TAXING CAPITAL IN THE PRESENCE OF TRICKLE-DOWN EFFECTS

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Abstract
Within a general macroeconomic environment, I derive the welfare effect of capital tax changes in terms of estimable sufficient statistics. Lower capital–labor substitutability in production not only induces a stronger responsiveness of wages and financial returns, but it also reduces the deadweight loss of capital tax hikes. Thus, contrary to conventional wisdom, optimal capital taxes may be higher precisely when "trickle down" effects are stronger. I apply my theoretical results to US data and discipline the welfare-relevant statistics with recent evidence. Despite its depressing effect on wages, the bottom two-thirds of the US income distribution would gain from an increase in the capital tax rate when marginal revenue is redistributed lump-sum and equally. I utilize the identified welfare-relevant statistics as calibration targets in a parametric version of the model and solve numerically for optimal linear capital- and progressive labor taxes. Standard welfare criteria warrant higher capital taxes as well as higher, but less progressive, labor taxes than the status quo. (JEL: E62, H21, H22, H24, H25)

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1. Introduction

The current high degree of economic inequality has spurred the public debate on what the appropriate level of redistribution through the tax system should be. Due to its high concentration at the top, the optimal taxation of capital receives particular attention in this context. Thereby, the political debate often centers around the equity–efficiency trade-off, or the notion that tax reductions result in higher, but more unequally distributed, economic output.

Arguably, the poor's relative income share is less relevant to their economic well-being than their absolute amount of disposable income. Along these lines, some argue that lowering taxes on capital encourages investment, which, in turn, increases the demand for labor. The resulting increase in wages would benefit poorer households, who tend to receive predominantly labor income. The practical relevance of this mechanism is subject to extensive political discussion.

To study this issue formally, I employ a rich dynamic general equilibrium environment that nests several important benchmark models as special cases (Judd 1985; Chamley 1986; Piketty and Saez 2013; Saez and Stantcheva 2018). Within this framework, I study local tax incidence and optimal taxation using a simple and realistic set of policy instruments. The capital tax is linear and allowed to be changed only once and for all. The labor tax schedule is progressive and I consider different assumptions on whether or not the planner can change it as well. The revenue raised through these taxes is partially used to finance an exogenously given spending requirement. Every revenue in excess of this requirement is redistributed lump-sum and equally to all agents.

In a first step, I impose only little structure on model primitives and I analytically derive the welfare effect of a marginal change in the capital tax rate in terms of sufficient statistics. This serves three goals: first, it provides an intuitive understanding of the economic forces that will shape the optimal capital tax; second, it identifies the welfare-relevant statistics that will serve as calibration targets for the study of optimal taxation; and third, it provides a clear distinction between positive effects that are independent of the social welfare criterion and distributional effects, the valuation of which requires a normative judgment.

Specifically, I show that the welfare effect of a change in the capital tax rate can be parsimoniously decomposed as the difference between two components: (i) a normative component, to which I refer as the 'equity effect'; it maps the choice of social welfare function to the redistributional gain from capital tax increases; and (ii) the marginal excess burden (MEB), or the change in the deadweight loss, which is independent of this choice and measures the efficiency loss through agents' responses in investment and labor supply.

While the sufficient statistics approach has a long tradition in the static taxation literature (Diamond 1998; Feldstein 1999; Saez 2001), only a few recent studies employ it in a dynamic setting of capital taxation (Piketty and Saez 2012, 2013; Golosov, Tsyvinski, and Werquin 2014; Saez and Stantcheva 2018). Importantly, these studies all assume constant factor prices, thereby ruling out 'trickle down' effects from the outset. In my framework, the case of constant prices is also nested, but only as a limiting special case, where capital and labor are perfect substitutes, that is, the production function is linear (Piketty and Saez 2013; Saez and Stantcheva 2018). In this case, the demand for capital is perfectly elastic such that the whole incidence of capital tax hikes is borne by the suppliers of capital, that is, by savers and investors. The equity effect, hence, simply aggregates the mechanical change in net capital- and transfer income of each agent, weighted by the chosen collection of social welfare weights. The MEB is mostly or—absent income effects on labor supply—fully given by the loss in revenue due to a reduction in agents' investment.

In contrast, when capital and labor are not perfect substitutes, a lower capital stock increases the marginal product of capital and reduces the marginal product of labor. Consequently, firms' factor demand is no longer perfectly elastic. Ceteris paribus, the reduction in capital supply induced by a capital tax hike causes an excess demand for capital and an excess supply of labor. To restore market clearing, in general equilibrium, the (gross) return on capital increases, while wages fall. These price responses, in turn, redistribute across agents with different compositions of capital-, labor- and transfer income, contributing to the equity effect. Specifically, in line with conventional 'trickle-down' logic, they reduce the income of a large middle class, whose main income source are wages, a mechanism that reduces optimal capital tax rates if the planner assigns high weight on wage workers. Importantly, the factor price changes also have a direct impact on revenue: When capital is initially taxed at a higher rate than labor, they increase revenue and thus government transfers, the main income source of society's worst off. Thus, contrary to the standard 'trickle-down' narrative, general equilibrium forces may call for higher–not lower–taxes on capital.

The marginal excess burden (MEB) hinges most crucially on the (average discounted) net-of-tax elasticity of the *equilibrium* capital stock, which is a 'policy elasticity' in the sense of Hendren (2016). It captures the causal impact of a change in the tax rate on capital accumulation, taking all equilibrium responses to simultaneous changes in transfers and prices into account. Since such a policy elasticity cannot be estimated directly (Kleven 2021), I develop a methodology to recover it from actually estimated statistics and equilibrium conditions. I show analytically that the long-run net-of-tax elasticity of the equilibrium capital stock depends linearly on the capital-labor substitution elasticity (σ) in production. Thus, while with an infinite substitution elasticity—the assumption necessary to rationalize constant factor prices—the net-of-tax elasticity of capital diverges to infinity, it remains bounded whenever σ is finite. Furthermore, I show that a sufficient statistic for the speed of convergence to the post-reform steady state is the net-of-tax elasticity of capital *supply*, which measures the change in wealth accumulation in response to a change in the tax rate only, keeping other policy parameters and prices fixed. Disciplining this elasticity with most recent quasi-experimental evidence (Jakobsen et al. 2020), I find that the policy elasticity is 1.24 when the substitution elasticity is infinite (constant prices), while it is only 0.38 with my preferred estimate of σ. Overall, I find that wrongly assuming constant prices ($\sigma = \infty$), but disciplining all other statistics in line with the evidence, leads to an overestimation of the additional deadweight loss by 160%. Specifically, accounting for capital-labor complementarity reduces the MEB from 88 to only 34 cents per dollar of revenue raised mechanically.

Of course, this reduction in the excess burden widens the set of social welfare criteria under which an increase in the capital tax rate is desirable. Using data from the Survey of Consumer Finances 2022 (Board of Governors of the Federal Reserve Board 2023), I compute the welfare gains of a capital tax hike for each percentile of the US income distribution. In the case of constant factor prices, the status quo capital taxes in the USA are close to optimal (the welfare gains close to zero) for a large part of the US population, about the bottom 60% of the income distribution. Absent responses in wages, the welfare effects of capital tax changes are quite homogeneous within this part of the population since even those around the 60th percentile earn very little capital income, which is concentrated among the very high earners. In contrast, taking into account the endogeneity of factor prices, one finds that the bottom 60% of the US income distribution would experience high gains from capital tax increases. Furthermore, rather than being homogeneous, due to the depressing effect on wages, households' welfare gains from capital tax hikes are strongly declining in their labor income. For households around the 67th income percentile, the negative effect of the decline in wages just offsets the positive effect of higher government transfers, rendering the satus quo tax rate about optimal for these households. At the same time, because capital is currently taxed at a higher average rate than labor, the simultaneous rise in gross returns and fall in wages, have a positive net impact on revenue and, hence, on government transfers, thus exacerbating—rather than mitigating—the welfare benefits of the earnings-poorest households.

The sufficient statistics approach provides us with exact welfare effects only locally, for marginal reforms (see Kleven 2021). In order to solve for globally optimal policies, I, hence, move on with a fully specified parametric model that is nested in my general framework. I calibrate this model such that it (locally) exactly replicates the estimates of the welfare-relevant sufficient statistics. For various social welfare criteria, I then compute the optimal capital tax rates. In a first instance, I consider the case where the planner takes (an approximated version of) the current US labor income tax code as given. In stark contrast to the case of constant prices ($\sigma = \infty$), which would render the current US capital tax (41.5%) close to optimal for most of the considered social welfare criteria, I find an optimal Rawlsian tax rate—which maximizes the welfare of households, who finance their consumption exclusively through government transfers—of 91%. Households higher up the income distribution, even those with little or no wealth, desire lower capital tax rates due to their depressing effect on wages. Yet, optimal tax rates remain above the status quo unless the planner assigns very high weight on households at the top of the income distribution. For example, the tax rate that maximizes the utilitarian objective is 75% and the tax rate that maximizes welfare of households in the 50th percentile of the income distribution is 61%, while the status quo (41.5%) would be optimal if the planner maximized welfare of households in the 67th income percentile.

In the final part of the paper, I abolish the restriction of a given labor income tax code. In a seminal paper, Diamond and Mirrlees (1971) show that, provided the planner can tax different factors of production at different rates, general equilibrium effects are irrelevant for the determination of optimal taxes. I first show that this result does not apply here. Specifically, in the present dynamic framework, the requirement not only means that the planner can tax capital and labor differently, but also that each factor can be taxed at different rates over time. Only then is the optimal tax problem equivalent to directly setting net prices such that general equilibrium effects disappear from optimal tax formulas. This requirement is obviously demanding and seems incompatible with the goal to derive policy prescriptions that can be applied in practice, using simple and realistic tax instruments.

To numerically solve for the optimal mix of linear capital- and non-linear labor taxes, I restrict the latter to the "constant-rate-of-progressivity" family of tax functions that is frequently employed in the recent macro-Public finance literature (Benabou 2000; Heathcote, Storesletten, and Violante 2017; Ferriere and Navarro 2025). The utilitarian welfare objective prescribes an almost flat labor tax of around 53%. The optimal Rawlsian tax code, which maximizes revenue, is regressive: Incomes below \$75K are taxed at very high tax rates of above 75%, while the marginal tax rate decreases to 60% around income level \$500K and to 50% around income level \$1.8M. These results are independent of the capital-labor substitution elasticity σ.

Since the planner obtains a certain level of redistribution already through the labor tax code, the optimal capital tax rates are somewhat lower compared to the case where the labor tax code is taken as given. With constant prices ($\sigma = \infty$), there is only little interaction between the two tax bases and optimal capital tax rates are only slightly below the unidimensional optimum. In contrast, with my preferred estimate of σ, the optimal Rawlsian (utilitarian) capital tax rate is 63% (53%), which is 28 (22) percentage points lower than with a fixed labor tax code. Since households with substantial capital income are concentrated at the top of the income distribution and thus have low marginal utility of consumption, the utilitarian planner does not value their consumption by much more than the Rawlsian planner. Instead, as I illustrate, the main reason for the 10 percentage point difference between the Rawlsian and the utilitarian optimum is again the depressing effect of capital taxes on wages, which the Rawlsian planner is not concerned about as he only values households with zero income.

Related Literature. I contribute to various strands of the Public Finance literature. First, to the best of my knowledge, all existing papers in the sufficient statistics literature on capital taxation assume that factor prices are invariant to tax policy (Piketty and Saez 2012, 2013; Golosov, Tsyvinski, and Werquin 2014; Saez and Stantcheva 2018). In a general equilibrium framework, this can be rationalized only when capital and labor are perfect substitutes. As described above, I find strong quantitative and qualitative discrepancies when imposing this counterfactual assumption compared to cases with more realistic degrees of factor complementarity. Since the goal of the sufficient statistics literature is to "better connect the theory of optimal capital taxation to the policy debate" (Stantcheva 2020, p.9.21f) and given the decade long political discourse on the welfare impact of endogenous factor price responses to tax policy, generalizing the framework in this dimension was a first order concern.

Second, I also contribute to the macro-Public Finance literature that studies capital taxation in parameterized dynamic general equilibrium environments.[1] By identifying the welfare-relevant statistics, my work informs the calibration of these models. For example, virtually all papers in this literature assume a capital-labor substitution elasticity equal to 1.[2] I show that the various effects crucially hinge on precisely this elasticity, empirical estimates of which span a broad range with most of it significantly lower than one (Antras 2004; Chirinko 2008; Gechert et al. 2022).

Finally, my paper also contributes to the literature that aims to measure the efficiency loss of taxes (Harberger 1964; Auerbach and Hines 2002; Saez, Slemdrod, and Giertz 2012), in particular, the one that quantifies the MEB of capital taxes in dynamic general equilibrium settings (Feldstein 1978; Chamley 1981; Judd 1987; Bernheim 2002; Tran and Wende 2021).

My paper relates to various other strands of the Public Finance literature. The importance of endogenous factor price responses is emphasized in a growing recent literature that studies optimal income taxation in frameworks where output is produced with complementary production factors (Rothschild and Scheuer 2013; Scheuer 2014; Ales, Kurnaz, and Sleet 2015; Scheuer and Werning 2017; Sachs, Tsyvinski, and Werquin 2020). While, in my framework, these factors are capital and labor, the latter of which is perfectly substitutable across agents, these models abstract from capital and instead consider different types of labor input that are imperfectly substitutable. All of these papers study optimal income taxation in static Mirrleesian environments, abstracting from the dynamic accumulation process of production factors, in particular, of capital.

The New Dynamic Public Finance (NDPF) literature instead considers dynamic Mirrleesian settings with savings (Golosov, Kocherlakota, and Tsyvinski 2003; Farhi and Werning 2013). Slavik and Yazici (2014) take explicit account of the complementarity between different types of capital and labor and the implications of general equilibrium spillover effects on wages for optimal capital taxes. In related settings, Guerreiro, Rebelo, and Teles (2022) and Thümmel (2023) study the optimal taxation of robots.

Finally, two papers very similar in spirit to mine are Badel and Huggett (2017), who derive a robust formula for revenue maximizing income tax rates, and Jacquet and Lehmann (2021), who derive optimal schedular and comprehensive tax systems in a general framework with income shifting. As the present paper, these studies find important interaction effects of one tax rate with other tax bases requiring to adjust standard formulas that neglect these interactions.

1. A non-exhaustive list of studies in this literature includes Judd (1985); Chamley (1986); Aiyagari (1995); Jones, Manuelli, and Rossi (1997); Atkeson, Chari, and Kehoe (1999); Erosa and Gervais (2002); Domeij and Heathcote (2004); Conesa, Kitao, and Krueger (2009); Chari, Nicolini, and Teles (2020); Straub and Werning (2020); Dyrda and Pedroni (2023); and Açıkgöz et al. (2024).

2. An exception is Kina, Slavik, and Yazici (2024), who study optimal capital taxation in a framework with capital-skill complementarity.

