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RESEARCH ARTICLE

Optimal labor income taxation with the dividend effect

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Abstract
The unequal distribution of dividends implies the unequal distribution of the profit share of workers' product of labor. In a Mirrleesian framework when dividends cannot be expropriated, we show that a progressive distribution of dividends creates a positive dividend effect on labor income taxes. Our numerical simulations show the dividend effect to be approximately four percentage points. We analyze the dividend effect under different market structures and its interplay with other forms of taxation.

Keywords Income tax policy · Inequality · Dividends · Market structure

JEL Classification H21 · H23 · D43

1 Introduction

In this paper, we present a new factor that has important implications for the design of labor income tax policy. A non-zero profit share of national income (Barkai 2020; De Loecker et al. 2020) implies that workers' earnings are not equal to their product of labor with the difference distributed in dividends according to workers' ownership of firm shares. Given that the top 10% of workers receive nearly all dividends (Saez and Zucman 2016), it means that a part of poorer workers' product of labor is apportioned by richer workers through dividends, but not *vice versa*. We demonstrate that in the presence of equity concerns, the unequal distribution of dividends calls for more

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redistribution and, thus, higher income tax rates even at the expense of production efficiency.

We extend the standard Mirrlees (1971) framework with an additional consumption good. This good is produced with a decreasing returns to scale technology, and its price and resultant profits from its production are determined by the market equilibrium condition. We assume profits are progressively distributed in the form of dividends, with more productive workers receiving a larger share. The public authority designs the optimal labor income tax schedule assuming that dividends cannot be fully expropriated.[1]

Our analysis shows that in the presence of equity concerns, the unequal distribution of dividends implies a binding market equilibrium condition in the optimum. The public authority finds it optimal to suppress production, as otherwise less productive and poorer workers can be disadvantaged because they obtain a lower share of profits or, put differently, retain a smaller share of their product of labor. From a different perspective and more intuitively, the public authority, motivated by equity concerns, uses the price level as an additional redistributing tool. A price decrease benefits less productive workers, as they can afford more consumption, but hurts more productive workers, as they lose in profits. To control for the price level, the public authority imposes higher marginal income taxes to decrease labor supply and earnings and, consequently, demand for products and their prices.

We assess the effect of unequal distribution of dividends—or, for brevity, "the dividend effect"—on labor income tax policy, using numerical simulations based on the U.S. housing market. The housing market is suitable for illustrating our theoretical results because the supply of housing is not perfectly elastic, housing costs constitute the largest share of household expenditures, and the housing sector is also associated with large profits. To estimate the size of the dividend effect, we compare the optimal income tax schedule with the Mirrleesian tax schedule that arises in the self-confirming policy equilibrium (Rothschild and Scheuer 2013). Using the calibrated model of the housing market based on Miles and Sefton (2021), we find that the dividend effect increases optimal marginal income taxes by approximately four percentage points on average.

The results presented above are derived for the case of the competitive market. Recent studies report increases in the degree of market concentration with resultant increases in price markups and the profit share of national income (Barkai 2020; De Loecker et al. 2020). Hence, we also consider an oligopolistic model with various degree of market power. In our model, an increase in market power has two effects. On the one hand, it strengthens the dividend effect due to increased profits, but on the other hand it leads to under-production in the equilibrium. To offset under-production, the public authority finds it optimal to stimulate labor supply and income and, thus, aggregate demand by decreasing marginal income taxes. Hence, this non-competitive effect works in the direction opposite to that of the dividend effect. We resort to numerical simulations to assess the interplay between the two effects. For medium and high degrees of equity concerns, we show that as the market structure varies,

[1] For a similar constraint, see Ábrahám et al. (2016). The problem of dividend taxation is cardinally different from labor income taxation; for a recent exposition see, e.g., Koethenbuerger and Stimmelmayr (2022).

changes in these two effects almost cancel each other out. Specifically, an increase in the dividend effect due to market power is offset by the emergence of the non-competitive effect, which leaves the optimal income taxation schedule unchanged across market specifications.

