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THE EFFECTS OF TAXES ON INNOVATION:
THEORY AND EMPIRICAL EVIDENCE

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ABSTRACT

Income taxes are typically set to raise revenues and redistribute income at the lowest possible efficiency costs, which result from the distortions in individual behaviors that taxes entail. Individuals can respond along many margins, such as labor supply, tax avoidance and evasion, and geographic mobility. But one margin that taxes may affect — innovation — is less frequently considered. Conceptually, taxes reduce the expected net returns to innovation inputs and can reduce innovation. Much like other margins of responses to taxes, this efficiency cost must be taken into account. Innovation is done by a relatively small number of people, but it is nevertheless likely to have widespread benefits. While inventors may have divergent motivations, such as social recognition or the love of discovery, they also face an economic reality. How strongly innovation responds to taxes is an empirical question that has been the subject of a growing body of recent work. In this paper, I study how to account for innovation when setting personal income and capital taxation. I distinguish between two cases: one in which the government can set a differentiated tax on inventors and one in which the government is constrained to set the same tax on all agents. I provide a model that flexibly accounts for the spillovers generated by innovation and the non-pecuniary benefits inventors receive from innovation and derive tax formulas expressed in terms of estimable sufficient statistics. The second part of the paper discusses the empirical evidence on the effects of taxes on the quantity, quality, and location of innovation, as well as tax avoidance and income shifting done through innovation.

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Abstract

Income taxes are typically set to raise revenues and redistribute income at the lowest possible efficiency costs, which result from the distortions in individual behaviors that taxes entail. Individuals can respond along many margins, such as labor supply, tax avoidance and evasion, and geographic mobility. But one margin that taxes may affect — innovation — is less frequently considered. Conceptually, taxes reduce the expected net returns to innovation inputs and can reduce innovation. Much like other margins of responses to taxes, this efficiency cost must be taken into account. Innovation is done by a relatively small number of people, but it is nevertheless likely to have widespread benefits. While inventors may have divergent motivations, such as social recognition or the love of discovery, they also face an economic reality. How strongly innovation responds to taxes is an empirical question that has been the subject of a growing body of recent work. In this paper, I study how to account for innovation when setting personal income and capital taxation. I distinguish between two cases: one in which the government can set a differentiated tax on inventors and one in which the government is constrained to set the same tax on all agents. I provide a model that flexibly accounts for the spillovers generated by innovation and the non-pecuniary benefits inventors receive from innovation and derive tax formulas expressed in terms of estimable sufficient statistics. The second part of the paper discusses the empirical evidence on the effects of taxes on the quantity, quality, and location of innovation, as well as tax avoidance and income shifting done through innovation.

1 Introduction

Income taxes are typically set to raise revenues and redistribute income at the lowest possible efficiency costs, which result from the distortions in individual behaviors that taxes entail. Individuals can respond along many margins, such as labor supply, tax avoidance and evasion, and geographic mobility. But one margin that taxes may affect — innovation — is less frequently considered. Conceptually, taxes reduce the expected net returns to innovation inputs and can reduce innovation. Much like other margins of responses to taxes, this efficiency cost must be taken into account.

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Innovation is done by a relatively small number of people, but it is nevertheless likely to have widespread benefits. First, it is generally considered to be the source of technological progress and the main driver of economic growth in the long-run (Aghion and Howitt (1992); Romer (1994), Jones (1995)). As Akcigit et al. (2022) show, U.S. states with the most innovations also witnessed the fastest growth between 1900 and 2000. Earlier work has found that innovation is also associated with social mobility (Aghion et al. (2019)) and well-being (Aghion et al. (2016)).

It may sometimes appear that innovation is a mysterious process conjured up by scientists who have little concern for taxation specifically or financial incentives in general. Path-breaking superstar inventors from history, such as Thomas Edison, Alexander Graham Bell, and Nikola Tesla, all strove for intellectual achievement, more so than rational economic agents who follow financial incentives. Yet, innovation is is also dependent on investments. While inventors may have divergent motivations, such as social recognition or the love of discovery, they also face an economic reality. How strongly innovation responds to taxes is an empirical question that has been the subject of a growing body of recent work.

In this paper, I study how to account for innovation when setting personal income and capital taxation. I distinguish between two cases: one in which the government can set a differentiated tax on inventors and one in which the government is constrained to set the same tax on all agents. I begin with a model that flexibly accounts for the spillovers generated by innovation and the non-pecuniary benefits inventors receive from innovation. Thanks to the framework of Saez and Stantcheva (2018), the problem can be turned into an equivalent static model, which allows for an easier derivation of formulas expressed in terms of estimable sufficient statistics.[1] The second part of the paper discusses the empirical evidence on the effects of taxes on the quantity, quality, and location of innovation, as well as tax avoidance and income shifting done through innovation.

2 Model

I start by presenting a simple way to think about optimal labor and capital income taxes when there is innovation that generates spillovers. Many of the assumptions can easily be relaxed and I will discuss some of these extensions below. There are two key elements in the model. The first is that innovation generates spillovers onto other agents in the economy (Akcigit et al. (2021), Bloom et al. (2013), Jones and Williams (1998)). The second is that innovators receive both pecuniary and non-pecuniary benefits from innovation (Putney and Putney (1962), Stuart and Ding (2006)).

2.1 Setting

Innovation spillovers. Innovators in the economy, indexed by i, exert effort and invest capital to produce innovation output. Innovation generates spillovers on other agents in the economy. To model these in a simple, reduced-form way, I assume that the labor and capital incomes of other agents are directly affected by innovation. Thus, if a socially valuable innovation is produced for which the private return to the innovator either in the form of capital or labor income is below its social return, other agents in the economy will benefit from higher incomes.