Outline. The remainder of this paper is organized as follows: Section 2 introduces the modeling framework and some basic notation that will be used in the analysis of tax policy. Section 3 describes the local welfare effects of marginal changes in the capital tax rate. Section 4 describes the methodology to recover unmeasured policy elasticities from existing estimates of supply elasticities. Section 5 provides a quantification and decomposition of the local welfare effects. Section 6 computes optimal capital tax rates taking the existing labor tax code as given. Section 7 computes the optimal mix of linear capital taxes and progressive labor taxes. Section 8 concludes.

2. The Framework

In this section, I will introduce the economic environment and introduce some notation that will be useful for the analysis of policy in the following sections.

2.1. Model

The model nests the economic environments studied in the seminal papers of Judd (1985) and Chamley (1986) as special cases. In addition to their models, here agents have heterogeneous labor productivity. In Online Appendix B, I consider a richer model with uninsurable idiosyncratic risk to both working- and investment ability, and I discuss which of my theoretical results carry over and which have to be adapted.

2.1.1. Households. There is a continuum of infinitely lived agents (dynasties) of measure one. Agents differ in their initial wealth endowment k_0 and in their working ability $\eta \in [\underline{\eta}, \bar{\eta}]$, which is assumed to be perfectly persistent. The joint distribution over initial individual states is denoted by $\Gamma(k_0, \eta)$. Households derive utility from consumption c and disutility from labor l. They discount the future with a constant discount factor $\beta \in (0, 1)$. The utility function satisfies standard properties:

ASSUMPTION 1. The Bernoulli utility function $u(.,.)$ is twice continuously differentiable in both arguments. For all $(c, l) \geq 0$, it satisfies the conditions $u_c(c, l) > 0$, $u_{cc}(c, l) < 0$, $u_l(c, l) \leq 0$, and $u_{ll}(c, l) < 0$.

Given their initial endowment k_0, agents choose the sequences of consumption c_t, labor supply l_t, and assets k_{t+1} to maximize their lifetime utility,

$$\max_{c_t, l_t, k_{t+1}} (1-\beta) \sum_{t=0}^{\infty} \beta^t u(c_t, l_t),$$

subject to the sequence of budget constraints for $t \in \{0, 1, 2, \ldots\}$,

$$k_{t+1} + c_t = k_t + (1 - \tau_{k,t}) \underbrace{r_t k_t}_{y_t^k(k_0,\eta)} + \underbrace{w_t \eta l_t}_{y_t^l(k_0,\eta)} - \tau_l(w_t \eta l_t) + T_t.$$

2.1.2. Taxes and Transfers. The income from capital $y_t^k(k_0, \eta)$ is taxed at a linear rate $\tau_{k,t}$. As Saez and Stantcheva (2018), I assume that at time $t = 0$, the government announces a change in the capital income tax rate τ_k, which comes into effect after an announcement period $t^a \geq 0$ passed. Formally, the capital income tax rate in period t is given by

$$\tau_{k,t} = \begin{cases} \tau_k^b & \text{for } t < t^a \\ \tau_k^r & \text{for } t \geq t^a, \end{cases}$$

where τ_k^b denotes the pre-existing tax rate in place before the reform, while τ_k^r denotes the tax rate after the reform comes into effect.

The function $\tau_l(.)$ is assumed to be twice continuously differentiable and maps gross labor income $y_t^l(k_0, \eta)$ into labor tax payments. For now, I assume that the planner takes the existing labor tax code as exogenously given, but I will relax this assumption in Section 7. Finally, T_t denotes a lump-sum transfer from the government, which has a time index since it is required to adjust in response to tax changes to ensure period-by-period government budget balance.

2.1.3. Firms. There is a representative price-taking firm, which maximizes profits by choosing capital K_t and labor L_t

$$\max_{K_t \geq 0, L_t \geq 0} \{F(K_t, L_t) - (r_t + \delta)K_t - w_t L_t\},$$

where $\delta \in (0, 1)$ is the depreciation rate of capital and the technology $F(.)$ satisfies the following standard assumption.

ASSUMPTION 2. Denote by k and l effective capital and effective labor, respectively. The production function $F(k, l)$ is twice continuously differentiable and has constant returns to scale. It satisfies for all $(k, l) \geq 0$ the conditions $F_k(k, l) > 0$, $F_l(k, l) > 0$, $F_{kk}(k, l) \leq 0$, $F_{ll}(k, l) \leq 0$, and $F_{kl}(k, l) \geq 0$.

Firms rent production factors in order to equalize marginal revenue and costs,

$$F_k(K_t, L_t) - \delta = r_t \quad \text{and} \quad F_l(K_t, L_t) = w_t.$$

The sufficient statistics literature on optimal capital taxation assumes that factor prices are invariant to policy changes. Within a general equilibrium framework, where output is produced with capital and labor, this can only be rationalized if the two production factors are assumed to be perfect substitutes. My model captures this special case. Specifically, when $F_{kl}(k, l) = 0$ for all (k, l), my model collapses to the frameworks of Piketty and Saez (2013) and Saez and Stantcheva (2018), allowing for a direct comparison.

2.1.4. Equilibrium. In each period t, factor markets need to clear, that is,

$$K_t = \int k_t(k_0, \eta) d\Gamma, \quad \text{and} \quad L_t = \int \eta l_t(k_0, \eta) d\Gamma.$$

Furthermore, the government budget needs to clear,

$$T_t + G = \tau_{k,t} r_t K_t + \int \tau_l(\eta w_t l_t(k_0, \eta)) d\Gamma, \tag{1}$$

where $G > 0$ is a constant stream of government expenditures that is exogenously given.

Total production of firms $\widetilde{Y}_t$ and total household income Y_t are given by, respectively,

$$\widetilde{Y}_t = \underbrace{(r_t + \delta)K_t}_{\widetilde{Y}_t^k} + \underbrace{w_t L_t}_{Y_t^l} \quad \text{and} \quad Y_t = \underbrace{r_t K_t}_{Y_t^k} + \underbrace{w_t L_t}_{Y_t^l}.$$

They differ to the extent that capital depreciates. The distinction between gross- and net factor shares, that is, factor shares before and after capital deprecation, is going to be important and shall therefore be made very explicit:

DEFINITION 1 (*Factor Shares*). Firms' *expenditure shares* on capital and labor are defined by, respectively,

$$\tilde{\alpha}_t^k = \frac{\widetilde{Y}_t^k}{\widetilde{Y}_t} = \frac{(r_t + \delta)K_t}{(r_t + \delta)K_t + w_t L_t} \quad \text{and} \quad \tilde{\alpha}_t^l = \frac{Y_t^l}{\widetilde{Y}_t} = \frac{w_t L_t}{(r_t + \delta)K_t + w_t L_t}.$$

Households' *shares* of capital and labor *income* are given by, respectively,

$$\alpha_t^k = \frac{Y_t^k}{Y_t} = \frac{r_t K_t}{r_t K_t + w_t L_t} \quad \text{and} \quad \alpha_t^l = \frac{Y_t^l}{Y_t} = \frac{w_t L_t}{r_t K_t + w_t L_t}.$$

2.1.5. Steady State. Given the distribution of skills and given taxes on capital and labor, the economy is in steady state when prices, transfers as well as households' supply of capital and labor are all time-constant, that is, $(r_t, w_t, T_t, k_t(k_0, \eta), l_t(k_0, \eta)) = (r_0, w_0, T_0, k_0, l_0(k_0, \eta))$ for all t. This definition implies that both aggregate production factors as well as the joint distribution of assets and productivity are also time-constant, $(K_t, L_t, \Gamma_t) = (K_0, L_0, \Gamma)$ for all t. In the analysis below, I follow Saez and Stantcheva (2018) and restrict attention to situations, in which the economy is originally in steady state, as this considerably simplifies the analysis.[3]

ASSUMPTION 3. In period $t = -1$, the economy is in a stationary equilibrium.

3. I refer to their framework in the second part of their paper with concave utility in consumption (their Section 5), which is nested as special case of mine. In the first part of their paper, Saez and Stantcheva (2018) assume preferences that are linear in consumption and concave in wealth, implying an immediate jump to the new steady state following a tax change, a behavior that is inconsistent with the evidence on consumption smoothing (see e.g. Browning and Lusardi 1996; Browning and Crossley 2001; Havranek and Sokolova 2020).

In the following, variables without time index refer to their value in the initial steady state.

2.2. Preliminaries for the Study of Taxation

Before studying the effects of policy, it is useful to define some recurring objects.

DEFINITION 2 (*Social Welfare and Marginal Social Welfare Weights*). Given a collection of Pareto weights $\bar{\omega} = \{\omega(k_0, \eta)\}$, social welfare is defined as

$$W(\bar{\omega}) = (1-\beta) \int \omega(k_0, \eta) \sum_{t=0}^{\infty} \beta^t u\big(c_t(k_0, \eta), l_t(k_0, \eta)\big) d\Gamma.$$

Marginal social welfare weights are given by

$$g(k_0, \eta) = \omega(k_0, \eta) u_c(c_0(k_0, \eta), l_0(k_0, \eta)).$$

Without loss of generality, the Pareto weights are normalized such that $\int g(k_0, \eta) d\Gamma = 1$.

Hence, $g(k_0, \eta)$ is the planner's relative valuation of a marginal dollar in the hand of agents with characteristics (k_0, η) versus the equal distribution of this dollar to the whole population.

DEFINITION 3 (*Income Weighted Marginal Social Welfare Weights*). The average capital- and labor income weighted marginal social welfare weights are defined by, respectively,

$$\bar{g}^k = \frac{\int g(k_0, \eta) k_0 d\Gamma}{K} \quad \text{and} \quad \bar{g}^l = \frac{\int g(k_0, \eta) y^l(k_0, \eta) d\Gamma}{Y^l}.$$

Average marginal social welfare, weighted by labor income and marginal net-of-labor-tax rates, is given by

$$\tilde{g}^l = \frac{\int g(k_0, \eta)(1 - \tau_l'(y^l(k_0, \eta))) y^l(k_0, \eta) d\Gamma}{(1 - \bar{\tau}_l') Y^l},$$

where

$$\bar{\tau}_{l,t}' = \frac{\int y_t^l(k_0, \eta) \tau_l'\big(\eta y_t^l(k_0, \eta)\big) d\Gamma}{Y_t^l}$$

is the labor income weighted average marginal labor tax rate.

The latter definition turns out to be useful when the labor tax schedule is non-linear. However, the intuition of most of the economic effects goes through with linear labor taxes, in which case $\tilde{g}^l = \bar{g}^l$. With a progressive labor income tax code and a concave welfare objective, we have $\tilde{g}^l > \bar{g}^l$ as agents with higher marginal social welfare weight tend to have higher marginal retention rates.

DEFINITION 4 (*Policy Elasticities*). The elasticity and semi-elasticity of any period-t equilibrium variable x_t with respect to the (reformed) net-of-capital tax rate $1-\tau_k^r$ are given by, respectively,

$$\varepsilon_{x_t,1-\tau_k} = \frac{d\ln x_t}{d\ln(1-\tau_k^r)} \quad \text{and} \quad \epsilon_{x_t,1-\tau_k} = \frac{d\ln x_t}{d(1-\tau_k^r)}.$$

The discounted average elasticities and semi-elasticities of x with respect to the (reformed) net-of-capital tax rate $1-\tau_k^r$ are given by, respectively,

$$\bar{\varepsilon}_{x,1-\tau_k} = (1-\beta)\sum_{t=0}^{\infty}\beta^t\varepsilon_{x_t,1-\tau_k} \quad \text{and} \quad \bar{\epsilon}_{x,1-\tau_k} = (1-\beta)\sum_{t=0}^{\infty}\beta^t\epsilon_{x_t,1-\tau_k}.$$

All these elasticities are what Hendren (2016) refers to as “policy elasticities”, which measure the causal effect of a concrete policy experiment. For example, $\varepsilon_{K_t,1-\tau_k}$ ($\epsilon_{K_t,1-\tau_k}$) measures the relative change in the *equilibrium* capital stock in period t following an increase in the net-of-tax rate $1-\tau_k$ by 1% (1 percentage point).

I define both elasticities ε and semi-elasticities ϵ because sometimes the formulas can be expressed more economically with one and sometimes with the other definition. Note, however, that they can be easily translated since

$$\varepsilon_{x,1-\tau_k} = (1-\tau_k)\epsilon_{x,1-\tau_k}.$$

Since the interpretation of none of the economic effects is qualitatively affected by which of the two concepts one uses, I employ different versions of the same greek letter (ε and ϵ) and I may, in the following, loosely refer to either of them as “elasticity”.[4]

Whenever capital and labor are imperfect substitutes, a change in the capital tax rate affects equilibrium factor prices. The following Lemma relates these factor price changes to changes in the capital–labor ratio, factor shares, and the elasticity in substitution.

LEMMA 1 (Net-of-tax Elasticities of Equilibrium Factor Prices). *Let Assumption* 2 *be satisfied. Then, for all* $t \geq 0$, *we have*

$$\varepsilon_{r_t,1-\tau_k} = -\frac{\varepsilon_{K_t,1-\tau_k} - \varepsilon_{L_t,1-\tau_k}}{\sigma_t}\tilde{\alpha}_t^k\frac{\alpha_t^l}{\alpha_t^k} \quad \textit{and} \quad \varepsilon_{w_t,1-\tau_k} = \frac{\varepsilon_{K_t,1-\tau_k} - \varepsilon_{L_t,1-\tau_k}}{\sigma_t}\tilde{\alpha}_t^k,$$

where

$$\sigma_t \equiv \frac{d\ln\left(\frac{K_t}{L_t}\right)}{d\ln\left(\frac{F_l(K_t,L_t)}{F_k(K_t,L_t)}\right)} = \frac{F_k(K_t,L_t)F_l(K_t,L_t)}{F(K_t,L_t)F_{kl}(K_t,L_t)} \geq 0$$

denotes the elasticity of substitution between capital and labor.

4. The distinction becomes important when a constant-elasticity assumption is used to extrapolate effects away from the current tax system. I will come back to this issue in Section 6.

Proof. See Online Appendix A.1. □

The responsiveness of factor prices is directly proportional to the relative change in the capital–labor ratio $\varepsilon_{K_t,1-\tau_k} - \varepsilon_{L_t,1-\tau_k}$ but indirectly proportional to the substitution elasticity σ_t. Higher complementarity between capital and labor (i.e., a lower σ_t) implies a more inelastic demand for production factors resulting in stronger price movements for any given change in factor supply. Whenever $\sigma < \infty$, the investment decline induced by an increase in the capital tax rate will increase the marginal product of capital but reduce the marginal product of labor. In turn, this increases the demand for capital but reduces the demand for labor, causing a rise in the equilibrium interest rate but a decline in the equilibrium wage. Depending on whether labor responds positively or negatively to capital tax changes, this change in factor prices may be amplified or mitigated.

Observe that the Lemma implies

$$\alpha_t^k \varepsilon_{r_t,1-\tau_k} = -\alpha_t^l \varepsilon_{w_t,1-\tau_k},$$

that is, that wage increases are accompanied by proportional reductions in the interest rate and vice versa.

