomes grow. Even among earners in the top tax bracket, there is a significant occupational difference in the long-term adjustment to the higher top tax rate. In order to gain a deeper understanding of what drives the diverging reaction of entrepreneurs, I take a closer look at changes in entrepreneur-specific variables in the next section.

Changes in the Entrepreneurial Sector.—For entrepreneurs, the relevant choice variables are not only savings and consumption but also investment into their company and the amount of labor that they hire on the market in addition to their own. Figure 5 shows the average changes in these variables. The computation of these values again follows the same strategy as before. Now, however, the changes in entrepreneurial choices in the first period of the transition are depicted by the black bars, while the gray bars show the adjustments in the new steady state, that is, when prices have fully adjusted to the new tax environment. Following a similar logic as in Section VC, the comparison of the adjustments in the short- and long-run scenarios helps to shed light on the drivers behind changes in entrepreneurial choices.

Entrepreneurs hardly adjust their investment in direct response to the tax increase, as the black bars in panel A of Figure 5 show. In fact, there is no change in average investment except in the third and fourth deciles (20–40 percent). The explanation for this lies in the fact that most entrepreneurs are constrained: even though changes in the interest rate affect the amount an entrepreneur would optimally invest in their company, the collateral constraint prevents them from doing so. In the first period of the transition, interest rates briefly fall, implying a larger optimal level of capital investment. Only entrepreneurs in the 20–40 percent income deciles are unconstrained and therefore able to change their capital investment accordingly. In the long run, it is those very same households that react to the higher new steady-state interest

Table 10—Effects on Entrepreneurial Sector

	Entry (in percent)	Exit (in percent)	Fraction (in percent)
Benchmark	2.3	22.2	7.2
$\tau^{\max} = 60\%$, steady state (percent)	+3.3	−1.3	+4.1
$\tau^{\max} = 60\%$, transition (percent)	−2.5	+4.3	−1.5

Notes: The second line shows percentage changes in the entry and exit rate to and from entrepreneurship as well as the total fraction of entrepreneurs when comparing steady states. The third line shows changes in the first period of the transition.

rate by lowering their investment into their firms. The reactions among households in other income deciles in the new steady state (captured by the gray bars) are purely compositional: the distribution of entrepreneurs shifts and changes average investments, without the changes in the underlying policy function.

The impact of the tax increase on hiring is different: the policy functions for hiring change in response to changing wages during the transition and in the new steady state. Since employers are usually large entrepreneurs at the top of the income distribution, the effects on hiring are most relevant among the top income deciles, as can be seen in panel B of Figure 5. In the first period of the transition, wages briefly increase (as panel B of Figure 2 shows), so that hiring becomes more expensive and entrepreneurs reduce their labor input slightly. Wages immediately drop after that short-lived increase and continue to drop to a new steady state level that is below the benchmark, leading to more hiring in the new steady state.

The effects of the tax increase on entrepreneurial choices described above only include entrepreneurs who do not switch occupations. Table 10 adds to that by describing the aggregate consequences that the compositional changes and occupational switches along the income distribution have on the size of the entrepreneurial sector. In the new steady state, entrepreneurial entry increases after the TMTR is raised to 60 percent, while the exit rate decreases. This leads to an overall increase in the number of entrepreneurs in the economy by 4 percent. In the short run, however, entry briefly falls and exit increases so that the overall number of entrepreneurs declines. This again underlines the importance of the price effects in the long run, which imply that the outside option of being a worker becomes less attractive for low-income households, which pushes more of them into entrepreneurship. At higher income levels, the wage drop makes entrepreneurship more lucrative and likewise pushes up entry. In the short run, on the other hand, higher taxes and higher wages push out entrepreneurs at a higher pace and encourage less entry.

D. *Exploring the Importance of Entrepreneurs and the Highest Labor Ability*

There are a number of factors in the model that shape the results on optimality in a significant manner. In this section, I show how the level of the long-run optimality results would change if two of the most influential characteristics of the model changed: the presence of entrepreneurs and the introduction of an additional highest state to the labor ability process.