Next, we investigate how commodity and profit taxation influences the dividend effect on income taxation. For both competitive and oligopolistic markets, we show that the introduction of commodity taxation changes the role of the dividend effect for income tax policy but does not eliminate it. In our model, alongside income taxation, commodity taxation plays a distinct redistributive role for extracting producers' surplus to the benefit of poorer workers. At the same time, if dividends are equally distributed among workers, the introduction of commodity taxation is optimal only for the case of oligopolistic markets, imposed to correct for production inefficiencies (see also Myles 1996). In an extension of our model with firm entry and exit, we show that profit taxation, like commodity taxation, changes the role of the dividend effect for income tax policy but again does not fully eliminate it.

The analysis of this paper is related to the seminal production efficiency theorem of Diamond and Mirrlees (1971), which says that optimal income tax policy entails efficient production. Scheuer and Werning (2016) provide an insightful connection between this theorem and the income taxation model of Mirrlees (1971). The production efficiency result holds only in the absence of profits or when profits are fully taxed, which has been commonly assumed in the literature except in a few papers. For instance, Stiglitz and Dasgupta (1971) show that production efficiency may not be desirable when the maximum profit tax rate is limited. Dasgupta and Stiglitz (1972) show that the government might not wish to tax away all profits in the economy with non-identical consumers when lump-sum taxes are not allowed and that production efficiency remains desirable if the government can set different profit taxes for different producers. For more discussion, see Atkinson and Stiglitz (1976, 2015), Mirrlees (1972), Munk (1978, 1980), and Naito (1999). The contribution our paper is to demonstrate that not only the existence of profits, but also their distribution matters for the production efficiency result.

Our paper also contributes to an emerging literature on the role of market structures for tax policy. In the framework of monopolistic competition, Gürer (2022) studies the role of profits and their taxation for income tax policy. Tarasov and Zubrickas (2023) take into account the quantity and variety distortions arising from income tax policy. Kaplow (2021) studies the influence of market power and firm markups on income taxation. da Costa and Maestri (2019) study optimal income taxation in non-competitive labor markets. They assume that firms' ownership is spread uniformly across agents, thus abstracting from the effect of firm profit distribution on optimal income taxation, which is the main object of our analysis. Our paper also relates to the work of Zubrickas (2022, 2023) concerned with the effect of income inequality on labor supply and the role of this effect for income tax policy. Similarly to our paper, Ábrahám et al. (2016) study the role of frictions of capital income taxation for labor income tax policy.

The remainder of the paper is organized as follows. In Sect. 2, we introduce the model of labor income taxation. We solve the model and numerically assess the dividend effect on the optimal labor income tax schedule for the case of competitive markets in Sect. 3. In Sect. 4, we present our analysis for the case of oligopolistic markets. We study extensions in Sect. 5 and Sect. 6 concludes the analysis of the paper. The omitted proofs and additional extensions are provided in Appendix A.

2 Model

In this section, we present the details of our model, formulate the market clearing conditions, and state the social welfare maximization problem of the public authority.

2.1 Supply side

There are good X and numeraire good G with their prices denoted by p and p_g, respectively. Each good is produced in a separate industry with labor as the only production input. In each industry, agents can earn the same wage for effective labor hours supplied that we normalize to $w = 1$.

In the industry producing numeraire good G there are many firms, each of which has a homogeneous of degree one production technology $F_g(L) \equiv L$. Hence, the total output of numeraire good G equals the total amount of labor supplied in the industry. Any level of equilibrium labor demand L_g^* is then consistent with the profit maximization condition that has $p_g = w = 1$ and zero profits.