3. The Welfare Effects of Capital Tax Changes

In this section, I describe the effects of marginal changes to the capital tax rate, given an existing, potentially suboptimal, tax system. These effects can be expressed in terms of estimable sufficient statistics and provide an intuitive understanding of the relevant trade-offs that will determine the size of optimal tax rates.

3.1. Decomposition

A main contribution of this paper is a didactical decomposition of the total welfare effect of capital tax changes. Each component has a clear and intuitive economic interpretation. Generally, the separate components can be grouped into positive and normative ones, depending on whether the respective welfare effect is or is not invariant to the choice of welfare weights.

PROPOSITION 1 (Local Welfare Effects). *Let Assumptions* 1–3 *be satisfied. The effect of a marginal tax increase* $d\tau_k > 0$ *on social welfare is given by*

$$dW = \big[EQ - MEB\big] Y^k d\tau_k, \tag{2}$$

where

$$MEB = \underbrace{\tau_k \bar{\varepsilon}_{K,1-\tau_k}}_{MEB_K} + \underbrace{\frac{\mathrm{E}[\tau_l' y^l \bar{\varepsilon}_{l,1-\tau_k}]}{Y^k}}_{MEB_L}$$

denotes the MEB and

$$EQ = \underbrace{\beta^{t^a}(1-\bar{g}^k)}_{EQ_M} + \underbrace{\frac{\bar{\varepsilon}_{K,1-\tau_k} - \bar{\varepsilon}_{L,1-\tau_k}}{\sigma}\tilde{\alpha}^k \frac{\alpha^l}{\alpha^k}\left[(1-\tau_k)\bar{g}^k - (1-\bar{\tau}_l')\tilde{g}^l + \tau_k - \bar{\tau}_l'\right]}_{EQ_P}$$

denotes the equity effect.

Proof. See Online Appendix A.2. □

The overall change in welfare is a cardinal measure that is not directly interpretable. In contrast,

$$d\overline{W} = \frac{dW}{Y^k d\tau_k}$$

is defined in money metric utilities, as fraction of the additional tax revenue raised "mechanically" each period. Specifically, $Y^k d\tau_k$ is the additional tax revenue that would be raised each period if agents were to keep their investment and labor supply unchanged. The MEB measures how much, per mechanically raised dollar, the government loses in revenue due to individuals' behavioral responses. The equity effect EQ measures the planner's valuation of the tax induced change in the distribution of utilities. While MEB is a purely positive measure, the equity effect EQ depends on the particular choice of social welfare weights.

3.1.1. Marginal Excess Burden. An increase in the capital tax rate discourages investment and thereby reduces capital tax revenue. Specifically, for every dollar, the government raises mechanically each period, it loses

$$MEB_K = \tau_k \bar{\varepsilon}_{K,1-\tau_k},$$

in revenue because households reduce their investment, which lowers taxable capital income.

Furthermore, per mechanical dollar raised, the government also loses

$$MEB_L = \frac{\mathrm{E}[\tau_l' y^l \bar{\varepsilon}_{l,1-\tau_k}]}{Y^k}$$

in labor income tax revenue due to reactions in agents' labor supply, where the expectation operator is with respect to the distribution Γ and necessary because of the non-linearity of the labor income tax schedule. Specifically, the numerator denotes the marginal-labor-tax-revenue-weighted discounted average elasticity of labor supply.

Observe that with a homogeneous labor supply elasticity across the population we have

$$MEB_L = \frac{\alpha^l}{\alpha^k}\bar{\varepsilon}_{L,1-\tau_k}\bar{\tau}_l'.$$

3.1.2. Equity Effect. Also, the equity effect consists of two sub-components. The *mechanical effect*

$$EQ_M = \beta^{t^a}(1-\bar{g}^k)$$

captures the change in welfare if individuals were to keep their (investment and savings) behavior unchanged. Everything else equal, the government redistributes from capital income earners, whom it values by $\bar{g}^k$, to the general population, whom it values by $\bar{g} = 1$. Since redistribution happens only after the pre-announcement period t^a past, the effect is discounted by β^{t^a}. With perfect capital–labor substitutability ($\sigma = \infty$), the mechanical effect constitutes the whole equity effect, $EQ = EQ_M$.

However, whenever the substitution elasticity is finite ($\sigma < \infty$), factor price responses indirectly redistribute across agents with different income compositions, a mechanism, which I label the *redistributive price effect*

$$EQ_P = \frac{\bar{\varepsilon}_{K,1-\tau_k} - \bar{\varepsilon}_{L,1-\tau_k}}{\sigma}\tilde{\alpha}^k\frac{\alpha^l}{\alpha^k}\Bigg[\underbrace{(1-\tau_k)\bar{g}^k}_{>0}\underbrace{-(1-\bar{\tau}_l')\tilde{g}^l}_{<0}\underbrace{+\tau_k-\bar{\tau}_l'}_{?}\Bigg].$$

The factor in front of the squared bracket describes the magnitude to which prices change following a marginal increase in the capital tax rate (compare Lemma 1). The term in the bracket describes the welfare impact per unit of price change, given the planner's relative valuation of households with different compositions of net capital-, net labor-, and transfer income. Specifically, $(1-\tau_k)\bar{g}^k > 0$ captures the positive welfare impact of rises in interest rates on net capital income, $-(1-\bar{\tau}_l')\tilde{g}^l < 0$ captures the negative welfare impact on net wages, and $\tau_k - \bar{\tau}_l'$ captures the impact of changing factor prices on government transfers. The latter is weighted with the average marginal social welfare weight $\bar{g} = 1$ and positive if and only if capital is originally taxed at a higher average rate than labor. Observe that absent redistributive considerations, that is, if the planner values each agent's marginal consumption equally ($\bar{g}^k = \tilde{g}^l = \bar{g} = 1$), the term in the bracket, and, hence, the redistributive price effect, is zero.

3.2. A Test for Optimality Using Sufficient Statistics

For the capital tax rate to be optimal, a marginal reform to the tax rate must have a zero effect on social welfare. Specifically, τ_k is optimal only if

$$\frac{dW}{d\tau_k} = 0 \iff EQ = MEB,$$

that is the increase in the deadweight loss due to a marginal tax increase needs to be exactly offset by the distributional gain (given the planner's Pareto weights).

COROLLARY 1 (Test for Optimality). *Let Assumptions* 1–3 *be satisfied. The pre-existing tax rate is optimal only if it satisfies*

$$\tau_k = \frac{\beta^{t^a}\left(1-\bar{g}^k\right) - \frac{\mathrm{E}[\tau_l' y^l \bar{\varepsilon}_{l,1-\tau_k}]}{Y^k}}{\bar{\varepsilon}_{K,1-\tau_k}} + \frac{\alpha^l}{\alpha^k}\frac{\tilde{\alpha}^k}{\sigma}\left(1-\frac{\bar{\varepsilon}_{L,1-\tau_k}}{\bar{\varepsilon}_{K,1-\tau_k}}\right)\Big[\underbrace{(1-\tau_k)\bar{g}^k}_{>0}\underbrace{-(1-\bar{\tau}_l')\tilde{g}^l}_{<0}\underbrace{+\tau_k-\bar{\tau}_l'}_{?}\Big].$$

When prices are invariant to tax changes ($\sigma = \infty$), the second term vanishes and the formula boils down to the optimality condition in Saez and Stantcheva (2018).[5] Given the redistributive preferences of the planner (captured parsimoniously by $\bar{g}^k$), the optimal tax rate is higher, the lower the (discounted average) net-of-tax-elasticity of capital. Redistributive gains are achieved only once the reform comes into effect, which is the reason why the mechanical gain is discounted by β^{t^a}. Note also that in this case, capital taxes can affect labor supply only through potential income effects. Specifically, a reduction in the capital tax rate induces (i) a positive income effect due to the increase in net capital income $(1-\tau_k)y^k$ and (ii) a negative income effect through a reduction in the transfer T. The sign of MEB_L (the second term in the numerator) is therefore ambiguous.

Consider now the general case ($\sigma < \infty$), in which the condition extends by the term $EQ_P/\bar{\varepsilon}_{K,1-\tau_k}$. Assume first that only capital income is heterogeneous, while labor productivity is homogeneous ($\tilde{g}^l = 1$).[6] Assume further that the planner likes to redistribute from rich to poor, that is, $\bar{g}^k < 1$. In this case, the bracketed term becomes $-(1-\bar{g}^k)(1-\tau_k) < 0$, is unambiguously negative, and captures conventional "trickle-down" logic: capital taxes depress wages and increase capital returns. Since these price responses have adverse distributional effects, they lower the optimal capital tax rate. The term is independent of the labor income tax schedule because, absent wage heterogeneity, any dollar of labor taxes paid ends up back in the hand of the agent through an equal increase in her lump-sum transfer. Hence, the wage decrease, in and by itself, has an equally negative effect on all agents' disposable income. However, it is discounted by $(1-\bar{g}^k)$ because the associated increase in the interest rate benefits the earners of capital income, whom the government values by $\bar{g}^k$.

5. Compare Propositions 8 and 9 in Saez and Stantcheva (2018) and note that with a linear labor tax rate, the condition is equivalent to

$$\tau_k = \frac{1-\bar{g}^k - \tau_l \frac{Y^l}{Y^k}\beta^{-t^a}\bar{\varepsilon}_{L,1-\tau_k}}{1-\bar{g}^k + \beta^{-t^a}\bar{\varepsilon}_{K,1-\tau_k}}.$$

6. The model then collapses to the one in Section 4 of Judd (1985).

Similarly, if instead one assumed that labor income was heterogeneous but capital income homogeneous ($\bar{g}^k = 1$), the bracketed term would be unambiguously positive ($(1 - \tilde{g}^l)(1 - \bar{\tau}_l') > 0$) as long as the planner likes to redistribute from high to low earners ($\tilde{g}^l < 1$). Applying analogous arguments, in this case, the planner aims to increase the (equally distributed) returns on capital and reduce (unequally distributed) wages, a force that would call for higher capital income taxes.

While in the data, both capital- and labor income are heterogeneous, the former is much more concentrated than the latter. One may, hence, conclude that overall the price responses should call for a lower taxation of capital, in line with conventional "trickle-down" logic. The formula makes apparent why such an interpretation is incomplete. Consider a planner who cares only about the very lowest earners with neither labor- nor capital income ($\bar{g}^k = \tilde{g}^l = 0$). In this case, the bracketed becomes $\tau_k - \bar{\tau}_l'$. If $\tau_k > \tau_l$ the price responses have a positive impact on revenue and thus increase the disposable income of the poorest individuals, which would call for higher—not lower—capital income taxes.[7]

4. Recovering Unmeasured Policy Elasticities

The elasticities of equilibrium quantities ($\varepsilon_{K_t,1-\tau_k}$, $\varepsilon_{L_t,1-\tau_k}$) are what Hendren (2016) refers to as "policy elasticities". They measure the causal effect of the concrete policy experiment performed in this paper. In particular, they capture not only the response in factor supply to changes in the capital tax rate but also the responses to the simultaneous changes in transfers and prices. Such elasticities are hard, if not impossible, to estimate directly. However, in this section, I develop a methodology to recover them. Exploiting equilibrium conditions, I derive a mapping from these policy elasticities to actually estimated *supply elasticities* and I apply this mapping to recent quasi-experimental evidence.

DEFINITION 5 (*Supply Elasticities*). Let $X = \{1 - \tau_k, \{w_s, r_s, T_s\}_{s=0}^{\infty}\}$. The supply elasticities of period-t capital and labor with respect to $x \in X$ are defined as

$$\tilde{\varepsilon}_{K_t,x} = \left.\frac{\partial \ln K_t}{\partial \ln x}\right|_{X \setminus x} \quad \text{and} \quad \tilde{\varepsilon}_{L_t,x} = \left.\frac{\partial \ln L_t}{\partial \ln x}\right|_{X \setminus x}.$$

They measure the relative change in households' supply of capital and labor to a change in x, where all other taxes, transfers, and prices are held fixed.

7. There is a close analogy between this analysis and the one in Sachs, Tsyvinski, and Werquin (2020), who study tax incidence and optimal income taxation in a static Mirrlees environment with complementary labor types. In their environment, an increase in the progressivity of the tax system increases the wages of top earners, whose labor input becomes more scarce, and decreases the wages of lower earners. Hence, the endogenous wage responses of further increasing the progressivity of an already progressive tax system positively impacts government revenue.

4.1. The Methodology in a Nutshell

My methodology exploits that the policy elasticities of equilibrium quantities can be decomposed as weighted sums of supply elasticities,

$$\varepsilon_{K_t,1-\tau_k} = \tilde{\varepsilon}_{K_t,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,T_s}\varepsilon_{T_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,r_s}\varepsilon_{r_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,w_s}\varepsilon_{w_s,1-\tau_k}, \quad (3)$$

and

$$\varepsilon_{L_t,1-\tau_k} = \tilde{\varepsilon}_{L_t,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{L_t,T_s}\varepsilon_{T_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{L_t,r_s}\varepsilon_{r_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{L_t,w_s}\varepsilon_{w_s,1-\tau_k}. \quad (4)$$

Though the weights $\{\varepsilon_{T_s,1-\tau_k}, \varepsilon_{r_s,1-\tau_k}, \varepsilon_{w_s,1-\tau_k}\}_{s=0}^{\infty}$ are unmeasured policy elasticities themselves, using government budget balance, factor market clearing, and firms' optimality conditions, one can express them as linear functions of $\{\varepsilon_{K_s,1-\tau_k}\}_{s=0}^{\infty}$ and $\{\varepsilon_{L_s,1-\tau_k}\}_{s=0}^{\infty}$. Plugging these expressions into the decompositions (3) and (4), one thus obtains a linear system with as many equations as unknowns. Solving this linear system then gives the desired mapping from the unmeasured policy elasticities $\varepsilon_{K_t,1-\tau_k}$ and $\varepsilon_{L_t,1-\tau_k}$ to estimable supply elasticities.

4.2. Reducing the Number of Policy Elasticities

It considerably simplifies the exposition if preferences do not exhibit income effects on labor supply, an assumption I will make from now on:

ASSUMPTION 4. Preferences exhibit no income effects on labor supply, that is, the Bernoulli utility function is of the form

$$u(c, l) = U(c - v(l)),$$

where $U'(.) > 0$, $U''(.) < 0$, $v(.)' \geq 0$, and $v(.)'' > 0$.