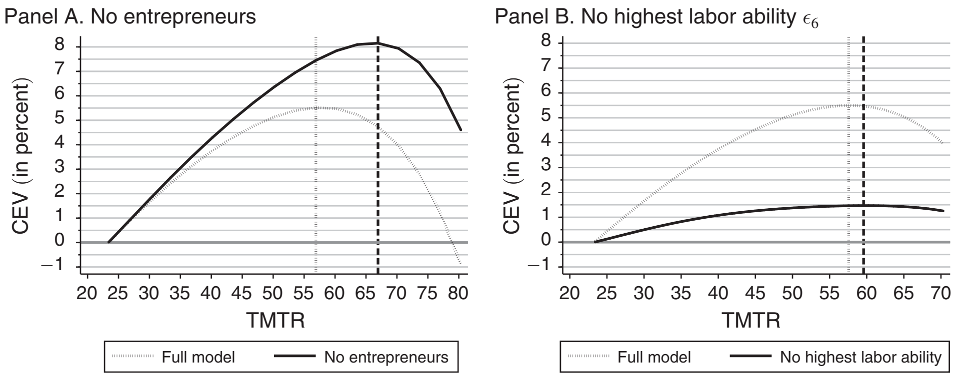

Figure 6. Optimal Tax Rates under Alternative Specifications

Notes: In panel A, the solid line shows the CEVs (in percent) associated with increasing the top marginal tax rate to the levels indicated on the x-axis when there are no entrepreneurs. In panel B, the solid line shows the CEVs (in percent) when there is no highest labor ability ϵ_6. In both panels, the dotted line shows the CEVs (in percent) in the baseline experiment. Vertical lines indicate optimal levels of associated TMTRs. All results obtained for steady state comparisons.

No Entrepreneurs.—The most essential element of the model that is shaping the welfare- and revenue-maximizing tax rates is of course the presence of entrepreneurs. It is thus informing to see how the experiment would play out if there were no entrepreneurs in the model. I implement this counterfactual by assuming that all working-age individuals are always endowed with $\theta_1 = 0$, which is the one entrepreneurial ability state that guarantees that households never choose to become an entrepreneur. The remaining parameters remain as they are in the benchmark calibration.[19] After solving the model including these new restrictions on the entrepreneurial ability process, I rerun the experiment. Panel A of Figure 6 shows the results. The solid line shows the resulting welfare-maximizing tax rate in the new scenario without entrepreneurs, while the dotted line shows the results from the initial experiment as shown in Figure 1.

The new effective top marginal tax rate that maximizes welfare in the new steady state amounts to approximately 67 percent; it is thus considerably higher than the 57 percent from the original experiment. Thus, the presence of entrepreneurs pushes down the welfare-maximizing tax rate and also the level and curvature of the welfare gains associated with the tax increase. Intuitively, two factors help explain these differences: First, without entrepreneurs, households in the model are on average poorer. Increases in net income through the lump-sum transfer therefore provide larger gains in workers' welfare given the concavity of the utility function. Second, the risk associated with being a worker is slightly higher in a world without the outside option of entrepreneurship, especially for workers who experience spells of low productivity. The social insurance benefits from more progressive taxes and redistribution are therefore higher. Without entrepreneurs, the optimal tax rate also moves closer to the welfare-maximizing tax rate of 80 found by Kindermann

[19] This worsens of course the overall fit of the benchmark calibration but can still serve as a simple first pass at a counterfactual analysis without entrepreneurs.

and Krueger (forthcoming) but does not quite reach their level. This is plausible since the highest productivity level, which is the main driver behind the very high welfare gains in their model, is significantly lower and less risky in my version of the model.

No Highest Labor Ability.—Next, I investigate what happens to the results if we go back to the original calibration of the entrepreneurial ability process but instead manipulate the labor ability process such that the probability of ever reaching the highest ability state ϵ_6 is equal to zero. Again, the calibration stays exactly as in the original benchmark calibration except with respect to the change in the labor ability process. The results of this experiment are depicted in panel B of Figure 6.

Not allowing households to reach the highest potential realization of labor ability has similarly large effects as omitting entrepreneurs. In this case, however, welfare gains are much smaller than in the original scenario and are maximized at a similar TMTR of approximately 60 percent.

Workers with the highest labor ability constitute roughly 60 percent of households in the top tax bracket, and without them, tax revenues increase by much less than in the baseline experiment. For households outside the highest tax bracket, this means that they receive a lower redistributive transfer and therefore experience lower welfare gains. Additionally, excluding the highest labor ability realization also reduces the variance in labor earnings and through that, the benefits of social insurance associated with higher progressivity. Together, these two mechanisms underline the important role that the high labor ability realization plays in generating the relatively high level of welfare gains in the baseline experiment. However, this alternative experiment without the highest labor ability state also reaffirms the finding that even in the presence of entrepreneurs, it is optimal to increase the top marginal tax rate relative to its benchmark level of 23.5 percent.