In the industry producing good X there are $M \geq 1$ identical firms, each of which has a production technology with decreasing returns to scale F_x. In the case of competitive markets, the firms treat price p as fixed and maximize their profits as $\max_L \{pF_x(L) - wL\}$. To ensure that the profit maximization problem has a well-defined interior solution, we assume that production function F_x is differentiable, strictly concave and satisfies the Inada conditions. The solution to the profit maximization problem for a given price p determines the aggregate equilibrium labor demand $L_x^*(p)$ found from the first order condition

$$pF_x'(L_x^*/M) = w = 1.$$

We can then denote the aggregate supply of good X as $S(p) = MF_x(L_x^*(p)/M)$ and total profits as $\Pi(p) = pS(p) - L_x^*(p)$.

We will also consider a more general model of oligopolistic competition in Sect. 4. To streamline the exposition, we postpone its details for later. Its analysis is, however, similar to the analysis of the competitive market model except for different supply function $S(p)$ and profit function $\Pi(p)$ that both depend on the form of market competition.

2.2 Demand side

On the demand side of the economy, there is a continuum of agents indexed by productivity type n and distributed over interval $[\underline{n}, \overline{n}]$ according to distribution $F(n)$ with the probability density function $f(n) > 0$. Agent n's labor income is given by $n\ell$, where ℓ is the amount of labor exerted. Following Saez et al. (2012) the labor cost is represented by a power function $c(\ell) = \ell^{\zeta+1/\zeta}\zeta/(\zeta+1)$ for some $\zeta > 0$.

Labor income $n\ell$ is taxed according to schedule $T(n\ell)$ with disposable labor income given by $y = n\ell - T(n\ell)$. Positive profits in industry X are distributed among agents in the form of dividends with agent n receiving share $\xi(n) \geq 0$, where $\int \xi(n) f(n)dn = 1$. The distribution of dividend shares is determined outside the model. Motivated by empirical evidence, we consider a progressive distribution of dividends when agents with higher labor income possess a larger share of dividends $\xi'(n) \geq 0$ (see Saez and Zucman 2016). Altogether, an agent's disposable income consists of after-tax labor income and dividends, which we express as $\tilde{y}(n) = y(n) + \xi(n)\Pi(p)$.

Agents spend their income on numeraire good G and good X. Their locally non-satiated consumption preferences are summarized by continuous utility function $u(x, g)$, where (x, g) are the consumed amounts of good X and numeraire good G, respectively. The solution to the individual utility maximization problem determines indirect utility function $v(p, \tilde{y}) = \max_{x,g}\{u(x, g) \; s.t. \; px + g \leq \tilde{y}\}$ so that an agent's net utility can be expressed as

$$U(p, \tilde{y}, \ell) = v(p, \tilde{y}) - c(\ell). \tag{1}$$

When dividends are unequally distributed, indirect utility $v(p, \tilde{y})$ can violate the single-crossing property (Mirrlees 1976). To avoid this problem, we assume that the indirect utility is linear in income (e.g., arising from a Cobb-Douglas utility) and, thus, can be expressed as $v(p, \tilde{y}) = a(p)\tilde{y}$, where $a(p)$ is some strictly decreasing function. Note that $a(p) \equiv v_y(p, \tilde{y})$, and we use both expressions interchangeably. The assumption of linear indirect utility also implies that there are no wealth effects on labor supply and the labor supply elasticity is constant and equal to $\zeta = c_\ell/(\ell c_{\ell\ell})$. Appendix A.2 shows how our analysis changes in the case of a non-linear indirect utility.

The Walrasian demand function for good X can be determined using Roy's identity as $x(p, \tilde{y}) = -v_p(p, \tilde{y})/v_y(p, \tilde{y})$. The linearity of indirect utility implies that good X is normal $x_y > 0$ and we require its demand satisfy the law of demand $x_p < 0$.[2] The demand for numeraire good G is then determined by the residual income $\tilde{y} - px(p, \tilde{y})$.