More precisely, if an inventor produces an innovation that yields an income value of y_i, they receive $z_i = \eta_i \cdot y_i$ with $0 < \eta_i$ as a private income. Hence, the reward to the

[1] The model does not cover targeted tax policies – such as R&D tax credits, local tax incentives for innovating firms, or subsidies for specific types of research, although these are discussed conceptually and in the empirical parts.

innovator can differ from their actual innovation value and the gap between the two is the spillover $\pi_i := (\eta_i - 1)y_i$. If $\eta_i > 1$, the innovator receives an additional rent above and beyond the social value of innovation and the spillover on others is negative. This could occur, for instance, if the monopoly power or business stealing effects are large relative to the net value of the innovation. In contrast, if $\eta_i < 1$, the innovator's reward is below the value of the innovation and they create a positive spillover on others. Similarly, for a given capital stock (wealth) $\tilde{k}_i$ and (heterogeneous) return on capital r_i, the innovator receives income $r_i k_i = \eta_i r_i \tilde{k}_i$. Denote the gap between the private and social returns on capital by $b_i := (\eta_i - 1)r_i \tilde{k}_i$. The inventor can influence the share of the spillover that goes to them by exerting effort or paying a cost. This will be called "rent-seeking" since it is about increasing one's private return without increasing the total social return.

The average spillover from innovation in the economy must come at the expense or benefit of some agents. Suppose that there are N agents in total in the economy. For simplicity, I assume that all agents bear the average spillover uniformly.[2] Thus, the government can fully tax or rebate back the average (negative or positive) spillover to everyone using a lump-sum tax or transfer.

Innovators face increasing and convex costs of producing innovation income and of capturing a higher share of their innovation output for themselves, $h_i(z_i)$ and $v_i(\eta)$. Furthermore, they also have a net utility from holding wealth (the capital stock k_i) equal to $a_i(k_i)$. This could be a net benefit, if innovators enjoy having wealth for prestige and social reasons or it could be negative if it takes a lot of effort to manage a larger stock of capital.

Innovators' non-pecuniary benefits. The justification for this formulation of "wealth-in-the-utility" comes from Saez and Stantcheva (2018). It essentially captures the fact that the benefits from capital income are not merely seen in the form of future consumption. This formulation is empirically justified. In practice, it is very difficult to rationalize the massive wealth holdings observed in the data through a consumption motive only: Bill Gates and Elon Musk probably do not plan to "consume" all of their wealth. Furthermore, models without wealth in the utility have difficulty reconciling the dispersion in labor income with the dispersion in capital and wealth holdings. It is likely that inequality in capital and wealth does not come from differences in labor income only, but also from differences in discount rates and returns, as well as heterogeneous values from holding wealth. Finally, there are also more technical reasons, since the neoclassical model of Chamley-Judd (Chamley (1986), Judd (1985)) has difficulty accommodating heterogeneity across respondents and generates infinite elasticities of capital income to the net-of-tax return in the steady state.

There are several ways to micro-found this wealth-in-the utility specification: social benefits and prestige from having wealth (or owning a successful, innovative business), a bequest motive, philanthropy and moral recognition, or "services" from having wealth. Importantly, these benefits go above and beyond the future consumption stream that wealth provides. Saez and Stantcheva (2018) provide an application of the wealth-in-utility model to entrepreneurship.

Dynamics and static equivalent. Time is continuous, infinite horizon, and each individual has a discount rate δ_i that captures pure discounting, as well as a (heterogeneous) probability of death. The per-period utility payoff of each innovator is thus:

$$u_i(c_i(t), k_i(t), z_i(t), \eta_i(t)) = c_i(t) + a_i(k_i(t)) - h_i(z_i(t)) - v_i(\eta_i(t)) \tag{1}$$

The individual index i can capture any arbitrary heterogeneity in the preferences for work and wealth, as well as in the discount rate δ_i. The discounted utility of i from an allocation

[2]This assumption can be relaxed; see Piketty et al. (2014).

$\{c_i(t), k_i(t), z_i(t), \eta_i(t)\}_{t\geq 0}$ is:[3]

$$V_i(\{c_i(t), k_i(t), z_i(t), \eta_i(t)\}_{t\geq 0}) = \delta_i \cdot \int_0^\infty [c_i(t) + a_i(k_i(t)) - h_i(z_i(t)) - v_i(\eta_i(t))]e^{-\delta_i t}dt. \quad (2)$$

At time 0, initial wealth of innovator i is k_i^{init}. For any given time-invariant tax schedule $T(z, rk)$ based on labor and capital incomes, the budget constraint of individual i is:

$$\frac{dk_i(t)}{dt} = r_i k_i(t) + z_i(t) - T(z_i(t), r_i k_i(t)) - c_i(t). \quad (3)$$

$T'_L(z, rk) \equiv \partial T(z, rk)/\partial \eta y$ denotes the marginal tax with respect to labor income and $T'_K(z, rk) \equiv \partial T(z, rk)/\partial rk$ denotes the marginal tax with respect to capital income.

The Hamiltonian of individual i at time t, with co-state $\lambda_i(t)$ on the budget constraint, is:

$$\begin{aligned} H_i(c_i(t), z_i(t), k_i(t), \eta_i(t), \lambda_i(t)) &= c_i(t) + a_i(k_i(t)) - h_i(z_i(t)) - v_i(\eta_i(t)) \\ &+ \lambda_i(t) \cdot [r_i k_i(t) + z_i(t) - T(z_i(t), r_i k_i(t)) - c_i(t)]. \end{aligned}$$

Taking the first order conditions, the choice $(c_i(t), k_i(t), z_i(t), \eta_i(t))$ is such that:

$$\lambda_i(t) = 1 \quad (4)$$

$$h'_i(z_i(t)) = (1 - T'_L(z_i(t), r_i k_i(t))) \quad (5)$$

$$a'_i(k_i(t)) = \delta_i - r[1 - T'_K(z_i(t), r_i k_i(t))] \quad (6)$$

$$v'_i(\eta_i(t)) = (1 - T'_K(z_i(t), r_i k_i(t)))r_i(t)\tilde{k}_i(t) + (1 - T'_L(z_i(t), r_i k_i(t)))y_i(t) \quad (7)$$

$$c_i(t) = rk_i(t) + z_i(t) - T(z_i(t), r_i k_i(t)) \quad (8)$$

In this model, $(c_i(t), k_i(t), z_i(t), \eta_i(t))$ jumps immediately to its steady-state value (c_i, k_i, z_i, η_i) characterized by $h'_i(z_i) = (1 - T'_L), a'_i(k_i) = \delta_i - r_i(1 - T'_K), v'_i(\eta_i) = (1 - T'_K)r_i\tilde{k}_i + (1 - T'_L)y_i, c_i = r_i k_i + \eta_i y_i - T(z_i, r_i k_i)$. This is achieved by a Dirac quantum jump in consumption at instant $t = 0$, so as to bring the wealth level from the initial k_i^{init} to the steady state value k_i. Because of this immediate adjustment and the lack of transition dynamics, we have that:

$$V_i(\{c_i(t), k_i(t), z_i(t), \eta_i(t)\}_{t\geq 0}) = [c_i + a_i(k_i) - h_i(z_i) - v_i(\eta_i)] + \delta_i \cdot (k_i^{init} - k_i),$$

where the last term $(k_i^{init} - k_i)$ represents the utility cost of going from wealth k_i^{init} to wealth k_i at instant 0, achieved by the quantum Dirac jump in consumption.