Absent income effects, labor supply in any given period t only responds to changes in the contemporaneous wage w_t. In contrast, labor supply does not respond to changes in other periods' wages ($\tilde{\varepsilon}_{L_t,w_s} = 0$ for all $s \neq t$) or to changes in capital taxes, transfers, or interest rates ($\tilde{\varepsilon}_{L_t,1-\tau_k} = \tilde{\varepsilon}_{L_t,T_s} = \tilde{\varepsilon}_{L_t,r_s} = 0$). The decomposition (4), hence, trivially reduces to[8]

$$\varepsilon_{L_t,1-\tau_k} = \tilde{\varepsilon}_{L_t,w_t}\varepsilon_{w_t,1-\tau_k}, \quad (5)$$

and the revenue loss due to changes in agents' labor supply becomes

$$MEB_L = \frac{\mathrm{E}[\tau_l' y^l \bar{\varepsilon}_{l,1-\tau_k}]}{(1-\tau_k)Y^k} = \frac{\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]\bar{\varepsilon}_{w,1-\tau_k}}{(1-\tau_k)Y^k} = \frac{\bar{\varepsilon}_{w,1-\tau_k}\alpha^l}{(1-\tau_k)\alpha^k}\frac{\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]}{Y^l}.$$

8. See Online Appendix C for a formal derivation.

Furthermore, Lemma 1 implies that the time-t policy elasticities of labor, interest rates and wages are all directly proportional to $\varepsilon_{K_t,1-\tau_k}$:

Corollary 2 (Relation between Policy Elasticities). *Let Assumptions* 1–4 *be satisfied. Then, the net-of-capital-tax elasticity of equilibrium labor in period is given by*

$$\varepsilon_{L_t,1-\tau_k} = \frac{\tilde{\alpha}^k \tilde{\varepsilon}_{L_t,w_t}}{\sigma + \tilde{\alpha}^k \tilde{\varepsilon}_{L_t,w_t}} \varepsilon_{K_t,1-\tau_k}$$

and the net-of-capital-tax elasticities of equilibrium factor prices are given by, respectively,

$$\varepsilon_{r_t,1-\tau_k} = -\frac{\frac{\tilde{\alpha}^k \alpha^l}{\alpha^k}}{\sigma + \tilde{\alpha}^k \tilde{\varepsilon}_{L_t,w_t}} \varepsilon_{K_t,1-\tau_k} \quad \text{and} \quad \varepsilon_{w_t,1-\tau_k} = \frac{\tilde{\alpha}^k}{\sigma + \tilde{\alpha}^k \tilde{\varepsilon}_{L_t,w_t}} \varepsilon_{K_t,1-\tau_k}.$$

The Corollary further implies that once we found $\varepsilon_{K_t,1-\tau_k}$, we also have $\varepsilon_{L_t,1-\tau_k}$, effectively reducing the dimensionality of the linear system (3)–(4) by half. The factors of proportionality depend only on measurable statistics: factor shares α^k and α^l, the substitution elasticity σ, and wage-elasticities of labor supply. Observe that labor and capital move in the same direction but the response of labor is weaker, $\varepsilon_{L_t,1-\tau_k} < \varepsilon_{K_t,1-\tau_k}$. Furthermore, with an infinite substitution elasticity ($\sigma = \infty$), we have $\varepsilon_{L_t,1-\tau_k} = \varepsilon_{r_t,1-\tau_k} = \varepsilon_{w_t,1-\tau_k} = 0$. In that case, wages are invariant to capital tax changes, which in the absence of income effects implies that also labor supply is unaffected.

Turning attention now to the decomposition of the net-of-tax elasticity of the equilibrium capital stock, equation (3), we have expressed $\varepsilon_{w_s,1-\tau_k}$ and $\varepsilon_{r_s,1-\tau_k}$ as linear functions of $\varepsilon_{K_s,1-\tau_k}$. The following Lemma does the same for the net-of-capital tax elasticity of the transfer $\varepsilon_{T_s,1-\tau_k}$:

Lemma 2 (Decomposition of Revenue Effect). *Let Assumptions* 1–4 *be satisfied. Then, for all* $s \geq 0$, *the elasticity of the transfer with respect to the net-of-tax rate can be decomposed as*

$$\begin{aligned}\varepsilon_{T_s,1-\tau_k} = {} & \frac{Y^k}{T}\left[-1_{t \geq t^a}(1-\tau_k) + \tau_k \varepsilon_{K_s,1-\tau_k}\right] \\ & + \frac{Y}{T} \frac{\varepsilon_{K_s,1-\tau_k}}{\sigma + \tilde{\alpha}^k \tilde{\varepsilon}_{L_s,w_s}} \tilde{\alpha}^k \alpha^l \left[\frac{\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]}{Y^l} + \bar{\tau}_l' - \tau_k\right].\end{aligned}$$

Proof. See Online Appendix A.3. □

The first term captures the revenue effect of capital tax reductions when prices are constant. The government mechanically loses $-1_{t \geq t^a}(1-\tau_k)\frac{Y^k}{T}$ in revenue. In addition, because capital tax reductions encourage investment, there is a positive "behavioral" effect of $\tau_k \frac{Y^k}{T} \varepsilon_{K_s,1-\tau_k}$. In the absence of income effects on labor supply, this would be the only revenue effects if prices were constant.

The second term captures the additional revenue effects due to changing factor prices. Note that with inelastic labor supply, the term in squared brackets becomes $\bar{\tau}_l' - \tau_k$. Changing factor prices induce a fiscal externality. Specifically, the wage increase and interest rate decline, associated with a reduction in capital taxes (an increase in $1 - \tau_k$), increase government revenue if and only if labor is taxed at a higher rate than capital to begin with. When labor supply is elastic, the increase in wages induces higher labor effort, which has an additional positive effect on revenue that is proportional to $\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l_s,w_s}]$.

4.3. *Supply Elasticities: Aligning Theory and Evidence*

The set $\{\tilde{\varepsilon}_{K_t,1-\tau_k}, \{\tilde{\varepsilon}_{K_t,T_s}, \tilde{\varepsilon}_{K_t,r_s}, \tilde{\varepsilon}_{K_t,w_s}\}_{s=0}^{\infty}\}_{t=0}^{\infty}$ of capital supply elasticities is large and we do not have readily available estimates for all of them. However, as I will show, imposing consistency with household optimization behavior, this whole set can be recovered from only one elasticity, for which, we have actual evidence: the net-of-tax elasticity of capital supply $\tilde{\varepsilon}_{K_t,1-\tau_k}$ for some $t > 0$.

Remember that $\tilde{\varepsilon}_{K_t,1-\tau_k}$ measures households' response in wealth accumulation if *only* the tax rate changes but both prices and transfers remain constant. This elasticity is therefore equal to the treatment effect of an experiment that changes the capital tax rate for a small part of the population, whose behavior has a negligible influence on the government budget and on equilibrium prices.

Fortunately, we do have evidence on this elasticity. Arguably the best currently available estimates are those by Jakobsen et al. (2020), who use administrative Danish data. The authors exploit natural experiments emanating from a 1989 wealth tax reform, with which they estimate the elasticity of wealth with respect to wealth taxes for 8 years following the reform.[9] The black solid line in Figure 1 depicts their estimated wealth elasticity with respect to the net-of-capital-tax rate for the first 8 years following the reform, where the net-of-wealth-tax elasticities are translated into net-of-capital-tax elasticities using the benchmark return on capital ($r = 6.58\%$).

The dotted red line depicts the theoretical counterpart, derived from households' optimization problem:

LEMMA 3 (Net-of-Tax-Elasticity of Capital Supply). *Let Assumptions* 1–4 *be satisfied and let $t^a = 0$. Then, for all $t \geq 0$, we have that*

$$\tilde{\varepsilon}_{K_t,1-\tau_k} = t\beta \frac{C}{K} \gamma_c,$$

9. The authors estimate the elasticity of wealth with respect to wealth taxes for (i) households between the 97.6th and 99.3rd percentile of the wealth distribution and (ii) households in the top percentile of the wealth distribution. I use their estimates on the former. The estimates on the latter are similar.

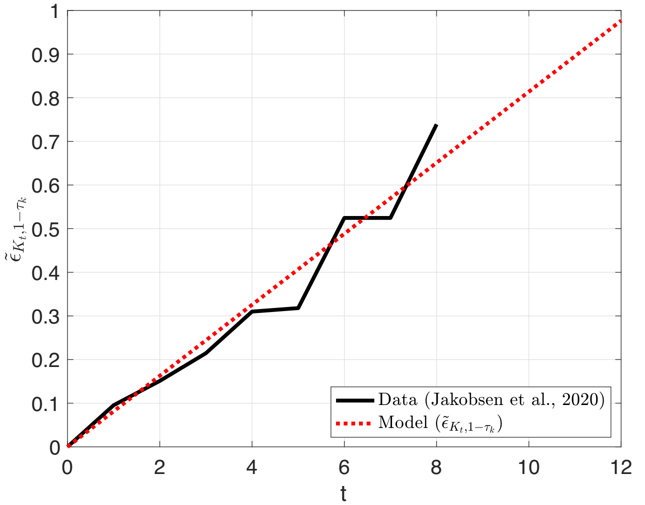

FIGURE 1. Capital supply elasticity. Data (solid line) from Jakobsen et al. (2020) Figure V (left panel); treatment on the treated; net-of-wealth-tax elasticities are translated to net-of-capital-tax elasticities using the return of $r = 6.58\%$; model (dotted line), $\tilde{\varepsilon}_{K_t,1-\tau_k} = t\tilde{\varepsilon}_{K_1,1-\tau_k}$.

where

$$\gamma_c = -\int \frac{c_0(k_0,\eta)}{C} \frac{u_c(k_0,\eta)}{c_0(k_0,\eta)\big(u_{cc}(k_0,\eta)\big)} d\Gamma$$

denotes the consumption weighted average elasticity of inter-temporal substitution.

Proof. See Online Appendix A.4. □

By Lemma 3, the supply elasticity is linear in time, $\tilde{\varepsilon}_{K_t,1-\tau_k} = t\tilde{\varepsilon}_{K_1,1-\tau_k}$, implying that from the supply elasticity of capital in any single period following the tax change, one can recover the whole path $\{\tilde{\varepsilon}_{K_t,1-\tau_k}\}_{t=1}^{\infty}$. The evidence in Jakobsen et al. (2020) provides eight such data points, implying that $\tilde{\varepsilon}_{K_t,1-\tau_k}$ is, in principle, over-identified. In order to make use of all the available evidence, I regress their estimates $\{\hat{\varepsilon}_{K_1,1-\tau_k}, \hat{\varepsilon}_{K_2,1-\tau_k}, \ldots, \hat{\varepsilon}_{K_8,1-\tau_k}\}$ on time (red dotted line). As we can see, the theoretically predicted linearity in time aligns remarkably well with the data.[10]

10. In the second part of their paper, Jakobsen et al. (2020) employ a structural life-cycle model to extrapolate the "long-run" wealth elasticity with respect to wealth taxes. They define the "long-run" elasticity as the end-of-life elasticity. However, although the authors argue that there is a high tax-elasticity of bequests, they abstract from the fact that when inheriting more, heirs also accumulate more wealth. As do the heirs of heirs, and so on. That is, the finiteness of their long-run supply elasticity is artificially introduced by the finite time horizon.

In an analogous way as in the derivation of $\tilde{\varepsilon}_{K_t,1-\tau_k}$, one can use households' optimality conditions and budget constraints to derive expressions for the supply elasticities of capital with respect to unearned income, wages, and interest rates:

LEMMA 4 (Other Capital Supply Elasticities). *Let Assumptions* 1–4 *be satisfied and let* $t^a = 0$. *Then, the supply elasticities of time-t capital with respect to time-s transfers, wages and interest rates are given by*

$$\begin{bmatrix} \tilde{\varepsilon}_{K_t,T_s} \\ \tilde{\varepsilon}_{K_t,w_s} \\ \tilde{\varepsilon}_{K_t,r_s} \end{bmatrix} = \begin{cases} -\frac{\beta^{-t}-1}{K}\begin{bmatrix} T \\ (1-\bar{\tau}_l')Y^l \\ (1-\tau_k)Y^k \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ (\beta^{s-t}-\beta^s)\tilde{\varepsilon}_{K_1,1-\tau_k} \end{bmatrix} & \text{if } 1 \le t \le s \\ \frac{\beta^{s+1}}{K}\begin{bmatrix} T \\ (1-\bar{\tau}_l')Y^l \\ (1-\tau_k)Y^k \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ (1-\beta^s)\tilde{\varepsilon}_{K_1,1-\tau_k} \end{bmatrix} & \text{if } t > s \ge 0. \end{cases}$$

The first (second) column on the right hand side captures the income (substitution) effect on capital supply following an increases in the period-s transfer, wage and interest rate, respectively. The substitution effect is equal to zero for changes in transfers and wages as they do not alter the relative return to capital in different periods. The increase in any transfer or wage raises agents' lifetime resources and the savings response is solely driven by optimal consumption smoothing. Specifically, savings respond in a way to equally increase consumption in all periods. This implies that in periods $t \le s$, prior to the receipt of the extra income, savings are reduced, while in periods $t > s$, after the receipt the extra income, savings increase. Observe that the capital supply elasticities with respect to wages are proportional to capital supply elasticities with respect to contemporaneous transfers, that is, for all t, s, we have

$$\tilde{\varepsilon}_{K_t,w_s} = \frac{(1-\bar{\tau}_l')Y^l}{T}\tilde{\varepsilon}_{K_t,T_s}.$$

Similarly, a change in r_s, the interest rate in period s induces an income effect

$$\frac{(1-\tau_k)Y^k}{T}\tilde{\varepsilon}_{K_t,T_s}$$

that is proportional to $\tilde{\varepsilon}_{K_t,T_s}$. However, in addition, an increase in r_s also induces a substitution effect, since it raises the return on capital in period s relative to all other periods. Thus, the agents' savings change is in part driven by a rent-seeking motive. Prior to s, agents sacrifice some consumption in order to accumulate more capital and benefit from the increased time-s return r_s. Observe that the substitution effect is increasing in t until $t = s$ and remains constant from then on. Importantly, it turns out that $\tilde{\varepsilon}_{K_1,1-\tau_k}$, an elasticity for which we have good estimates (see above), carries all the information we need to recover all the substitution effects.

4.4. *The Net-of-Tax Elasticities of the Equilibrium Capital Stock*

We have now all the ingredients to recover the policy elasticities. Recalling decomposition (3)

$$\varepsilon_{K_t,1-\tau_k} = \tilde{\varepsilon}_{K_t,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,T_s}\varepsilon_{T_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,r_s}\varepsilon_{r_s,1-\tau_k} + \sum_{s=0}^{\infty} \tilde{\varepsilon}_{K_t,w_s}\varepsilon_{w_s,1-\tau_k},$$

which expresses the net-of-tax elasticity of the equilibrium capital stock as weighted sum of supply elasticities, we can plug in the derived expressions for the $\tilde{\varepsilon}_{K_t,1-\tau_k}$, $\tilde{\varepsilon}_{K_t,T_s}$, $\tilde{\varepsilon}_{K_t,w_s}$ and $\tilde{\varepsilon}_{K_t,r_s}$ (Lemmas 3 and 4) as well as the expressions for the weights $\varepsilon_{r_s,1-\tau_k}$, $\varepsilon_{w_s,1-\tau_k}$, and $\varepsilon_{T_s,1-\tau_k}$ (Corollary 2 and Lemma 2) in order to obtain a system of equations that is linear in $\{\varepsilon_{K_t,1-\tau_k}\}_{t=0}^{\infty}$. Solving this linear system then gives the sequence of policy elasticities.