E. *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 realistic distributions of income 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, Díaz-Giménez, and Ríos-Rull (2003), they calibrate the labor ability process 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. The optimal top marginal tax rate in economies that are shaped by such a labor ability process is very high; see Kindermann and Krueger (forthcoming) and Brüggemann and Yoo (2015). This is mainly caused by households that are endowed with the highest realization of labor ability: even when confronted with very high tax rates, they 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, resulting in large social insurance benefits.

The inclusion of entrepreneurs in my model helps to endogenously create a large degree of wealth inequality while requiring a much less extreme level for the highest labor ability realization. In fact, the main reason for introducing the additional high-ability level into the labor ability process is not a failure in achieving the right degree of overall wealth inequality but rather the goal of having the right shares of workers and entrepreneurs among the top 1 percent of the income distribution. Without it, all top earning households would be entrepreneurs.

The resulting welfare-maximizing top marginal tax rate is 60 percent when taking into account the transition (57 percent when comparing steady states). When implementing the optimal top marginal tax rate, entrepreneurs who are directly confronted with the higher top marginal tax rate see their welfare decrease, but 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. Their desire to grow their business is not deterred by the fact that this may at some point in the future cause them to face the now higher top marginal income tax rate. The additional savings motive due to the need for self-financing causes entrepreneurs to reduce their savings to a much lesser degree than workers, which is reflected in a shift of resources toward the more productive entrepreneurial sector. Only the highest-earning entrepreneurs in the top tax bracket are negatively affected by the tax increase but much less so than workers in the same bracket since these entrepreneurs also benefit from lower wages and therefore lower production costs.

The fact that entrepreneurs on average gain from higher taxes at the top does not necessarily mean that welfare gains and optimal increases are lower when entrepreneurs are not explicitly considered. Instead, Section VD showed that more risk and lower efficiency and wealth in the economy without entrepreneurs makes redistribution after increases in TMTRs more beneficial and leads to higher welfare gains and higher optimal top marginal tax rates, yielding results that are more similar to what has been found in papers that abstract from entrepreneurship like Kindermann and Krueger (forthcoming).

VI. 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 after the tax increase, the effect in the long run is the opposite: lower wages induce entrepreneurs not directly affected by the tax increase 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 60 percent. Workers also 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 and taking into account the transition of 8.1 percent.

There are margins of adjustment that might be important to take into account when talking about top income taxes and entrepreneurs but that were beyond the scope of this paper. The issue of tax avoidance and/or evasion is looming large in the public debate, and its quantitative consequences would be a compelling avenue for further research. 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 from my analysis.

Appendix

A. *SCF Data*

I obtained data for the distributions of income and wealth, as well as income and wealth statistics for entrepreneurs, from the 2010 Survey of Consumer Finances (Board of Governors of the Federal Reserve System 2010a, b). *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 proprietorship), which is the case for 92 percent of all entrepreneurs.

B. *Calibrated Labor Ability Process*

The full set of labor ability levels ϵ and associated transition matrix Γ are given by

$$\epsilon = \{\epsilon_1, \ldots, \epsilon_6\} = \{0.24675, 0.44732, 0.76541, 1.30970, 2.37424, 26.0\},$$

$$\Gamma = \begin{pmatrix} 0.73639 & 0.24689 & 0.01497 & 0.00016 & 0.00000 & 0.00160 \\ 0.19437 & 0.55460 & 0.23242 & 0.01689 & 0.00012 & 0.00160 \\ 0.01124 & 0.22172 & 0.53248 & 0.22172 & 0.01124 & 0.00160 \\ 0.00012 & 0.01689 & 0.23242 & 0.55460 & 0.19437 & 0.00160 \\ 0.00000 & 0.00016 & 0.01497 & 0.24689 & 0.73639 & 0.00160 \\ 0.00000 & 0.00000 & 0.07109 & 0.00000 & 0.00000 & 0.92891 \end{pmatrix}.$$

C. *Consumption Equivalent Variation*

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

$$\text{(A1)} \qquad W(\tau^{\max} = 23.5\%) = \int_{\mathcal{X}} V(a, \epsilon, \theta)\, dm^*,$$

$$W(\tau^{\max} = 23.5\%) = \int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \right] dm^*$$