The dynamic model captured by (2) is therefore equivalent to a static model. Put differently, the optimal choice (c_i, k_i, z_i, η_i) from the dynamic problem also maximizes the static utility equivalent:[4]

$$U_i(c_i, k_i, z_i, \eta_i) = c_i + a_i(k_i) - h_i(z_i) - v_i(\eta_i) + \delta_i \cdot (k_i^{init} - k_i), \quad (9)$$

[3]The utility is normalized by the discount rate δ_i so that an extra unit of consumption in perpetuity increases utility by one unit uniformly across all individuals.

[4]The key assumption that drives this result is the linearity of utility in consumption, which precludes any consumption smoothing motive and, hence, avoids any transitional dynamics. While this assumption is not always appealing, Saez and Stantcheva (2018) provide both a justification of why it may be quite relevant when thinking of top income taxation, and show that it can be relaxed without affecting the core qualitative findings. Intuitively, the faster transitional dynamics are, i.e., the faster capital income responds to taxes, the closer the simpler model with linear utility comes to a full-fledged model with concave utility. Furthermore, Saez and Stantcheva (2018) argue that it is morally and politically unappealing for the government to exploit sluggish short-run responses, and that the long-run elasticity that applies after agents have made short-run adjustments is more relevant for sound fiscal policy.

subject to the static budget constraint $c_i = r_i k_i + z_i - T(z_i, r_i k_i)$.

In the rest of the paper, I will use the static equivalent U_i from equation (9), keeping in mind that it is equivalent to the original discounted utility V_i from equation (2).

2.2 Optimal Tax Formulas

Having specified the setting and converted the dynamic problem into an equivalent static one, we can consider the optimal tax rates in two cases. In the first case, the government is able to set a differentiated tax regime for innovators. In this case, the tax rates derived here apply specifically to innovators' capital and labor income. In the second case, the government is unable to distinguish between innovators and other agents. Thus, the tax rates apply to all agents in the economy, regardless of whether they engage in innovation or not.

In either case, the government sets the time invariant tax system $T(z, rk)$, subject to budget-balance, to maximize its social objective:

$$SWF = \int_i \omega_i \cdot U_i(c_i, k_i, z_i, \eta_i) di, \tag{10}$$

where $\omega_i \geq 0$ is the Pareto weight on individual i. We denote by $g_i = \omega_i \cdot U_{ic}$ the social marginal welfare weight on individual i. With utility linear in consumption, we have $g_i = \omega_i$. Without loss of generality, the weights can be normalized to sum to one over the population so that $\int_i \omega_i di = 1$.

2.2.1 Optimal capital and labor income taxation of inventors

I start by studying the optimal linear taxes at rates τ_K and τ_L on capital and labor income of inventors. Suppose that there is a mass one of innovators in the economy. Denote by $\bar{r}_i \equiv r_i \cdot (1 - \tau_K)$ the net-of-tax (social) return on capital. The individual maximizing choices are such that

$$a_i'(k_i) = \delta_i - \bar{r}_i \tag{11}$$

$$h_i'(z_i) = [1 - \tau_L] \tag{12}$$

$$v'(\eta_i) = (1 - \tau_L) z_i / \eta_i + \bar{r}_i k_i / \eta_i \tag{13}$$

so that k_i depends positively on $\bar{r}_i$, while z_i depends positively on $1 - \tau_L$. In addition, η_i depends positively on both net-of-tax rates. For budget-balance, tax revenues are rebated lump-sum.

Let $\pi^m(1 - \tau_L) := \int_{i=0}^1 \pi_i di$ be the average income spillover of innovators and $b^m(\bar{r}) := \int_{i=0}^1 b_i di$ the average capital return spillover, which are both functions of the net-of-tax rates. Let also $z^m(1 - \tau_L) = \int_{i=0}^1 z_i di$ be the aggregate labor income of inventors that depends on $1 - \tau_L$, and let $rk^m(\bar{r}) = \int_{i=0}^1 r_i k_i di$ be the aggregate capital income of innovators, which depends on $\bar{r}$. By the assumption that the spillover hits all agents in the economy uniformly and that the government can rebate or tax it lump-sum, the transfer to each individual (innovators and non-innovators) is $G = \tau_K \cdot rk^m(\bar{r}) + \tau_L \cdot z^m(1 - \tau_L) - [b^m + \pi^m]$.

The government chooses τ_K and τ_L to maximize social welfare SWF in (10), with $c_i = (1 - \tau_K) \cdot r_i k_i + (1 - \tau_L) \cdot z_i + \tau_K \cdot rk^m + \tau_L \cdot z^m - [b^m + \pi^m]$ and $U_i(c_i, k_i, z_i, \eta_i) = c_i + a_i(k_i) - h_i(z_i) - v_i(\eta_i) + \delta_i \cdot (k_i^{init} - k_i)$.[5]

[5]The government thus sets tax rates on innovators to maximize overall social welfare. This can be done in this setting without consideration of what other taxes are in place on (non-innovating) agents, because the only interaction for the purpose of taxes of the innovating and non-innovating agents is through the spillover, which will be taken into account in the tax revenues. Two critical assumptions for being able to look at the tax rates on

Let the elasticity of aggregate innovator capital income rk^m with respect to the net-of-tax capital rate $1-\tau_K$ be denoted by e_K and the elasticity of their aggregate labor income z^m with respect to the net of tax rate $1-\tau_L$ be e_L. Because there are no income effects, we have $e_L > 0$ and $e_K > 0$. Similarly, define $e_b = \frac{d\log(b^m)}{d\log(1-\tau_K)}$ to be the elasticity of the spillover with respect to the net-of-tax capital income tax rate and $e_\pi = \frac{d\log(\pi^m)}{d\log(1-\tau)}$ the elasticity of the spillover with respect to the net-of-tax labor income rate. Taking the derivative of the government objective with respect to the capital tax rate τ_K and applying the envelope theorem for the agents' choices yields:

$$\frac{dSWF}{d\tau_K} = rk^m \cdot \left[\int_i g_i \cdot \left(1 - \frac{r_i k_i}{rk^m}\right) di - \frac{\tau_K}{1-\tau_K} \cdot e_K + e_b \frac{b^m}{rk^m} \frac{1}{1-\tau_K}\right]$$

At the optimal τ_K, we have $dSWF/d\tau_K = 0$, leading to the following proposition.