It is instructive to first consider the case of constant prices ($\sigma = \infty$):

LEMMA 5 (Policy Elasticity with Constant Prices). *Let Assumptions* 1–4 *be satisfied and let* $t^a = 0$. *In addition assume that* $F_{kl}(k,l) = 0$ *for all* $(k,l) \geq 0$. *Then,*

$$\varepsilon_{K_t,1-\tau_k} = t\frac{1-\beta}{1-\beta(1-\tau_k r)}\tilde{\varepsilon}_{K_1,1-\tau_k} \leq t\tilde{\varepsilon}_{K_1,1-\tau_k} = \tilde{\varepsilon}_{K_t,1-\tau_k}.$$

Proof. See Online Appendix A.6. □

The policy elasticity of Lemma 5 is the one entering the tax formulas in Saez and Stantcheva (2018). Contrary to the supply elasticity $\tilde{\varepsilon}_{K_t,1-\tau_k}$ of Lemma 3, it takes into account the effect of budget neutral adjustments in the transfer on agents' savings decision. Observe that when the initial capital tax rate is $\tau_k = 0$, the policy elasticity with constant prices coincides with the pure supply elasticity to capital tax changes, that is, $\varepsilon_{K_t,1-\tau_k} = \tilde{\varepsilon}_{K_t,1-\tau_k}$. The reason is that in this case, the additional savings induced by the lowering of the capital tax rate do not generate additional revenue and therefore no additional unearned income to the agents. However, when $\tau_k > 0$, the investment increase induced by the tax cut increases tax revenue and therefore the agents' transfer income over time. Agents want to partially consume their higher future government income, which reduces their savings. As a consequence, the policy elasticity is muted.

Now, the main difference in my framework is that the demand for production factors does not fully accommodate the changes in supply, such that in order to restore equilibrium on factor markets, interest rates and wages need to adjust, which, in turn, impacts demand and supply, and so forth. The policy elasticities capture this whole equilibrium adjustment process:

PROPOSITION 2 (Policy Elasticity with Endogenous Prices). *Let Assumptions* 1–4 *be satisfied and let* $t^a = 0$. *In addition, assume that* $F_{kl}(k,l) > 0$ *for some* $(k,l) > 0$.

Then, the path $\varepsilon_{K_t,1-\tau_k}$ of equilibrium capital elasticities with respect to the net-of-capital-tax rate is given by

$$\varepsilon_{K_t,1-\tau_k} = (1 - (\lambda(\mathbf{s}))^t)\varepsilon_{K_\infty,1-\tau_k} \qquad \forall t \geq 0,$$

where the long-run capital elasticity is given by

$$\varepsilon_{K_\infty,1-\tau_k} = \frac{\alpha^k}{\alpha^l}\left(\frac{\sigma}{\tilde{\alpha}^k} + \tilde{\varepsilon}_{L,w}\right) < \infty,$$

and $\lambda(\mathbf{s}) \in (0, 1)$ is a constant that depends only on the vector of sufficient statistics

$$\mathbf{s} = \left(\tilde{\varepsilon}_{K_1,1-\tau_k}, r, \tau_k, \bar{\tau}_l', \frac{\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]}{Y^l}; \varepsilon_{K_\infty,1-\tau_k}\right)$$

and satisfies

$$\frac{d\lambda(\mathbf{s})}{d\tilde{\varepsilon}_{K_1,1-\tau_k}} < 0.$$

Proof. See Online Appendix A.7. □

Proposition 2 expresses the policy elasticity $\varepsilon_{K_t,1-\tau_k}$ in terms of actually estimated objects only. When $\sigma < 0$, the long-run capital elasticity is finite. The increase in capital supply following a reduction in τ_k is not fully accommodated for by capital demand as the marginal product of capital decreases. Consequently, the equilibrium interest rate declines, discouraging investment. In the long run, the equilibrium capital stock will, hence, settle at a finite level. The estimated capital supply elasticity $\tilde{\varepsilon}_{K_1,1-\tau_k}$ determines the speed of convergence. The higher $\tilde{\varepsilon}_{K_1,1-\tau_k}$, the quicker does the sequence of policy elasticities $\{\varepsilon_{K_t,1-\tau_k}\}_{t=0}^{\infty}$ converge to its long run value $\varepsilon_{K_\infty,1-\tau_k}$.

Figure 2 plots the path of equilibrium capital elasticities for my benchmark finite substitution elasticity (blue dash-dotted line) as well as for the case where capital and labor are assumed perfect substitutes, that is, when prices are assumed to be invariant to tax changes (red dashed line) along with the pure supply elasticities of Figure 1. When the substitution elasticity is infinite ($\sigma = \infty$), the equilibrium capital elasticity grows linearly in time, though the income effect from the budget neutral transfer mitigates the savings response relative to the pure supply elasticity. However, whenever the substitution elasticity is finite ($\sigma < 0$), the policy elasticity converges to a finite level.[11] The reason for this difference is that whenever the substitution elasticity is finite, a tax cut that induces an increase in capital accumulation reduces the marginal product of capital and thus the rental rate of capital, which firms are willing to pay to investors. This decline in r mitigates the overall increase in the net return $\bar{r} = (1 - \tau_k)r$ and, thus, moderates the investment increase. Such a mechanism is absent when capital and

11. In Online Appendix D, I perform a sensitivity analysis with respect to the range of empirical estimates of σ.

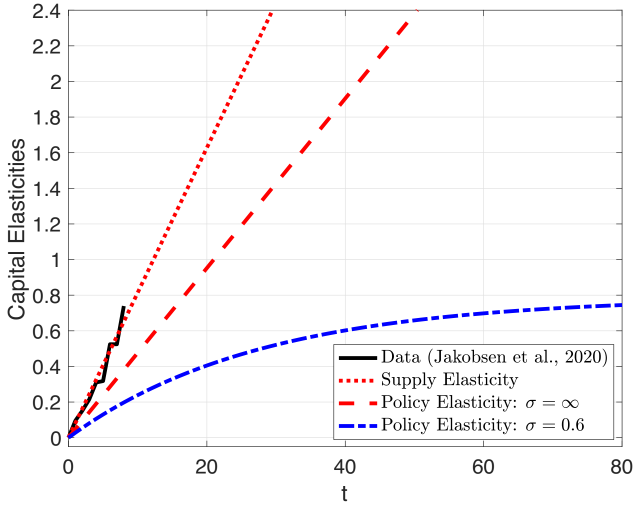

FIGURE 2. Capital elasticities. Solid line and dotted line as in Figure 1; dashed line: policy elasticity $\varepsilon_{K_t,1-\tau_k}$ with constant prices ($\sigma = \infty$); and dash-dotted line line: policy elasticity $\varepsilon_{K_t,1-\tau_k}$ with with varying prices ($\sigma = 0.6$).

TABLE 1. Summary of sufficient statistics.

Suff. Stat.		Value		Note
$\tilde{\alpha}^k$		0.4000		Capital expenditure share
α^k		0.2980		Capital income share
$\bar{\tau}_l'$		0.2250		Inc. wgt. av. marg. labor tax rate
τ_k		0.4150		Initial capital income tax rate
$\tilde{\varepsilon}_{L,w}$		0.3755		Wage elasticity of agg. labor supply
$\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]/Y^l$		0.0845		Wgt. av. labor supply elasticity
r		0.0658		Return on capital
$\tilde{\varepsilon}_{K_1,1-\tau_k}$		0.0814		Tax-elasticity of capital supply
σ	0.6000	1.0000	∞	Capital-labor substitution elasticity
$\bar{\varepsilon}_{K,1-\tau_k}$	0.3778	0.4890	1.2368	Policy elasticity capital
$\bar{\varepsilon}_{L,1-\tau_k}$	0.0756	0.0639	0.0000	Policy elasticity labor

labor are assumed to be perfect substitutes. In that case, capital increases to infinity for similar reasons as in the *Ak* model of economic growth. The implicit, counter-factual, assumption behind this is that the marginal product of capital is constant. As we will see below, these differences in the net-of-tax elasticities of equilibrium capital will imply strong differences in MEB of capital taxation.

5. Quantification of Local Welfare Effects

I can now move to the quantification of the various welfare effects. Table 1 summarizes the values of the sufficient statistics, which I employ in the analysis of the main text. I provide various sensitivity analyses in Online Appendix D. The upper panel summarizes my baseline values for those sufficient statistics, for which, we have readily available estimates, whereas the lower panel consists of the unmeasured policy elasticities that are derived from them.

Factor Shares and Taxes. Many studies estimate gross factor shares (before depreciation), all attributing around 40% of firms' expenditure to capital. One of the rare studies that also estimates net income shares (after capital depreciation) is Rognlie (2015), who finds that the net capital share is 74% of the gross share. Given the gross capital share of $\tilde{\alpha} = 0.4$ this implies $\alpha^k = 0.296$. Trabandt and Uhlig (2012) estimate a labor income weighted average marginal tax rate of $\bar{\tau}_l' = 0.225$ and a capital income tax rate of $\tau_k = 0.415$.

Labor Supply Elasticities. To obtain values for $\tilde{\varepsilon}_{L,w} = \mathrm{E}[y^l \tilde{\varepsilon}_{l,w}]/Y^l$ and $\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]/Y^l$, one could, in principle, use estimates of individual wage elasticities of labor supply across the US income distribution and aggregate up accordingly, that is, weighting by labor income (and marginal tax rates). Given the focus of this paper, I take a simpler route: As I show formally in Online Appendix C, in the absence of income effects, the wage-elasticity of labor supply of individual (k_0, η) is given by

$$\tilde{\varepsilon}_{l_t(k_0,\eta),w_t} = \frac{\gamma_l(k_0,\eta)(1 - p(y^l(k_0,\eta)))}{1 + \gamma_l(k_0,\eta)p(y^l(k_0,\eta))},$$

where $\gamma_l(k_0, \eta)$ is the agent's Frisch elasticity and $p(y^l(k_0, \eta))$ the local rate of tax progressivity at the agent's labor income level $y^l(k_0, \eta)$. Heathcote, Storesletten, and Violante (2017) document that the tax function

$$\tau_l(y^l) = y^l - (1 - \tau_0)(y^l)^{1-p}, \tag{6}$$

which features a constant rate of progressivity with $p(y^l(k_0, \eta)) = p = 0.181$, provides an exceptionally good fit of US gross and net income data. Assuming also a homogeneous Frisch elasticity of $\gamma_l(k_0, \eta) = \gamma_l = 0.5$, we then have that the wage elasticities of labor supply are homogeneous,

$$\tilde{\varepsilon}_{l_t(k_0,\eta),w_t} = \tilde{\varepsilon}_{L,w} = \frac{\gamma_l(1-p)}{1 + \gamma_l p},$$

which also identifies $\mathrm{E}[\tau_l' y^l \tilde{\varepsilon}_{l,w}]/Y^l = \bar{\tau}_l' \tilde{\varepsilon}_{L,w} = 0.0845$. I show in Online Appendix D.2 that results are quite robust even if one assumes values for Frisch elasticities below ($\gamma_l = 0$) and above ($\gamma_l = 1$) the empirical range.

Return on Capital. My baseline value for the return on capital is $r = 6.58\%$, the annual post 1980 average return on wealth in the US estimated by Jorda et al. (2019).[12]

12. In their comprehensive cross-country analysis, Jorda et al. (2019) find an almost identical estimate (6.62%) for Denmark, the country for which, Jakobsen et al. (2020) provide us with quasi-experimental estimates for net-of-wealth-tax elasticities of capital supply. Furthermore, Xavier (2021) estimates capital returns in the USA by combining the SCF waves from 1989 to 2019 with data on private business equity from the US Financial Accounts as well as public equity- and real estate indices. She finds a very similar wealth weighted average annual return of 6.80%.

I provide robustness checks with lower and higher capital returns (of $r = 5\%$ and $r = 9\%$, respectively) in Online Appendix D.1.

Net-of-tax Elasticity of Capital Supply. The value of $\tilde{\varepsilon}_{K_1} = 0.0814$ is disciplined using quasi-experimental evidence on the net-of-wealth-tax elasticity of wealth. Using a difference-in-difference approach, Jakobsen et al. (2020) exploit a 1989 reform in Denmark, which reduced the wealth tax rate from 2.2% to 1% and at the same time doubled the exemption threshold for married couples. It therefore eliminated wealth taxes for couples owning less than twice the pre-reform exemption threshold (the treatment group), while reducing it to 1% for singles with similar wealth (the control group). In order to apply their estimates to the present setting, one needs to translate them into net-of-capital-income-tax elasticities. Specifically, given a wealth tax rate τ_w, the net return on wealth is $\bar{r} = (1 - \tau_w)(1 + r) - 1$. Thus, the net return for couples in the exempted range increased by

$$\frac{\Delta \bar{r}^c}{\bar{r}} = \frac{0.022(1 + r)}{0.978(1 + r) - 1} \ \%,$$

while for singles with similar wealth, it increased only by

$$\frac{\Delta \bar{r}^s}{\bar{r}} = \frac{0.012(1 + r)}{0.978(1 + r) - 1} \ \%.$$

The difference in the changes of net returns is, hence,

$$\frac{\Delta \bar{r}^c}{\bar{r}} - \frac{\Delta \bar{r}^s}{\bar{r}} = \frac{0.01(1 + r)}{0.978(1 + r) - 1} = 25\%,$$

implying that the estimates in Jakobsen et al. (2020) need to be multiplied by 4 (compare my Figure 1 with Figure V on p. 358 in Jakobsen et al. 2020). $\tilde{\varepsilon}_{K_1} = 0.0814$ is the coefficient when regressing the eight estimates $\{\hat{\varepsilon}_{K_t,1-\tau}\}_{t=1}^{8}$ on time. It also corresponds to the slope of the dotted red line in Figure 1.

Capital–Labor Substitution Elasticity. Empirical estimates of the substitution elasticity σ are vast. In his review of the empirical literature, Chirinko (2008) concludes that "the weight of evidence suggests a value of σ in the range of 0.4-0.6". While the more recent meta-analysis of Gechert et al. (2022) suggests that σ may be even lower, using US micro data on the cross-section of plants, Oberfield and Raval (2021) recently estimated $\sigma = 0.6$, which will serve as my benchmark value. For comparability, I also report the Cobb–Douglas ($\sigma = 1$), which is assumed in most of the Macro Public Finance literature, and the case of perfect factor substitutability ($\sigma = \infty$), which is the assumption necessary for prices to be constant. In Online Appendix D.2, I report the results for the whole empirical range of σ.

Policy Elasticities. By Proposition 2, the sufficient statistics in the upper panel of Table 1 are enough to recover the sequence of unmeasured policy elasticities for capital $\{\varepsilon_{K_t,1-\tau_k}\}_{t=0}^{\infty}$, which is depicted by the dash-dotted blue line in Figure 2. Corollary 2 then also provides us with the sequence of policy elasticities for labor $\{\varepsilon_{L_t,1-\tau_k}\}_{t=0}^{\infty}$. In the lower panel of Table 1, I report the discounted averages $\bar{\varepsilon}_{K,1-\tau_k}$ and $\bar{\varepsilon}_{L,1-\tau_k}$. One can observe that they crucially depend on the capital–labor substitution elasticity σ. With the benchmark value of $\sigma = 0.6$, the discounted average capital

TABLE 2. Decomposition of the MEB.