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

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 $\tilde{W}(\tau^{\max})$. 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., $W(\tau^{\max} = 23.5\%) = \tilde{W}(\tau^{\max})$. Thus,

$$\text{(A2)} \quad \tilde{W}(\tau^{\max}) = \int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{\left((1 + \Delta^{CEV})\, c_t^* \right)^{1-\sigma_1}}{1-\sigma_1} - \chi \frac{(l_t^*)^{1+\sigma_2}}{1+\sigma_2} \right) \right] dm^*.$$

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

$$\text{(A3)} \qquad \Delta^{CEV} = \left[\frac{\tilde{W}(\tau^{\max}) - W(\tau^{\max} = 23.5\%)}{\int_{\mathcal{X}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^*)^{1-\sigma_1}}{1-\sigma_1} \right) \right] dm^*} + 1 \right]^{\frac{1}{1-\sigma_1}} - 1.$$

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

D. *Solving for the Transition Path*

After having solved for the benchmark steady state as well as the new steady state, I start by guessing a path for prices and redistributive lump-sum transfers between the two steady states, assuming that the new steady state will be reached after $T = 150$ periods. Using the value function from the new steady state after the tax increase for period T, I then solve the household problem backward starting with period $T - 1$ all the way until period 2. After having obtained the optimal policies for every period of the transition this way, I compute the paths for the distribution and all relevant aggregate variables along the transition, such as implied prices and the government budget balance. If the government budget is not balanced, I update the lump-sum transfer and repeat the previous steps until it is. Given a balanced government budget, I compare the implied interest rate to the guessed interest path, update again, and re-solve for the transition path. I keep updating the lump-sum transfer and interest rate until both the government budget is balanced and the interest rate has converged.

E. *Revenue-Maximizing Top Marginal Tax Rate*

In order to determine the optimal top marginal tax rate in terms of tax revenue, I calculate and compare the lump-sum transfer that the government pays out to every household using its newly raised tax revenue (keeping all other government expenditure at its benchmark level) in the new steady state as well as in the first period of the transition. Looking at the lump-sum transfer is equivalent to looking at the per capita increase in tax revenue.

Gains in income tax revenues as indicated by the lump-sum transfer are slightly higher in the first period of the transition than the one in the new steady state. Both peak at TMTR levels of slightly above 60 percent.