Proposition 1 ***Optimal linear capital and labor income taxes on innovators.*** *The optimal linear capital tax on innovators is given by:*

$$\tau_K = \frac{1-\bar{g}_K + e_b(b^m/rk^m)}{1-\bar{g}_K + e_K} \quad \textit{with} \quad \bar{g}_K = \frac{\int_i g_i \cdot r_i k_i}{\int_i r_i k_i} \quad \textit{and} \quad e_K = \frac{(1-\tau_K)}{rk^m} \cdot \frac{drk^m}{d(1-\tau_K)} > 0. \tag{14}$$

The optimal labor tax on innovators, obtained through similar derivations, is given by:

$$\tau_L = \frac{1-\bar{g}_L + e_\pi(\pi^m/z^m)}{1-\bar{g}_L + e_L} \quad \textit{with} \quad \bar{g}_L = \frac{\int_i g_i \cdot z_i}{\int_i z_i} \quad \textit{and} \quad e_L = \frac{1-\tau_L}{z^m} \cdot \frac{dz^m}{d(1-\tau_L)} > 0. \tag{15}$$

The optimal capital tax rate on innovators. Consider first the optimal capital tax. It depends on the social preferences embodied in the social welfare weights g_i. These can take many forms and lead to interesting tax results. In a nutshell, as long as wealth is concentrated among individuals with lower social marginal welfare weights (such that g_i is decreasing in k_i), we have $\bar{g}_K < 1$ and, absent the spillover, the optimal capital tax is strictly positive. The higher the social welfare weight put on inventors relative to other agents and the wealthier inventors overall are relative to the average person in the economy, the lower the optimal capital tax rate is. On the other hand, if inventors have very unequal levels of capital income and society puts more weight on the entrepreneurs who start out with little capital, the optimal capital tax rate will be higher in order to redistribute towards the lower-income innovators (and lower-income agents overall).

The optimal capital tax rate also depends on the elasticity of capital income to taxes, which captures the efficiency costs of taxing capital. The higher this elasticity, the lower the optimal capital tax rate should be. Imagine for instance that capital is highly mobile or easy to hide from tax authorities (as we will review in the empirical sections below). Then it may be difficult, from a feasibility standpoint, to heavily tax the capital of innovators.

Finally, the optimal tax rate depends on the strength and responsiveness of the innovation spillover to taxes. This term is a Pigouvian correction for the externality induced by the capital investment of inventors. The higher the positive spillover on other agents (i.e., the less the innovator's private return relative to the social return), the lower the capital tax rate should be set. Furthermore, if the (positive) spillover is also highly elastic to taxes, then the tax rate should be lower too. In fact, if the spillover on others is very large and positive, that optimal tax could be negative (i.e., a capital subsidy).

innovators separately from the tax rates on other agents are that the government can rebate or tax the spillover lump-sum and that agents do not have income effects. Other agents' spillovers on innovators do not interact with the choice of the optimal tax rates on innovators either.

Contrary to the often-cited Chamley-Judd result, the optimal capital tax is not generically zero. It will only be zero in a few specific cases. The first is if $\bar{g}_K = 1$ and $e_b = 0$, which means that there are no redistributive concerns for capital income or capital income is perfectly equally distributed (i.e., g_i is uncorrelated with k_i) and that there are either no spillovers ($b^m = 0$) or that the spillovers are inelastic to taxes ($e_b = 0$). A second case is if capital is infinitely elastic to taxes, i.e., if $e_K = \infty$.

The optimal labor tax rate on innovators. The labor income tax rate is driven by the same considerations as the capital tax rate: the social welfare weight on inventors relative to the weight on non-inventors, the elasticity of inventor's labor income to taxes, and the strength and elasticity of the spillover from inventors' effort. Imagine that inventors only care about the thrill of the discovery and about adding to society. This would imply that their elasticity to taxes is close to zero. On the contrary, one may imagine that there is nothing special about the payoff of inventors relative to many other high-skilled professions, and that their labor supply elasticity is thus comparable to that of non-inventors.

The revenue maximizing tax rates on innovation are the ones that arise when zero weight is placed on innovators per se ($\bar{g}_K = 0$ and $\bar{g}_L = 0$) and are given by:

$$\tau_K^R = \frac{1 + e_b(b^m/rk^m)}{1 + e_K} \quad \textit{and} \quad \tau_L^R = \frac{1 + e_\pi(\pi^m/z^m)}{1 + e_L}. \tag{16}$$

Generalization. These formulas, expressed in terms of sufficient statistics are more general and hold beyond the specific model presented. In particular, individual utilities can have arbitrary heterogeneity. However, it is important to bear in mind that all elasticities can depend on the tax system. Thus, evaluating large tax reforms or finding the optimum that is very different from the status quo (at which elasticities are empirically estimated) would require a way of estimating elasticities structurally.

The model only considered intensive-margin responses on the choice of labor effort, capital investments, and rent-appropriation of inventors. Individual inventors can also respond to taxes by switching between the corporate and non-corporate sector, by changing occupation altogether, by hiding their income, or by moving to another country. The observed macro-level elasticities in the formulas will be the combination of all these micro-level responses. For a discussion of the possible channels through which general tax policy and targeted incentives (such as R&D tax credits) can shape innovation, see Akcigit and Stantcheva (2020).

The general rule on how to think about these margins of responses is as follows: tax base externalities (say, to another taxed occupation or the non-corporate sector) would lead to additional terms in the formulas above (see Piketty et al. (2014)). Migration responses or outright evasion (i.e., any shift of income towards tax bases that are *de facto* taxed at a zero rate) would appear in the elasticities, but would not change the actual formulas.