	MEB_K	MEB_L	MEB
Constant prices ($\sigma = \infty$)	0.8774	0.0000	0.8774
Cobb–Douglas ($\sigma = 1$)	0.3469	0.0584	0.4053
Baseline ($\sigma = 0.6$)	0.2680	0.0692	0.3372

Notes. Components of the MEB; numbers in dollar per mechanical dollar in capital tax revenue raised; MEB_K: loss in capital income tax revenue due to lower investment; and MEB_L: loss in labor income tax revenue due to lower labor supply.

elasticity is $\bar{\varepsilon}_{K,1-\tau_k} = 0.378$, while in the Cobb–Douglas case, it is $\bar{\varepsilon}_{K,1-\tau_k} = 0.489$ and in the case of perfect substitutes, it is $\bar{\varepsilon}_{K,1-\tau_k} = 1.237$. This means that imposing the counter-factual assumption necessary for factor prices to be constant leads to an exaggeration of $\bar{\varepsilon}_{K,1-\tau_k}$ by a factor greater than 3. The policy elasticity for labor is increasing in the degree of capital–labor complementarity since, absent income effects, labor supply is only affected through wage changes. While wages, and, hence, labor supply, do not react at all when $\sigma = \infty$, we have moderate discounted average labor supply elasticities of $\bar{\varepsilon}_{L,1-\tau_k} = 0.076$ and $\bar{\varepsilon}_{L,1-\tau_k} = 0.064$ for $\sigma = 0.6$ and $\sigma = 1.0$, respectively. I report these elasticities for different combinations of substitution- and Frisch elasticities in Online Appendix Table D.4 in Online Appendix D.2.

5.1. The Marginal Excess Burden

Having collected all those sufficient statistics that are independent of the planner's social welfare weights, I can proceed to quantify the MEB of capital taxation. Table 2 summarizes the three components of MEB. The first line covers the case where capital and labor are perfect substitutes, that is, factor prices are constant. Absent changes in the equilibrium wage, a change in the capital tax rate does not affect labor supply and, hence, keeps labor income tax revenue constant ($MEB_L = 0$). Consequently, the total MEB consists exclusively of the revenue loss due to a reduction in agents' savings. This revenue loss of $MEB = MEB_K = 0.88$, however, is substantial. For each mechanical, dollar raised the government loses 88 cents due to the investment decline. Since the marginal product of capital is constant, firms' demand for capital is perfectly elastic and the equilibrium interest rate does not respond. As a consequence, the net-of-tax elasticity of the equilibrium capital stock is large (see Figure 2), implying a large tax distortion.

In contrast, when capital and labor are complements ($\sigma < \infty$), the marginal product of capital is decreasing and firms' capital demand curve is downward-sloping. As a consequence, the decline in households' capital supply following the increase in the capital tax rate, results in a higher equilibrium interest rate. This rise in the gross return r mitigates the reduction in the net return $(1 - \tau_k)r$, which has a moderating effect on the investment decline. Consequently, for each dollar, it raises mechanically, the government loses only 27 cents (35 cents) in capital income tax revenue when $\sigma = 0.6$ ($\sigma = 1$).

When $\sigma < \infty$, the tax induced reduction in the wage also lowers labor supply and thus negatively affects labor income tax revenue. With $\sigma = 0.6$ ($\sigma = 1$), the government loses around 7 cents (6 cents) in labor income tax revenue per dollar raised mechanically, implying a total MEB of 0.34 in the baseline case and 0.41 in the Cobb–Douglas case. Thus, considering $\sigma = 0.6$ as the "true" substitution elasticity, one would exaggerate the MEB by 160% when wrongly assuming that factor prices are constant and by around 20% when wrongly assuming a Cobb–Douglas production function.

The MEB is a measure of the efficiency loss from capital tax increases and thus independent of the choice of social welfare weights. However, a lower MEB implies a larger set of social welfare criteria under which increases in the capital tax rate are beneficial.

5.2. Distributional Sufficient Statistics

In order to quantify the equity effect, we need to assign values to the capital- and labor income weighted average marginal social welfare weights $\bar{g}^k$ and $\tilde{g}^l$, which depend both (i) on the distribution of capital and labor income (taxes), and (ii) on the chosen welfare objective, that is, on the marginal social welfare weights, the planner assigns to each household.

5.2.1. Distribution of Income Components and Marginal Labor Tax Rates. I use the Survey of Consumer Finances 2022 (SCF), which has excellent wage income- and wealth data for a representative sample of US households. I restrict this sample to prime-age workers (non-retirees aged 25–64). I line with my model, I define capital income as the product of net worth and the return on capital, $y^k(k_0) = k_0 r$.[13] Labor income comprises wage income and some of the receipts from privately owned businesses and farms. It is known to be empirically difficult to disentangle the capital- and labor component of the latter. To discipline this choice somewhat, I calibrate that 77.6% of business and farm income is to be assigned as labor income, such that for the (representative) population in the SCF, the aggregate capital income share is $\tilde{\alpha}^k = 0.296$ with the benchmark return of $r = 6.58\%$. Since taxes are not reported in the SCF, I employ the tax function (6) to translate gross into net labor income and to obtain estimates for marginal tax rates, which enter into the statistic $\tilde{g}^l$.

5.2.2. Marginal Social Welfare Weights. An increase in the capital tax rate affects the distribution of disposable income. The welfare assessment of this redistribution requires a normative judgment, that is a stand on how to value the relative consumption of different households. Specifically, while the MEB quantifies the efficiency loss and

13. More direct measurements of capital income in the SCF and similar surveys are imprecise due to (i) the non-exclusion of unrealized capital gains; and (ii) the difficulty to decompose private business income into a capital- and labor income.

is, hence, "universal" across social welfare objectives, the valuation of the equity effect depends on the welfare criterion. The Macroeconomics literature typically confines the analysis to the equally weighted utilitarian objective. However, policy makers may very well have a preference for a different social welfare criterion. In order to be agnostic and to explore the welfare effects across the distribution, I follow the strategy of Piketty and Saez (2013) by considering hundred different social welfare functions, each of which concentrates the whole weight in a specific percentile of the total gross income distribution. Formally, for each social welfare function indexed by $pct \in \{1, 2, ..., 100\}$, the corresponding marginal social welfare weights are given by

$$g_{pct}(k_0, \eta) = \begin{cases} 100 & \text{if} \quad \Gamma_y(y(k_0, \eta)) \in [pct - 1, pct) \\ 0 & \text{else,} \end{cases}$$

where Γ_y is the distribution of gross total income induced by the distribution Γ and agents' optimal choices. In turn, this implies for each of these welfare objectives that the capital (labor) income weighted marginal social welfare weight for the social welfare function pct is simply the average capital (labor) income within percentile pct of the income distribution divided by the mean capital (labor) income of the whole population,

$$\bar{g}^k_{pct} = \int_{\Gamma_y(y(k_0,\eta))\in[pct-1,pct)} \frac{y^k(k_0, \eta)}{Y^k} d\Gamma \quad \text{and}$$

$$\bar{g}^l_{pct} = \int_{\Gamma_y(y(k_0,\eta))\in[pct-1,pct)} \frac{y^l(k_0, \eta)}{Y^l} d\Gamma.$$

Similarly, $\tilde{g}^l = \tilde{g}^l_{pct}$ is the (relative) average labor income weighted by the marginal retention rate $(1 - \tau_l'(y^l))$ within percentile pct.

Figure 3 depicts $\bar{g}^k_{pct}$, $\bar{g}^l_{pct}$, and $\tilde{g}^l_{pct}$, with the percentiles pct on the X-axis. Since gross income is naturally positively correlated with its components, both the labor- and the capital income weighted average marginal social welfare weight are increasing in pct. Observe that $\bar{g}^k < 1$ ($\bar{g}^l < 1$) with welfare objectives that value the lowest 80% (the lowest 67%) of the gross income distribution. Due to the progressivity of the labor tax code, however, already the 33rd percentile of the income distribution earns the net-of-marginal-tax-rate weighted average labor income ($\tilde{g}^l_{33} \approx 1$).

5.3. *The Equity Effect*

We have now all the necessary ingredients for the quantification of the equity effect. Figure 4 plots the components of the equity effect EQ, where the values pct on the horizontal axis again refer to the welfare function that concentrates all welfare weight in percentile pct of the total income distribution. The left panel captures the case with constant prices ($\sigma = \infty$) and the right panel the baseline ($\sigma = 0.6$).[14]

14. The Cobb–Douglas case ($\sigma = 1$) is in between the two, though it is much more similar to the baseline case ($\sigma = 0.6$) than to the case of perfect factor substitutability ($\sigma = \infty$).

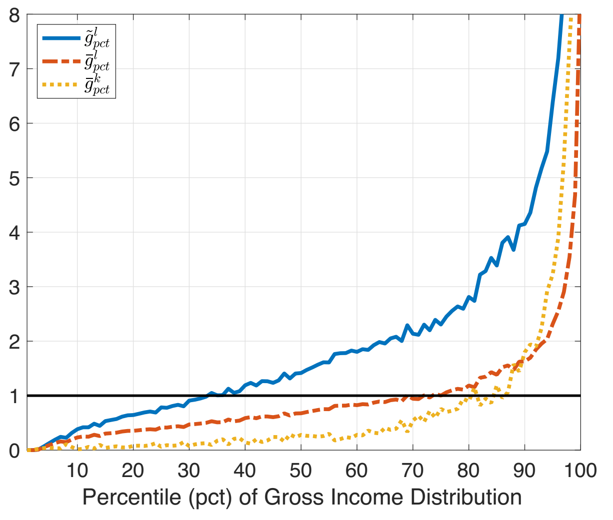

FIGURE 3. Weighted average marginal social welfare. $\bar{g}^k_{pct}$ ($\bar{g}^l_{pct}$): average capital (labor) income in percentile *pct* of the total income distribution as fraction of capital (labor) income in the whole population; $\tilde{g}^l_{pct}$: average net-of-marginal-tax-weighted labor income in percentile *pct* relative to average in population.

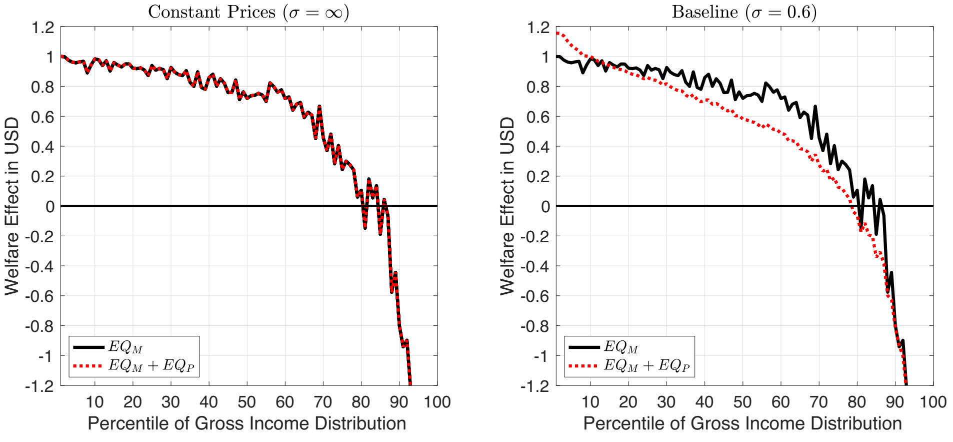

FIGURE 4. The equity effect: in USD per dollar of revenue mechanically raised; EQ_M: mechanical effect (same for all σ), EQ_P : redistributional effect of factor price changes; value p on X-axis corresponds to the social welfare function that concentrates the whole welfare weight at percentile p of the total gross income distribution.

5.3.1. Mechanical Redistribution. The solid black line depicts the mechanical effect $EQ_M = 1 - \bar{g}^k$, which measures the change in welfare if agents' consumption, savings, and labor supply were to be fixed at their pre-reform level. Naturally, the mechanical effect is identical across the two cases since without behavioral responses also prices are unaffected. The bottom of the gross income distribution does not earn any significant capital income, implying that a planner who only values those individuals does not discount the mechanically raised dollar, that is, $\bar{g}^k \approx 0$. As one moves up the total gross income distribution, households tend to earn more and more capital income, implying that $\bar{g}^k_{pct}$ tends to increase in the percentile pct. However, since capital income is concentrated at the very top, the decline in the mechanical effect EQ_M is relatively modest until about income percentile 70, from which on households tend to have more substantial wealth and, hence, capital income. The skewness of the wealth distribution implies that the mean capital income is much higher than the median. Average capital income is earned by households around the ninth income decile, which is where the mechanical effect crosses the *X*-axis.

5.3.2. Effect of Redistributing Factor Price Changes. The overall equity effect comprises the mechanical effect and the redistributional effect of factor price changes, $EQ = EQ_M + EQ_P$. When capital and labor are perfect substitutes (left panel of Figure 4), prices do not change, that is, $\varepsilon_{w,1-\tau_k} = \varepsilon_{r,1-\tau_k} = 0$. Consequently, the price effect is zero ($EQ_P = 0$) and the total equity effect coincides with the mechanical effect, $EQ = EQ_M$.

In contrast, whenever capital and labor are not perfect substitutes ($\sigma < \infty$, right panel of Figure 4), a marginal increase in the capital tax rate increases interest rates and reduces wages, causing redistribution across households with different income compositions. Specifically, the redistributive price effect can be further decomposed,

$$EQ_P = \underbrace{-(1-\tau_k)\bar{g}^k\bar{\varepsilon}_{r,1-\tau_k}}_{EQ_P^r \geq 0} \underbrace{-\alpha^l/\alpha^k(1-\bar{\tau}_l')\tilde{g}^l\bar{\varepsilon}_{w,1-\tau_k}}_{EQ_P^w \leq 0} \underbrace{-\tau_k\bar{\varepsilon}_{r,1-\tau_k} - \alpha^l/\alpha^k\bar{\tau}_l'\bar{\varepsilon}_{w,1-\tau_k}}_{EQ_P^t},$$

into (i) the gain in net capital income due the increase in interest rates ($EQ_P^r \geq 0$ since $\bar{\varepsilon}_{r,1-\tau_k} \leq 0$), (ii) the loss in net labor income due to the reduction in wages ($EQ_P^w \leq 0$ since $\bar{\varepsilon}_{w,1-\tau_k} \geq 0$), and (iii) the change in transfer income due to the direct impact of these factor price changes on revenue EQ_P^t. Though, theoretically ambiguous, in the present example, the latter is positive since capital is taxed at a higher average rate than labor, $0.415 = \tau_k > \bar{\tau}_l' = 0.225$. Thus, households at the very bottom of the gross income distribution, who earn neither labor- nor capital income, benefit from the price changes. In Figure 4, this can be seen with the dotted red line crossing the *Y*-axes above 1. Specifically, when $\sigma = 0.6$, the positive impact of price changes on revenue implies that the poorest households obtain an additional 16 cents on top of the mechanically raised dollar. However, at the same time, the price effect is negative (the dotted line below the solid one) for a large middle class, approximately those between the 15th and the 90th income percentile, which finance most of their consumption through net labor income and thus suffer from the depressing effect of capital tax increases on wages.