F. *Welfare Effects for Occupation Switchers and Retirees*

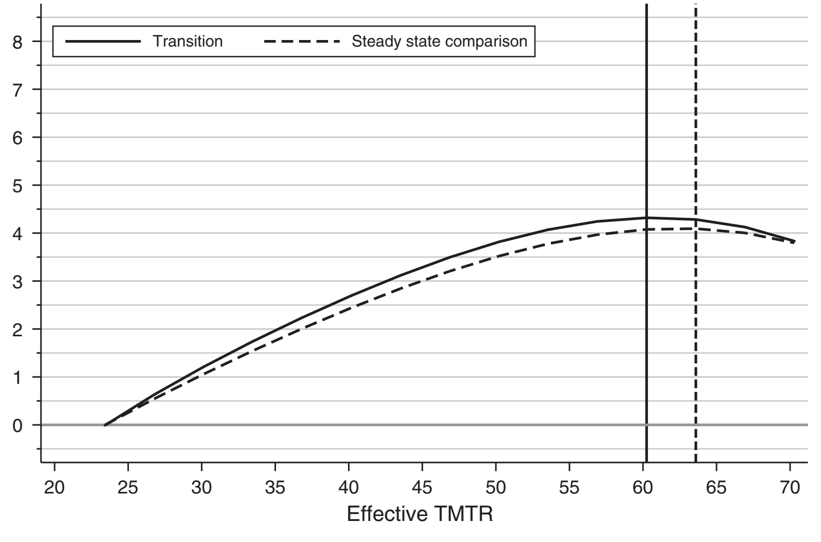

Figure A1. Revenue-Maximizing Top Marginal Tax Rate

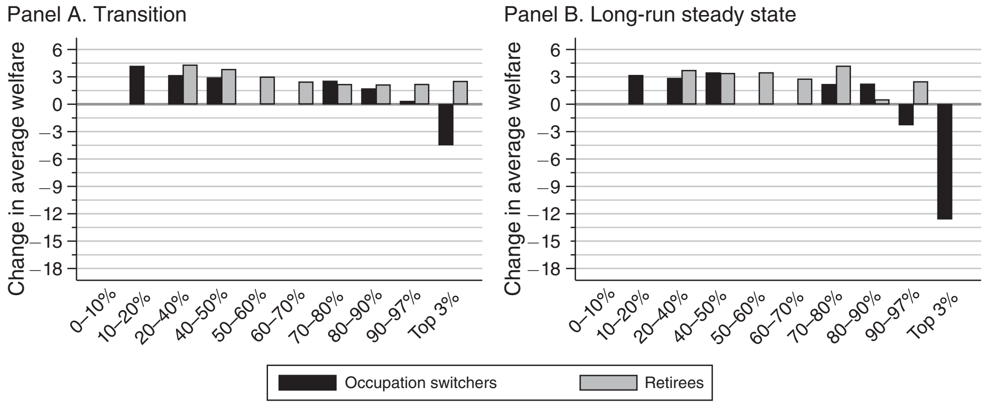

Figure A2. Welfare Gains by Income Deciles for Occupation Switchers and Retirees

Notes: The black bars show the average changes in welfare for occupation switchers as measured by changes in households' expected lifetime utility for each decile of the distribution of gross income. The gray bars show the same for retirees. Panel A shows the welfare changes when taking into account the transition path to the new steady state. Panel B compares the two steady states only. A household is characterized by its occupation, age, and endowments with wealth, labor, and entrepreneurial ability.

G. *Robustness: Redistribution through Lowering the Consumption Tax*

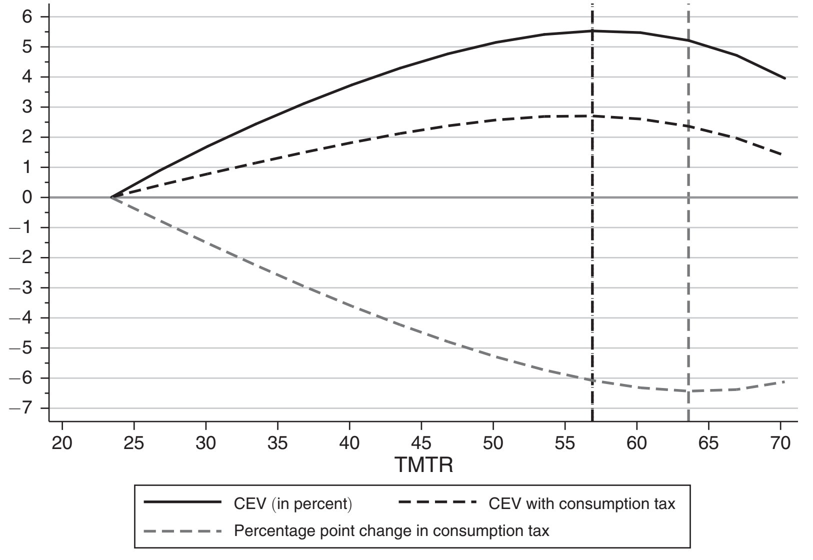

Figure A3. Optimal TMTRs with Redistribution through Lower Consumption Taxes

Notes: The solid line shows the CEVs (in percent) associated with increasing the top marginal tax rate to the levels indicated on the x-axis in the baseline experiment, comparing steady states. The black dashed line shows the CEVs (in percent) when consumption taxes are lowered instead of redistributing additional tax revenue through a lump-sum transfer. The gray dashed line depicts the corresponding percentage point changes in consumption taxes.

Redistribution through a lump-sum transfer leads to large welfare gains, especially for low-income households, for whom the zero borrowing constraint is binding. In order to make sure the high welfare-maximizing TMTR is not just a consequence of this highly redistributive character of the lump-sum transfer, I run a sensitivity check where lower consumption taxes are used to redistribute the additional tax revenue raised by the increase in the TMTR. The results are very much aligned with those of the original experiment, as can be seen in Figure A3. The dashed lines indicate the welfare gains when comparing steady states in a scenario with lower consumption taxes after an increase in the TMTR.

Revenue is maximized at a TMTR of approximately 63.5 percent, which is exactly the same tax rate that led to maximum revenue in the original experiment. The welfare-optimizing tax rate is approximately 57 percent, the same as in the original experiment (represented by the solid curve), although the level of the welfare gains is considerably lower. Despite a decrease in the consumption tax being less favorable to low-income (and low-consumption) households than the lump-sum transfer, the welfare gains still peak at the same level.

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