2.2.2 Optimal top labor tax and capital tax rates

Suppose now that the government cannot distinguish between innovators and non-innovators. In this section, I derive the optimal labor and capital income tax rates that apply above a given threshold (i.e., the "top" tax rates). This is without loss of generality, as it nests the case of the optimal overall linear capital and labor income tax rates, by simply setting the top tax thresholds to zero.

Suppose that there is a mass one of top earners who have labor income higher than $\bar{z}$ and capital income higher than $\bar{k}$. Among these top earners, there are innovators as well as other professions. These top earners may all generate different levels of positive, negative, or zero spillovers. When considering the top tax rates, the government has to take into account the composition of top earners and their average spillovers and responses to taxes.

The government sets linear tax rates τ_L and τ_K in the top tax brackets. Redefine our variables introduced above to signify averages across top earners. For instance, let $z^m := \int_{i:z_i \geq \bar{z}} z_i di$ be the average labor income of top bracket taxpayers and $\pi(1-\tau) := \int_{i:z_i \geq \bar{z}} \pi_i di$ their average spillover, which are both functions of the top net-of-tax rate. Similarly, redefine the elasticities introduced above to be elasticities with respect to the net-of-tax top rates of the variables pertaining to top earners. Furthermore, introduce the Pareto parameters $a_L = z^m/(z^m - \bar{z})$ and $a_K = rk^m/(rk^m - \bar{rk^m})$ that capture the thickness of the top tail of the distributions. Suppose again that the average spillover generated in the top bracket comes at the equal expense of all agents in the economy. Finally, let $\bar{g}_K^{top} = \frac{\int_{i:k_i \leq \bar{k}} r_i k_i g_i}{\int_i g_i r k^m}$ be the capital income-weighted average marginal social welfare weight on top earners relative to the average weight in the economy, and define $\bar{g}_L^{top} = \frac{\int_{i:z_i \leq \bar{z}} z_i g_i}{\int_i g_i z^m}$ similarly.

Similar derivations as above yield to the optimal linear tax rates in the top brackets above a given capital income and labor income threshold.

Proposition 2 ***Optimal top capital and labor income tax rates.*** *The optimal capital and labor income tax rates on agents (inventors and non-inventors) earning income above thresholds $\bar{z}$ and $\bar{rk}$ are given by:*

$$\tau_K^{top} = \frac{1 - \bar{g}_K^{top} + a_K \cdot b^m/(rk^m) \cdot e_b}{1 - \bar{g}_K^{top} + a_K^{top} \cdot e_K^{top}} \tag{17}$$

$$\tau_L^{top} = \frac{1 - \bar{g}_L^{top} + a_L \cdot \pi^m/z^m \cdot e_\pi}{1 - \bar{g}_L^{top} + a_L \cdot e_L^{top}} \tag{18}$$

Note that because capital income is so concentrated, a fully non-linear tax system would converge quickly to the top linear capital tax rate and this rate has wide applicability. This is not true to the same extent with the labor income tax.

Discussion. The broad factors shaping top capital and labor income taxes are similar to the ones affecting the optimal tax rate on innovators. The most important distinction is that, as these rates apply to all top earners, regardless of their occupation, the parameters reflect the composition of top earners.

For instance, imagine that society believes that inventors are "deserving" top earners because they have positive spillovers on others, but that other high-earning professions are not as deserving. The higher the share of inventors among top earners, and the higher the social welfare weight on all top earners will be, leading to lower optimal top tax rates. Similarly, if inventors have large positive externalities, the more represented they are among top earners and the lower top tax rates should be. Interestingly, voters' perceptions of the composition of top earners are not always in line with reality, as shown in Stantcheva (2020) by using large-scale survey evidence. Respondents tend to underestimate the share of managers, executives, doctors, and finance professionals in the top 1%: for instance, the perceived share of executives and managers (10%) is three times lower than the actual share (31%). On the contrary, respondents tend to overestimate the share of scientists (5% perceived to 2% actual), and that of media, arts, and sports professionals (9% perceived to 2% actual). Importantly, respondents tend to overestimate the share of entrepreneurs (10% perceived to 2% actual).

In practice, if tax rates cannot be differentiated by inventors and non-inventors, given that very small share of inventors among top earners, spillovers would have to be very large and positive in order to warrant a lower top tax rate on all top earners. This is the consequence of having a blunt tool that cannot be differentiated.

2.2.3 The Choice of Instruments

The above formulas give the optimal tax rates on either inventors or all top earners, taking into account the effects of taxation on innovation. They do not explicitly try to foster innovation. If the goal is to stimulate innovation, general taxation policy may not be the best tool as it is not targeted at all. A specific incentive on inventors (section 2.2.1) may be a less blunt tool.

Regarding targeted policies, the first issue is whether subsidies on inputs (such as R&D tax credits or subsidies) are more efficient than lower tax rates (which can be viewed as subsidies on the output). Akcigit et al. (2021) show that the answer depends on what information the government has. Their analysis is for innovative firms, but would apply similarly to individual innovators.

If the government cannot observe firms' research productivity and is trying to screen good firms from bad ones, uniform tax or subsidy rates are not optimal. Instead, it is efficiency-enhancing to have R&D subsidy rates that are decreasing in the amount of R&D, and profit taxes that are declining in profits. This finding is driven by the high complementary of R&D investments and firms' research productivities in the data: higher productivity firms generate disproportionately more innovation from a given R&D investment. Since higher productivity firms have a comparative advantage at innovation, it is better to incentivize R&D investments less for lower productivity firms. Otherwise, it becomes excessively attractive for high productivity firms to pretend to be low productivity ones. A higher incentive for R&D for higher research productivity firms is provided with a lower marginal profit tax at higher profit levels and a lower R&D marginal subsidy rate at higher R&D levels. Intuitively, higher productivity firms are able to generate more profits from the same research investments, and an allocation with a lower marginal profit tax and a lower marginal R&D subsidy is more attractive to high-productivity firms than to low productivity firms.

Furthermore, it turns out that the most important feature is the nonlinearity in the R&D subsidy: making the profit tax linear (and lower) only generates a small welfare loss. The intuition is that a constant profit tax that is more generous than it should be for low profit firms, and at about the right level for high profit firms, does reasonably well since the loss from being too generous to low profit firms is small (because taxing their low profit levels does not yield much revenues to start with). Thus, linear corporate income taxes–common in practice– can be very close to optimal for innovating firms if combined with the right nonlinear R&D subsidy.