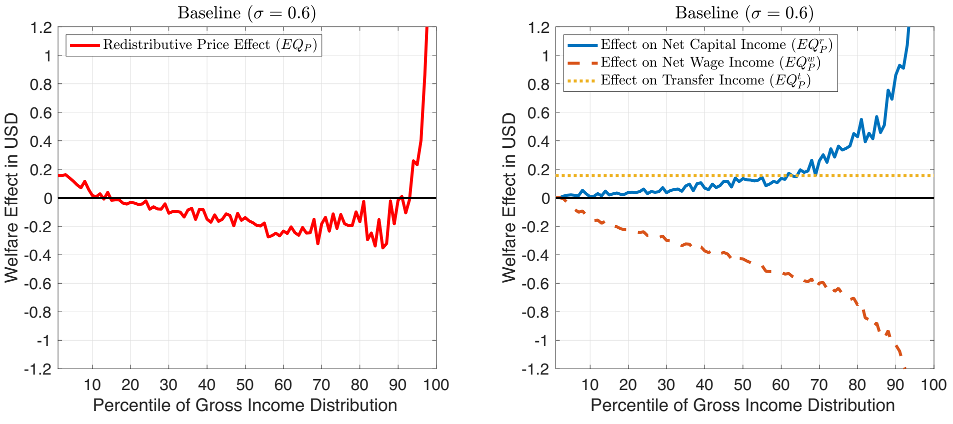

FIGURE 5. The redistributive price effect. In USD per dollar of revenue mechanically raised; left panel: redistributional effect of factor price changes; right panel: decomposition of EQ_P in three components; value p on X-axis corresponds to the social welfare function that concentrates the whole welfare weight at percentile p of the total gross income distribution.

In Figure 5, I study the price effect in more detail for the baseline case of $\sigma = 0.6$. The left panel depicts the overall price effect (it coincides with the difference between the dotted and solid line in Figure 4 above), while the right panel separately plots its three components. Since by assumption, the whole population receives the same transfer, the component $EQ_P^t = 0.16$ is independent of the social welfare function. At the bottom of the income distribution, the price effect consists exclusively of EQ_P^t since the poorest households live exclusively from transfer income. As one moves up the income distribution, the price effect declines until around percentile 60, a result of the increasingly negative effect on households' net labor income (EQ_P^w). From the seventh income decile on households start earning more substantial amounts of capital income and as a consequence, the positive effect on capital returns (EQ_P^r) counteracts the negative effect on wages. However, only the very richest earn more capital income than labor income, which is the reason why the positive effect on capital returns dominates the negative effect on wages only well above the 90th income percentile.

5.4. *The Total Welfare Change*

Simply adding the MEB to the equity effect gives the total welfare change per mechanically raised dollar in revenue,

$$d\overline{W} = \underbrace{EQ_M + EQ_P}_{=EQ} - \underbrace{(MEB_K + MEB_L)}_{MEB}.$$

The two panels of Figure 6 again depict the cases for $\sigma \in \{\infty, 0.6\}$. The dotted lines depict the equity effect EQ and are identical to the total equity effect in Figure 4. The solid lines add the MEB. As discussed above, the MEB is independent of the choice

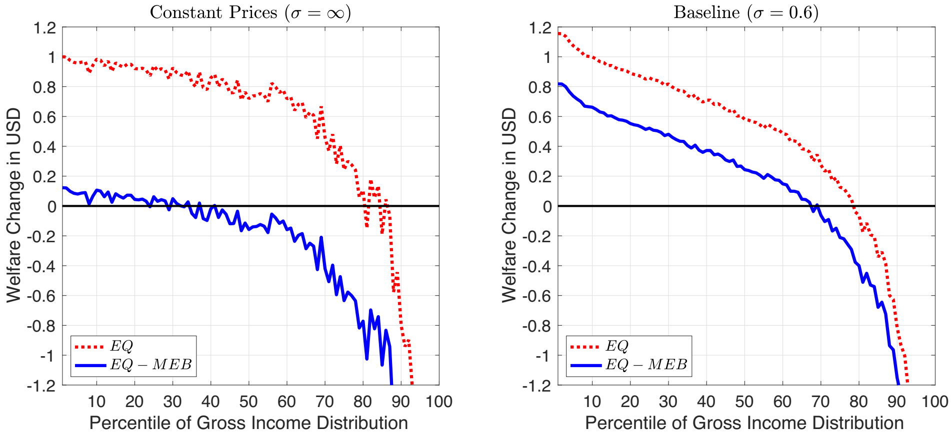

FIGURE 6. Welfare change. In USD per dollar of revenue mechanically raised; *EQ*: equity effect, *MEB*: marginal excess burden; value p on X-axis corresponds to the social welfare function that concentrates the whole welfare weight at percentile p of the total gross income distribution.

of social welfare function. Hence, adding it results simply in a parallel downward shift along the Y-axis.

In the case of constant prices (left panel), $MEB = 0.88$ is very large. Consequently, even for welfare objectives that only value agents with about zero capital income, say the bottom 20% of the income distribution, the total welfare gains from capital tax increases is very small, while it is about zero for households between income percentiles 20 and 40 and slightly negative between percentiles 40 and 60.

In the cases with varying prices (right panel), the depressive effect of capital tax hikes on wages causes the equity effect to decline much sharper as one moves up the income distribution. However, at the same time, the welfare gains at the bottom of the income distribution are much larger. First, and most importantly, $MEB = 0.34$ is much lower. Second, since in the USA, capital is taxed at a higher average rate than labor, the factor price changes have a positive impact on revenue and, hence, on the transfer.

Overall, we observe that in the baseline case, the bottom 60% of the income distribution gain substantially from a capital tax hike, while the gains are close to zero in the case with constant prices. This may seem counter-intuitive in light of the extensive policy debate on the wage depressing effect of capital taxes. However, remember from Section 4 that as $t \to \infty$, the elasticity of the equilibrium capital stock $\varepsilon_{K_t, 1-\tau_k}$ diverges to infinity when $\sigma = \infty$, while it remains bounded whenever $\sigma < \infty$. Thus, in the long run, the distortion of capital tax hikes on investment must be higher in the economy with constant prices. Although wages only decline when $\sigma < \infty$, this decline is bounded too.[15] Hence, the only way in which households with substantial labor- but little capital income could gain more from a capital tax increase

15. Specifically, Corollary 2 and Proposition 2 together imply that $\varepsilon_{w_\infty, 1-\tau_k} = \frac{\alpha^l}{\alpha^k}$.

in the economy with constant prices than in the economy with varying prices, is if the aforementioned divergence is sufficiently slow. This would be the case if households' elasticity of capital supply, or equivalently, the elasticity of intertemporal substitution (EIS) is sufficiently small (see Lemmas 3 and 5). As discussed in Section 4.3, I discipline the capital supply elasticity with the quasi-experimental evidence provided by Jakobsen et al. (2020). The EIS consistent with this evidence turns out to be $\gamma_c = 0.4$, a value well in the middle of empirical estimates.[16] In contrast, to overturn the result that welfare gains for the middle class are higher in the economy with varying prices, one would need a much lower value of $\gamma_c < 0.1$. I discuss this in more detail and more formally in Online Appendix D.3.

In sum, although with endogenous prices, the depressive effect on wages implies that welfare gains decline in labor income, the bottom 60% of the income distribution would experience large gains from capital tax increases. In Online Appendix D, I show that these results are quite robust to the whole range of estimates for the substitution elasticity and the wage elasticity of labor supply as well as to different assumptions on the return to capital. Specifically, for the whole, empirical range of estimates would the bottom 60% of the total income distribution gain from increases in the capital tax rate, while the top 30% would lose.

6. Optimal Capital Taxes Taking the Labor Tax Code as Given

Until now, the analysis was confined to the study of local welfare effects following marginal changes of the capital tax rate. Corollary 1 above provides a test for optimality of the *pre-existing* capital tax rate. In case of sub-optimality, however, it only provides the direction of a welfare improving reform but not its optimal size. The reason is that the sufficient statistics are endogenous to the tax rate and thus may change, in particular, when the reform is large.[17]

In this section, I will, hence, employ a fully specified model, which will allow me to compute *optimal* capital tax rates. For now, I will continue to take the labor income tax code as given.

6.1. Calibrating a Nested Parametric Model

The calibration of the model is informed by the sufficient statistics analysis above. Specifically, the parameters of the model, summarized in Table 3, are chosen such that the sufficient statistics of Table 1 are all *exactly* matched in the initial steady state.

16. For example, in his meta analysis of 2,735 empirical studies, Havranek (2015) finds values between 0.3 and 0.4 to be "the literature's best shot of the calibration of the EIS."

17. See Kleven (2021), in particular, his Section 3.3, for a thorough discussion of this issue. In Online Appendix E, I compare the results from the global solution method of the present section to those when using the condition of Corollary 1 and simply assuming that the sufficient statistics, that is, the relevant elasticities and marginal social welfare weights, are all invariant to tax changes (what Kleven (2021) calls

TABLE 3. Parameters.

Parameter		Value		Note
$\tilde{\gamma}_c$		0.5005		Preference parameter
γ_l		0.5000		Frisch elasticity
β		0.9629		Time discount factor
σ	0.6000	1.0000	∞	Capital–labor substitution
α	0.9879	0.4000	0.1043	Technological parameter
δ		0.0385		Depreciation rate
τ_k		0.4150		Initial capital tax rate
p		0.1810		Labor tax progressivity parameter
τ_0		0.0180		Labor tax level parameter
T		0.1022		Initial government transfer
G		0.0585		Government expenditures

6.1.1. Preferences. I assume agents have GHH preferences [Greenwood, Hercowitz, and Huffman (1988)],

$$u(c,l) = \frac{\left(c - \frac{l^{1+\frac{1}{\gamma_l}}}{1+\frac{1}{\gamma_l}}\right)^{1-\frac{1}{\tilde{\gamma}_c}}}{1-\frac{1}{\tilde{\gamma}_c}},$$

which satisfy Assumption 4. The parameter γ_l is equal to the Frisch elasticity of labor supply, which I set to the standard value of $\gamma_l = 0.5$. The parameter $\tilde{\gamma}_c$ is related to the EIS (γ_c). The two do not exactly coincide due to the non-separability between consumption and labor. Calibrating $\tilde{\gamma}_c$ such that the model replicates the net-of-tax-elasticity of capital supply $\tilde{\varepsilon}_{K_1,1-\tau_k}$, I obtain a value of $\tilde{\gamma}_c = 0.501$. The corresponding EIS of $\gamma_c = 0.404$ is well in the middle of empirical estimates. The discount factor $\beta = 0.963$ is chosen to be consistent with a steady state interest rate of $r = 6.58\%$ and a status quo-capital income tax rate of $\tau_k = 0.415$.

6.1.2. Technology. I assume a production function that features a constant elasticity of substitution,

$$F(K,L) = \left(\alpha K^{\frac{\sigma-1}{\sigma}} + (1-\alpha)L^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}},$$

where I use the same values for the capital–labor substitution elasticity as above: the baseline value of $\sigma = 0.6$, the Cobb–Douglas value of $\sigma = 1$, and the case of perfect substitutes $\sigma = \infty$. When changing σ the parameter α needs to be recalibrated in order to ensure that the expenditure share on capital is $\tilde{\alpha}^k = 0.4$ in all three calibrations.[18] As before, capital is assumed to depreciate at rate δ each period. In order to be consistent

the "Optimal Tax Trick"). As it turns out, the approximation of the optimal tax rates via this approach is in fact quite good, at least in the present context.

18. Note that in the Cobb–Douglas case, it coincides with the capital expenditure share ($\alpha = \tilde{\alpha}^k$) and in the case of perfect substitutes it coincides with the sum of depreciation and interest rate ($\alpha = r + \delta$).

with $r = 0.0658$, $\tilde{\alpha}^k = 0.4$ and $\alpha^k = 0.296$, the capital depreciation rate needs to be set $\delta = 3.85\%$ per annum, a value in line with empirical evidence.

6.1.3. Taxes and Transfers. The labor income tax code is given by the mapping (6), which I also used in Section 5 to approximate labor income tax payments in the data. Both labor- and capital income taxes are set in the same way as above.[19] I calibrate the initial transfer T and—as a residual in the government budget constraint—expenditures G, such that the model matches a transfer-expense ratio of 71% as reported by the Organization for Economic Cooperation and Development (OECD). For the purpose of this calculation, I include into transfers the subsidies, which the labor income tax schedule (6) generates for low earnings. However, note that, out of the sufficient statistics in Table 1, only $\tilde{\varepsilon}_{K_1,1-\tau_k}$ is affected by changes in the initial transfer T. The transfer is hence, in principle, a free parameter since with any change in T, the preference parameter $\tilde{\gamma}_c$ adjusts in order to generate the same net-of-tax-elasticities of capital supply. While the initial transfer—of course—affects initial welfare, it does not directly affect the welfare gains from changes in τ_k as long as they are expressed in monetary units.[20]

6.1.4. Ability Distribution. The present framework exhibits an indeterminate steady state wealth and income distribution, a feature that enables me to pick the distribution $\Gamma(k_0, \eta)$, such that the joint distribution of wealth and labor income in the model economy is exactly identical to the one in the data. Initial wealth k_0 is directly observed in the SCF, but ability η is not. To recover labor abilities, I, hence, follow the strategy of Saez (2001): for each household observed in the SCF, I compute the labor ability η that rationalizes their observed labor income as optimal.[21]

Thus, each type of agent (k_0, η) in my model economy corresponds to one observation in the SCF, and I pick the mass $\gamma(k_0, \eta)$ of this type to equal the corresponding sampling weight in the SCF. As a consequence, for any chosen social welfare function, the model exactly replicates the (initial) values of $\bar{g}^k$ and $\tilde{g}^l$ that are used in the sufficient statistics analysis above.

19. The level parameter of the labor income tax code (6) is not scale invariant. One obtains a value of $\tau_0 = 0.0180$ when income is normalized such that $Y = 1$.

20. Simply speaking, 100 more dollars are 100 more dollars irrespective whether T increased from \$1,000 to \$1,100 or from \$10,000 to \$10,100.

21. Specifically, any optimizing household with characteristics (k_0, η) must satisfy the intra-temporal labor supply condition,

$$l(k_0, \eta) = \left[(1-\tau_0)(1-p)(y^l(k_0, \eta))^{1-p}\right]^{\frac{1}{1+\frac{1}{\gamma_l}}}.$$

This provides a mapping from observed labor income $y^l(k_0, \eta)$ to unobserved labor supply $l(k_0, \eta)$. Given the model implied steady state wage w, the household's labor productivity is then given by $\eta = \frac{y^l(k_0,\eta)}{wl(k_0,\eta)}$.