The second important issue with targeted incentives for innovation is whether there are supply-side constraints. For instance, any increase in tax incentives may end up pushing up costs of R&D (e.g., wages of researchers) if the supply of inventors is limited (Van Reenen, 2021; Akcigit et al., 2020). Akcigit et al. (2020) show that R&D incentives' strength can be multiplied when coupled with higher education policy targeting credit-constrained talented people. In highly unequal societies, human capital policies are likely to be more effective than R&D incentives. Furthermore, these two types of policies act at different horizons, with human capital policies affecting longer-run outcomes more strongly. Overall, Van Reenen (2021) and Akcigit et al. (2020) suggest that human capital policies may have large returns, and they may be important complements to any tax incentives for innovation.

I now turn to the empirical evidence on the effects of taxes on innovation. To my knowledge, there is no direct estimate of the elasticities of *income* specific to inventors that we would need to calibrate the formulas in Section 2.2.1. However, I will point to all the pieces of information that we do have, which all contribute to the elasticity of inventors' taxable incomes. The formulas in Section 2.2.2 require estimates of taxable income and rent elasticities for all top earners. For taxable income elasticities, see Saez et al. (2012). For estimates of rent elasticities among executives and CEOs, see Piketty et al. (2014).

3 Historical Evidence

I start with historical, long-term evidence. Historical data is an invaluable resource in the study of major questions, such as the effects of taxes on growth, as it permits leveraging the abundant tax variation that has happened over time.

Akcigit et al. (2022) provide long-run historical evidence on the impact of both personal and corporate income taxation at both the individual inventor and the state levels over the twentieth century. They leverage four historical datasets: a panel dataset based on inventors from digitized patent data since 1920, which lets them track inventors and their innovations, citations, place of residence, technological fields, and firms (if any) to which they assign their patents; a new dataset on historical state-level corporate income taxes; a database on personal income tax rates from Bakija (2006); and additional innovation-related outcomes, such as patent values from Kogan et al. (2017), and state-level value added, manufacturing share, average weekly earnings, establishment size, and total payroll from Allen (2004) and Haines et al. (2010).

As in the model above, the macro-level responses (here, at the state level) are an aggregate of the micro-level responses (of each individual inventor), although the authors consider a wider range of possible adjustment margins to taxes, such as cross-state mobility and reallocation between the corporate and non-corporate sectors. They also distinguish between inventors who work for companies ("corporate inventors") and individual "garage" inventors (non-corporate) operating outside the boundaries of firms that may react differently, based on different incentives and motivations.

Using several distinct and complementary strategies to identify the impact of taxes on innovation, the authors find that at the macro state level, personal and corporate income taxes have significant negative effects on the quantity of innovation, as captured by the number of patents, and on the number of inventors working in the state. The elasticities for personal net-of-tax rates are between 0.8 to 1.8.[6] The quality of innovation, as proxied by the forward citations received by patents, is similarly responsive, and hence, average quality is not meaningfully affected by taxation. The authors also find that there is a shift in the composition of patents from non-corporate to corporate if the corporate tax rate declines.

At the individual inventor level, personal income taxes significantly negatively impact inventors' likelihood of having any patent and the number of their patents. There is, again, only a small effect on the quality of the average patent, but a larger effect on "home-run" patents with many citations. The elasticity of patents to the personal income net-of-tax rate is around 0.8, and the elasticity of citations is around 1.[7]

The authors also find significant mobility responses to taxes. The elasticity to the net-of-tax personal income tax rate of the number of inventors residing in a state is between 0.10 and 0.15 for inventors from that state and 1.0 to 1.5 for out-of-state inventors. On average, the mobility elasticity is 0.34. Non-corporate inventors are elastic to both corporate and personal income taxes when choosing in which state to live and work. More precisely, their elasticity with respect to net-of-tax personal rates is 0.72 or 0.6 with respect to the net-of-tax corporate rate. The authors estimate that the large macro-level elasticities to personal net-of-tax rates come from both mobility and innovation output responses. Overall, the elasticities of inventors to taxes are comparable, but somewhat larger, than those of other high-skilled agents. The macro-level elasticities of patents are also consistent with other macro estimates for employment or output.

We can relate these estimates to the optimal tax on inventors formula in Section 2.2.1. To calibrate these formulas, we would need to convert the elasticities of innovation into

[6] The corresponding elasticities for the corporate tax rate are between 1.3 to 2.8.

[7] Interestingly, corporate income taxes only affect the innovation output of corporate inventors, but not that of non-corporate inventors. The elasticity of patents of corporate inventors with respect to the net-of-tax corporate rate is 0.49 and that of their citations is 0.46.

elasticities of income of inventors, using estimates of how inventor income changes with innovation quantity and quality.

4 Quantity and Quality of Innovation

In modern-day data, there is abundant evidence on the effect of tax incentives on innovation. Most studies focus on the effects of direct tax breaks for innovation, e.g., R&D tax credits, with very few papers considering the indirect effects of general corporate taxation. On the latter topic, Schwellnus and Arnold (2008) report a negative effect of corporate taxation on productivity and investment for firms in manufacturing and services across many countries. Atanassov and Liu (2020) study US publicly traded firms in the period 1998–2006 and find that corporate tax cuts lead to higher innovation output, as measured by the number of patents (quantity) and citations per patent (a measure of patent quality), especially for firms that are financially constrained, have smaller collateral assets and weaker corporate governance, and more frequently use tax avoidance strategies. In a study of European MNEs, Karkinsky and Riedel (2012) estimate that for the period 1995–2003, a 1 percentage point increase in the tax rate on royalty income leads to a decrease of -3.5% to -3.8% in the number of patents in a given country.

On R&D-specific incentives, most of the key papers find significant effects. Reviewing the US innovation tax policy in the 1980s, Hall (1993) finds an elasticity of R&D spending to R&D tax credits of around one. These findings appear to hold across OECD countries overall, for which Hall and Van Reenen (2000) find that a dollar in tax credit for R&D stimulates a dollar of additional R&D. Bloom et al. (2002) study the effectiveness of R&D tax credits in OECD countries from 1979 through 1994. They find that reducing the cost of R&D by 10% leads to a 1% increase in R&D in the short run and an almost 10% increase in the long run.