6.2. *Computing Tax Reforms*

I perform a sequence of tax reforms, where one such reform is characterized by a one-off change in the capital income tax rate from its status quo of $\tau_k = 0.415$ to a new (reformed) tax rate $\tau_k^r \in \{..., 0.40, 0.41, 0.42, 0.43, ...\}$. In each case, I adjust the transfer T over time to ensure period-by-period government budget balance.[22]

When σ is finite, the economy converges to a new steady state and I apply standard recursive numerical methods to compute the transitional path of all equilibrium variables (see, e.g., Domeij and Heathcote 2004 for an early contribution and an algorithm). In contrast, when $\sigma = \infty$, the model behaves similar to the AK model of economic growth and one can characterize the path of equilibrium variables in closed form [see King and Rebelo (1990) for analysis of taxation in the AK model and my Online Appendix F for a detailed discussion of the differences in my setting].

I then find the optimal tax rate for the same set of social welfare functions that I considered above, that is, the tax rates that maximize each income percentiles' welfare.

6.3. *Optimal Capital Tax Rates*

As in the local welfare analysis above, I focus on the case of unannounced reforms in the main text, while I discuss the case with pre-announcement in Online Appendix G.[23] Figure 7 plots the optimal tax rates for the same set of social welfare objectives. We observe a similar pattern as above. Specifically, while the constant price case ($\sigma = \infty$) suggests that the current tax rate is approximately optimal for the bottom 60% of the income distribution, more realistic values of σ render current tax rates too low for this part of the population. The main reason is, as discussed above, the significantly lower excess burden.

Furthermore, contrary to the constant price case, optimal tax rates are strongly decreasing in income when prices are endogenous, especially in the baseline ($\sigma = 0.6$). For example, with constant prices ($\sigma = \infty$), the "optimal" tax rate from the perspective of the very bottom of the income distribution is 44%, only 6 percentage points higher than what households in percentile 60 of the income distribution would find optimal. In contrast, in the Cobb–Douglas case ($\sigma = 1$), the corresponding tax rates decrease by 34 percentage points, from 82% (Rawlsian) to 48% (welfare objective maximizing welfare of percentile 60), and in the baseline case ($\sigma = 1$), the decrease is even 39 percentage points, from 91% to 52%. As explained above, the main reason is the depressing effect of capital tax increases on wages. As one moves up the income distribution, the net income loss due to the decrease in wages tends to become more and more important relative to the gain in transfer income. Households around the 67th

22. With small tax reforms $\tau_k^r \in (0.41, 0.42)$, the model generated path of net-of-tax elasticities of the equilibrium capital stock $\{\varepsilon_{K_t,1-\tau_k}\}_{t=1}^{\infty}$ replicates those plotted in Figure 2. This is a numerical confirmation of Proposition 2. Consequently, for small tax changes, also the values for $\bar{\varepsilon}_{K,1-\tau_k}$ and $\bar{\varepsilon}_{L,1-\tau_k}$ are matched.

23. For sensible pre-announcement periods (say less than 10 years), the results are very similar.

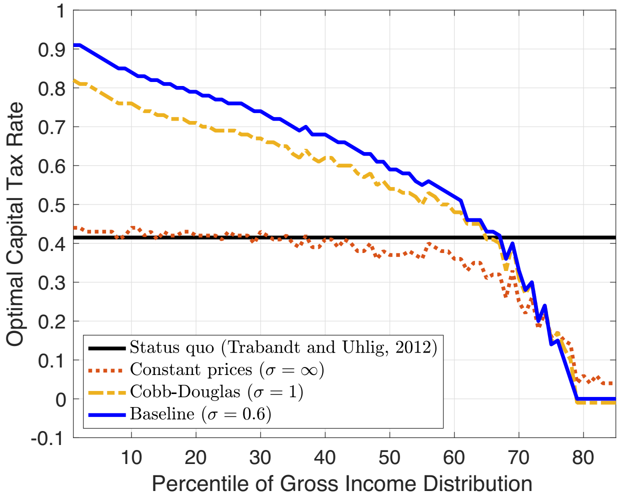

FIGURE 7. Optimal capital tax rates. Value p on the X-axis corresponds to the social welfare function that concentrates the whole welfare weight at percentile p of the total gross income distribution.

income percentile find the current tax rate approximately optimal, while higher income households would like to see capital tax reductions.

7. Joint Optimization of Capital and Labor Taxes

So far I studied the effects of capital taxation when taking a pre-existing labor income tax schedule as given. In this pen-ultimate section, I will instead consider the case where the planner can simultaneously choose both capital taxes and labor taxes.

7.1. Theory: Another Test for Optimality

For general preferences and arbitrary non-linear labor taxes, this becomes analytically untractable when $\sigma < \infty$. However, assuming that preferences do not exhibit income effects on labor supply and that both capital and labor are taxed linearly, the following result can be derived. I will focus on the main insights in the main text but provide a more detailed discussion of the joint optimum in Online Appendix H.

PROPOSITION 3 (Test for Joint Optimality). *Let Assumptions* 1–4 *be satisfied and let capital- and labor income taxes both be linear. Furthermore, let* $\sigma < \infty$. *The pre-existing tax rates* (τ_k, τ_l) *are jointly optimal only if*

$$\tau_k = \frac{1 - \bar{g}^k}{1 - \bar{g}^k + \frac{\beta(1-\lambda)}{1-\beta}\varepsilon_{K_\infty, 1-\tau_k}}, \tag{7}$$

where $\varepsilon_{K_\infty,1-\tau_k}$ *and* λ *are defined as in Proposition* 2, *and*

$$\tau_l = \frac{1-\bar{g}^l}{1-\bar{g}^l+\gamma_l}, \tag{8}$$

where γ_l *denotes the (income weighted average) Frisch elasticity of labor supply.*

Proof. See Online Appendix A.8. □

These conditions exhibit several noteworthy properties:

- Condition (7) is independent of the distribution of labor income (of $\bar{g}^l$) but depends on technology.
- Condition (8) is independent of both the distribution of capital income (of $\bar{g}^k$) and of technology.

To see why Condition (7) depends on technology, note that the long-run net-of-tax elasticity of the equilibrium capital stock is given by

$$\varepsilon_{K_\infty,1-\tau_k} = \frac{\alpha^k}{\alpha^l}\left(\frac{\sigma}{\tilde{\alpha}^k}+\gamma_l\right)$$

and, hence, depends linearly on σ. As in the analysis above, we see that capital taxes should be higher the more complementary capital and labor are. Furthermore, they should be higher the lower the speed of convergence $1-\lambda$ to the new steady state is. As discussed above, the latter depends positively on the capital supply elasticity $\tilde{\varepsilon}_{K_1,1-\tau_k}$ or, equivalently, on the EIS γ_c.

The other properties are reminiscent of the seminal optimal tax result by Diamond and Mirrlees (1971), according to which, optimal tax formulas are invariant to technology, provided that the planner can tax different factors of production at different rates. A direct consequence is that in such a case, general equilibrium effects of tax changes on factor prices can be ignored. The proof of Proposition 3 reveals that indeed an envelope-type of argument applies. Specifically, *starting in the steady state associated with the optimal policy*, the cross-base responses to a change in either of the two tax rates have a zero first order effect on welfare. Furthermore, because of Assumption 4, we have that labor supply in any period t is exclusively determined by the net wage in that same period, implying that the tax rate τ_l that solves the problem with constant prices automatically also solves the general problem. Hence, condition (8) is not only independent of technology, it also coincides with the static optimality condition with exogenous wages (Sheshinski 1972).

However, contrary to the labor supply decision, the investment decision is dynamic. For a similar argument as with the optimality condition for labor to go through, one would need that households' wealth in any period t only reacts to changes in the net return $(1-\tau_k)r_t$ of the same period, but is unresponsive to changes in all other (after-tax) prices and transfers. This is inconsistent with optimal consumption smoothing and rent-seeking (see Lemma 4). The time-invariance restriction on taxes violates the

Diamond–Mirrlees assumptions. In the context of their theory, the different production factors are not simply capital and labor, but the sequences of capital and labor over time. If the planner has as many tax instruments at her disposal as there are prices, choosing optimal taxes is equivalent to directly choosing after-tax factor prices, such that general equilibrium effects disappear from optimal tax formulas. However in the present setting, with transitional dynamics, the set of net prices is $\{(1-\tau_k)r_t, (1-\tau_l)w_t\}_{t=0}^{\infty}$. If they are time-varying, which is the case whenever $\sigma < \infty$, there are infinitely many different prices, which the planner can target with only two instruments.

It is important to emphasize that Proposition 3 again only offers a *test for the optimality of the pre-existing tax system*. In case of sub-optimality, it does *not* provide a precise prescription on how to optimally set the tax rates. Given this and the fact that in reality, we observe progressive—rather than linear—labor tax systems, I will next solve numerically for the optimal mix of linear capital taxes and progressive labor income taxes, using the analogous method as in Section 6.

7.2. Quantification

I restrict the labor tax code to the "constant-rate-of-progressivity" family (6) of tax functions. For each of the three cases of $\sigma \in \{0.6, 1, \infty\}$, I search for the optimal triple (τ_k, τ_0, p), where τ_k is the linear capital income tax rate, τ_0 is the parameter that determines the level of labor taxes, and p is the rate of progressivity of the labor income tax code. In each case, I assume that the reform is unannounced ($t^a = 0$).

I consider the two most widely used social welfare objectives: the utilitarian objective, which assigns equal Pareto weights on all agents; and the Rawlsian objective, which maximizes welfare of the worst off individuals. The idea behind this choice is that while the Rawlsian objective is concerned with maximizing government revenue, the utilitarian objective will, at least to some extent, take into account the adverse effect of capital taxes on wages.

In line with Proposition 3 above, I find that—when the capital tax rate is simultaneously optimized—the optimal labor income tax code (τ_0, p) is independent of the capital–labor substitution elasticity σ. Thus, the technology-invariance property, which I have derived analytically for linear labor taxes locally around the optimal steady state, also holds when policy is initially suboptimal and labor taxes exhibit a constant rate of progressivity. Both welfare objectives prescribe much higher, but also less progressive, labor taxes than the status quo. The utilitarian optimum is very close to a flat tax of around 53%. With the Rawlsian objective, the optimal labor tax code is even regressive, with incomes below \$75K taxed at 75% and above, and marginal tax rates declining to 60% around income level \$500K and to 50% around income level \$1.8M. The Rawlsian planner wants to extract as many resources as possible. A more regressive system (a lower value of p) allows the planner to increase the level of taxation with lower additional distortions.[24] The tax system is not regressive for the

24. It is easy to show that the elasticity of labor supply with respect to $1-\tau_0$ is given by $\tilde{\varepsilon}_{l(\eta),1-\tau_0} = \gamma_l/1+p\gamma_l$.

TABLE 4. Optimal capital tax rates.

	Fixed Labor Tax Code		*Optimized Labor Tax Code*	
σ	Rawlsian	Utilitarian	Rawlsian	Utilitarian
∞	0.44	0.42	0.41	0.37
1.0	0.82	0.69	0.61	0.51
0.6	0.91	0.75	0.63	0.53

Notes. left panel: labor tax code fixed to status quo, $(\tau_0, p) = (0.02, 0.18)$; right panel: labor tax code simultaneously optimized: $(\tau_0, p) = (0.70, -0.16)$ for Rawlsian welfare objective, and $(\tau_0, p) = (0.52, 0.01)$ for utilitarian welfare objective; capital–labor substitution elasticities for constant price case ($\sigma = \infty$), Cobb–Douglas case ($\sigma = 1.0$), and baseline case ($\sigma = 0.6$).

utilitarian planner, who also values redistribution across households with positive labor income. See Online Appendix H.2 for details, including a visualization of the optimal tax codes.

In Table 4, I summarize the optimal capital tax rates for the two welfare objectives and the three values of σ. The left panel summarizes the optimal capital tax rates when the labor tax code is fixed at its current level. As discussed above, in that case, the optimal Rawlsian tax rates for the three values of σ are, respectively, 44%, 82%, and 91%. The optimal utilitarian tax rates are naturally lower: 42% in the case of constant prices, 69% in the Cobb–Douglas case, and 75% in the baseline. The more complementary the production factors, the more pronounced the depressing effect of capital taxes on wages. Consequently, the difference between the Rawlsian and the utilitarian optimum is higher for lower values of σ. While the Rawlsian optimum is only 2 percentage points above the utilitarian optimum in the case of constant prices ($\sigma = \infty$), the difference is 13 percentage points in the Cobb–Douglas case ($\sigma = 1$) and 16 percentage points in the baseline ($\sigma = 0.6$).

The right panel summarizes optimal capital tax rates when the labor tax code is jointly optimized. As discussed above, the optimal capital tax rates depend on σ. Specifically, for the three values of σ, the optimal Rawlsian tax rates are 41%, 61%, and 63%, respectively, while the utilitarian optima are 37%, 51%, and 53%, respectively. Each of these rates is lower than their respective counterpart in the left panel. With a higher level redistribution through labor taxes than in the status quo, the gains of additional redistribution through capital income taxes are lower. The reduction in the optimal capital tax rate is stronger for lower values of σ because stronger capital–labor complementarity increases the adverse effects of capital taxes on wages and thus on labor supply and labor income tax revenue.

Observe next that for $\sigma = 0.6$ and for $\sigma = 1$ the utilitarian optimum is 10 percentage points lower than the Rawlsian optimum, while the difference is only 4 percentage points when $\sigma = \infty$. Since households with substantial capital income are concentrated at the top of the income distribution and thus have low marginal utility of consumption, the utilitarian planner does not value their consumption by much more than the Rawlsian planner. Instead, the main reason why, with realistic values of σ, the utilitarian optima are substantially lower than the Rawlsian optima, is again the depressing effect on wages, which the Rawlsian planner is not concerned about as he only cares about households with zero income. Specifically, the property above, that the capital tax is independent of the distribution of labor income, was derived locally around the optimal steady state. It does not carry over to the present case, where the tax system is initially suboptimal. I illustrate this in more detail in Online Appendix H.2.

8. Conclusion

In this paper, I analytically characterize the welfare effects of capital tax changes in terms of estimable sufficient statistics. I apply my theoretical results to US income and wealth data and find that the majority of the US population, at least the bottom 60% of the income distribution, would benefit from significant capital tax increases relative to the status quo. Due to their depressing effect on wages, however, the desired capital tax rates across this part of the population are strongly declining in labor income. While the size of optimal capital tax rates depends on the welfare objective and whether the planner can simultaneously optimize labor taxes, standard welfare criteria prescribe substantially higher taxes on capital than the status quo in the USA.

An interesting extension, which I will leave for future research, would be to allow for heterogeneous labor skill types that exhibit different degrees of substitutability with capital, implying that capital tax hikes have an asymmetric impact on the wages of different workers. Since empirically high-skilled labor exhibits higher complementarity with capital than low-skilled labor (Krusell et al. 2000), this should further increase optimal capital tax rates for welfare objectives that assign high weight on households in the lower middle class, that is, households who finance their consumption mostly through wages—rather than government transfers—but who do not earn particularly much.

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Supplementary Data

Supplementary data are available at *JEEA* online.

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