Moreover, Romero-Jordán et al. (2014) use EESE survey data for 1995-2015 to study the impact of two Spanish tax incentives for R&D. They estimate that tax credits exert a positive and significant effect on private R&D investments, but only for large firms. Public grants act very differently: They contribute to R&D investment by alleviating firms' financial constraints through a signalling effect, which in turn simplifies access to external debt for firms that obtain the grants.

Dechezleprêtre et al. (2016) exploit a change in the UK R&D tax regime in 2008 which raised the size threshold for a more generous "SME" tax regime. The authors find that this led to an economically and statistically significant increase in R&D investment and patenting. Furthermore, they find no evidence of a fall in the quality of patents, which supports the idea that R&D tax credits do not merely cause relabeling of existing spending. Concerning effectiveness, they estimate that the policy stimulated £1.7 of R&D for every £1 of subsidy and that in its absence, R&D would be around 10% lower over the period 2006–2011. Their findings are supported by Guceri and Liu (2019), who estimate an elasticity of -1.6 and £1.3 of R&D for every pound of forgone corporate tax revenue in the UK for the same period.

Chen et al. (2021) leverage China's InnoCom program, which provided large tax cuts for companies investing in R&D over a predetermined threshold. They find that this tax incentive significantly increased R&D investment over the period 2008–2011. However, they are also able to show that expense relabeling reduces the effective R&D investment by one fourth.

Several papers focus on innovation tax policy across US states. Wilson (2009) examines R&D tax incentives across US states between 1981 and 2004 and estimates that, on average, a 1 percentage point increase in a state's effective R&D tax credit rate leads to a long-run increase in R&D spending of 3%–4% inside the state and a decrease of 3%–4% in R&D spending outside of it. A possible interpretation of this high elasticity is that there is ample cross-state R&D and business shifting. Rao (2016) studies the impact of the US federal R&D tax credit over the period 1981–1991 and estimates that a 10% reduction in the user cost of R&D leads to a 19.8% short-run increase in the research intensity-ratio, measured as the ratio of R&D spending to sales. It is specifically R&D deemed as qualified for the federal tax credit that increases the most. Long-run estimates suggest that the average firm faces adjustment costs when scaling up R&D and increases spending over time. Most of the increase in R&D spending seems to be accounted for by additional spending on wages and research supplies.

5 Mobility of Inventors

Taxes can also influence the location choices of innovators. Moretti and Wilson (2017) focus on a select group of scientists' responses to changes in personal and business tax differentials across states. They uncover large, stable, and precisely estimated effects of personal and corporate taxes on the scientists' migration patterns. The long-run elasticity of mobility relative to taxes is 1.8 for personal income taxes, 1.9 for state corporate income tax, and -1.7 for the investment tax credit. While there are many other factors that matter for innovative individuals and innovative companies decide to locate, there are enough firms and workers on the margin that state taxes matter. Moretti and Wilson (2014) examine the effect of R&D tax credits on the number of these so-called "star inventors" in the biotech sector. They estimate that a 10% decline in the user cost of capital induced by an increase in R&D tax incentives raises the number of star scientists by 22%. An important question about differential R&D tax credits across U.S. states is whether the total effect is zero-sum at the federal level. This same question was asked above regarding state personal and corporate income taxes by Akcigit et al. (2022), who found that the corporate tax was more likely to generate cross-state business shifting without actual gains in innovation at the federal level.

The impact of top tax rates on the international mobility of inventors is studied by Akcigit et al. (2016). The authors also focus on what they term "superstar inventors," those with the most and highest-cited patents since 1977. By using panel data on inventors from the US and European Patent Offices, the authors are able to track inventors across countries and over time. Superstar inventors' location choices are significantly affected by top tax rates: the elasticity to the net-of-tax rate of the number of domestic superstar inventors is around 0.03, while that of foreign superstar inventors is around 1.

It is important to bear in mind that these are the partial effects of taxation, holding all else constant. But tax revenues are used to fund amenities that may be valuable too. Akcigit et al. (2016) find that inventors are less elastic to taxes if they work in a field that is particularly successful in a given location. Akcigit et al. (2022) also find that elasticities to taxes are dampened when there are "agglomeration effects," i.e., when there are more people working in the same field in a given location.

6 Income Shifting and Tax Avoidance through Innovation

Individuals and firms engaging in innovation can respond to taxes also by misreporting their innovative activity and the resulting income. Furthermore, innovation may in itself be a channel of tax avoidance and tax sheltering of income.

Blair-Stanek (2015) considers different ways in which a US company can engage in tax avoidance practices. First, IP rights could be sold to the subsidiary at a price that is below market ("transfer pricing"), either bundled with a "service" related to the IP or on their own. In this way, the true value of the patent could be hidden from tax authorities. The reason that tax-induced manipulation of transfer prices is possible lies in the difficulty of finding comparable IP transactions between unrelated parties to accurately price these transactions.

Alternatively, a company can license patent rights to a subsidiary in a tax haven. By doing so, future profits will be subjected to the low tax rate of the country of the subsidiary, whereas the legal ownership remains in the United States. US legal ownership can be attractive if it offers greater protection for IP rights. In the context of the US taxation, this practice may often be more advantageous than the outright sale of IP to the subsidiary for an artificially low price. Lastly, another possibility consists of a Cost Sharing Agreement (CSA), where the US company will provide the IP for an artificially low price while the subsidiary will contribute to the funding for the IP improvement. This kind of agreement will guarantee that profits coming from outside the US will not be subject to US taxation. Multinational companies are more likely to engage in CSAs if their domestic intangible assets are more valuable and if the nature of the IP development makes it easy to understate the fair market value of the IP (De Simone and Sansing, 2019).

In a meta-analysis of international corporate tax avoidance, Beer et al. (2020) confirm that the separation between the country of ownership and the country where R&D is conducted is an important way for firms to reduce their tax burdens. Dischinger and Riedel (2011) also argue that the relocation choice of IP is driven by the incentive to save taxes through the relocation of highly profitable intangible assets to low-tax countries and confirm this on European MNEs over the period 1995–2005.

Cheng et al. (2021) find a positive correlation between patents and tax planning using Compustat and USPTO data for 1987–2012. Firms with more domestic patents shift more income outside the US as compared to firms with fewer patents, suggesting that income shifting through patents may be a significant way to avoid tax obligations. Gao et al. (2016) use the same data for the period 1987–2010 and find a strong connection between patenting activity and tax avoidance. Furthermore, the magnitude of tax avoidance is more pronounced for innovative firms headquartered in states offering R&D tax credits.

Dudar and Voget (2016) calculate the tax elasticity of patent and trademark location choices for the period 1996–2012. The elasticity of patent location ranges between -0.05 and -0.85 and the elasticity of trademark locations falls between -0.77 and -3.14. Thus, this study not only supports the hypothesis of IP driving tax erosion, it also highlights that differences between various types of intangible assets should not be neglected. Trademarks are more mobile within a company group than patents are.

Skeie et al. (2017) estimate the effect of taxes on multinational companies' choice of patent location. They distinguish between non-shifted patents, for which the country of the applicant is the same as the country of the inventor, and shifted patents, for which these countries differ. Using the OECD-PATSTAT and OECD-Orbis database for the period 2004–2010, they show that a 5 percentage point cut in the preferential tax rate on patent income correlates with a 6% increase in patent applications. However, higher-tax rate countries that have stricter anti-avoidance rules also have a greater volume of non-shifted patents, suggesting that fewer patents may be shifted out of them than out of similar countries with less strict rules. Similar conclusions are reached by Baumann et al. (2020). They combine PATSTAT and Amadeus data for the period 1990–2006 and find that, even though the general tendency for firms is to match high-value patents to low-tax countries, this inclination is lower if controlled foreign corporation (CFC) rules are enforced.

7 Patent Boxes: Preferential Tax Treatment of Innovation

An important tax reduction policy for innovation consists of so-called "patent boxes." They offer a reduced tax rate — either through a separate tax schedule or special deductions —

on income arising from licensing or using intellectual property (Merrill, 2016). Differing from other existing tax incentives for R&D, IP boxes provide a back-end tax reduction for successful innovations. Hall (2020) emphasizes that they not only target the activities receiving a reward through the patent, they also promote patent assertion and provide an additional incentive to renew patents that might otherwise be abandoned. At the same time, the author recognizes that they may also encourage "patent trolling" by protecting the income of firms specializing in patent litigation and enforcement. Patent boxes can affect the full chain of decision-making of firms, as do direct subsidies of innovation inputs. Thus, Brannon and Hanlon (2015) find that profitable survey respondents in the biotech and pharmaceutical industries would allocate more income, R&D, and manufacturing to the United States if an innovation box system were to be adopted.

Patent boxes have been argued to encourage tax shifting by firms since the profits from intangible assets and IP are difficult to disentangle from other profits. They may affect the location of profits without truly affecting the location of R&D activities. The extent to which such shifting actually happens depends on the conditions set in the patent box.

First, there are some restrictions to patent boxes, following the directives of the so-called "nexus approach" promoted by the OECD (Faulhaber, 2017), whose rationale can be summarized as follows: Countries are only permitted to provide benefits under patent boxes as long as there is a nexus between certain qualifying R&D expenditures and the income receiving advantageous tax treatment. In particular, the latter must be commensurate to the amount of R&D undertaken by the taxpayer receiving benefits. Even though this rule does not eliminate the income-shifting problem, it significantly constraints it.

A further solution that has been implemented to mitigate tax avoidance is the "addback statute." Suppose a company has a patent held by one of its subsidiaries in a tax haven. With the enactment of this statute, the company must add back the royalty from the patent to the taxable income in the company's state. Clearly, any enforcement policy that de facto increases the tax rate of companies comes with a cost. Li et al. (2021) study the effects of the addback statute and find a statistically and economically significant decrease of 5% in the number of citations received by patents and of 4.77 percentage points for the number of patents filed by relevant firms after three years. Furthermore, Martins (2018) contends that implementation of the nexus approach in 2016 to the Portuguese IP box significantly increased tax and accounting complexity.

Mohnen et al. (2017) analyze the Dutch innovation box policy, which requires that the tax advantage must be linked to the firm's own and, therefore, local R&D activity. Using difference-in-difference and matching evidence, they find that firms that take advantage of this policy instrument tend to have higher R&D activities, but the extra R&D generated is not sufficient to justify the tax losses. Nevertheless, their estimate is not far off from those obtained for tax credits of different kinds in several countries.

IP box regimes can also differ in how they define IP income. Some regimes apply to income derived from patents that already existed prior to the box and acquired after its implementation, while others only apply to newly created IP. Boxes can also apply to all revenues generated from IP or, instead, to income (revenues minus costs). Therefore, when studying firms' responses, such specificities matter. Ohrn (2016) merges data on IP Box Regimes from Evers et al. (2015) and international payment flows and R&D from the U.S. Bureau of Economic Analysis (BEA) and finds that R&D spending only responds to IP boxes that apply to newly developed R&D or to revenues rather than income. Furthermore, US payments to foreign affiliates for the use of IP rise only in innovation box regimes that apply to income derived from existing or acquired R&D.

Finally, Faulhaber (2017) suggests that the introduction of patent box regimes exerts competitive — and not necessarily efficient — pressure on neighbouring countries. They cite the case of Spain, which modified its patent box regulation following the implementation of patent boxes in other countries, such as Malta and Cyprus. In the latter, the patent boxes were advantageous and did not require that the R&D takes place in their jurisdictions.

8 Conclusion

This paper derived optimal formulas for the taxes on labor and capital incomes, taking into account the spillovers from innovation. Inventors can engage in productive effort and saving, but also in rent-seeking by trying to capture a larger share of the total social surplus from innovation. The formulas derived are in terms of sufficient statistics that can, in principle, be estimated in the data.

Ultimately, if the goal is to foster innovation, general taxes, such as income and capital taxes that cannot be differentiated for innovators and non-innovators, are blunt tools. The spirit of this paper is rather to show that the efficiency costs from reduced innovation may need be taken into account when setting taxes and to pinpoint the factors on which the magnitudes of these costs depend. For instance, if innovators make up a significant share of top earners or if spillovers from innovation are very large, optimal tax rates may be meaningfully different when innovation is taken into account than when it is not. If the goal is to stimulate innovation, direct research incentives allow for better targeting (see Akcigit et al. (2021)).

The second part of the paper reviewed some of the evidence to date on the effects of taxes on innovation. In recent years, significant progress has been made on these issues thanks to the creative use of patent and inventor data, historical data, and administrative data. Future work could shed more light on the elasticities of innovators' incomes to taxation and on the specific ways in which they adjust to tax changes.

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