2.3 Market clearance

The solution to the individual utility maximization problem determines labor supply $\ell^*(n, p)$ and consumption bundle $(x^*(n, p), g^*(n, p))$ for each agent with productivity n. In turn, these values determine aggregate labor supply and consumer demand for both goods:

$$L^*(p) = \int n\ell^*(n, p) f(n)dn, \qquad X^*(p) = \int x^*(n, p) f(n)dn,$$
$$G^*(p) = \int g^*(n, p) f(n)dn.$$

[2] In particular, from Roy's identity we have $x(p, \tilde{y}) = d(p)\tilde{y}$, where $d(p) \equiv -a'(p)/a(p)$ is a decreasing function, for which to hold function $a(p)$ needs to be log-convex.

The government collects taxes to cover its expenditures $\int T(n\ell^*(n,p))f(n)dn \geq R$. This resource constraint must be binding in the optimal income taxation policy. We assume that the government spends money for the numeraire good only. In the economy, three market clearing conditions must hold:

$$S(p) = X^*(p), \qquad L_g^*(p) = G^*(p) + R, \qquad L^*(p) = L_x^*(p) + L_g^*(p).$$

Recall that any level of labor demand $L_g^*(p)$ is consistent with profit maximization behavior in industry G. We now show that if we set $L_g^*(p) = G^*(p) + R$, then the first market clearing condition implies the third one. To establish this, note that the budget constraint in the individual utility maximization problem implies

$$pX^*(p) + G^*(p) = \int y(n)f(n)dn + \Pi(p) = L^*(p) - R + \Pi(p).$$

Using $\Pi(p) = pS(p) - L_x^*(p)$, $S(p) = X^*(p)$, and $L_g^*(p) = G^*(p) + R$ we obtain

$$L^*(p) = pX^*(p) + G^*(p) + R - \Pi = L_x^*(p) + L_g^*(p).$$

Overall, the only market clearance condition that the public authority needs to account for in its tax policy design problem is the market clearance condition for good X.

2.4 Social welfare and taxation

The social welfare function is given by

$$W = \int U(p, \tilde{y}(n), \ell(n))\psi(n)f(n)dn, \tag{2}$$

where $\psi(n)$ is the welfare weight of agent n and satisfies $\int \psi(n)f(n)dn = 1$. Assuming that the public authority has equity concerns, we take function $\psi(n)$ to be decreasing.[3] In our main analysis, we assume that the public authority uses only labor income tax $T(n\ell)$ to maximize the social welfare and is not permitted to tax dividends or firm profits due to reasons outside the model. Otherwise, the full appropriation of dividends or firm profits is optimal (unless firm entry and exit are endogenous; see Sect. 5.2).

The public authority maximizes social welfare W subject to three constraints. The first one is the resource constraint

$$\int T(n\ell(n))f(n)dn = \int (n\ell(n) - \tilde{y}(n) + \xi(n)\Pi(p))\, f(n)dn \geq R. \tag{3}$$

[3] To model equity concerns we follow the approach typically used in the microeconomics literature: agent utility is linear in consumption and equity concerns are captured by welfare weights decreasing in consumption. Alternatively, as typically considered in the macroeconomics literature, we could model equity concerns by assuming that the public authority maximizes average expected agent utility, which is strictly concave in consumption (e.g., Conesa et al. 2009).

The second one is the incentive compatibility constraint

$$U(p, y(n) + \xi(n)\Pi(p), \ell(n)) \geq U(p, y(m) + \xi(n)\Pi(p), m\ell(m)/n) \tag{4}$$

for all $n, m \in [\underline{n}, \overline{n}]$, which ensures that an agent with productivity n does not seek the labor income of an agent with productivity m. The third one is the market clearance condition that determines price p

$$S(p) = \int x(p, \tilde{y}(n)) f(n) dn. \tag{5}$$

Before we study the public authority's maximization problem, let us simplify incentive compatibility constraints (4). Denote agents' utility from revealing their productivity type truthfully as

$$u(n) \equiv U(p, y(n) + \xi(n)\Pi(p), \ell(n)) = v(p, y(n) + \xi(n)\Pi(p)) - c(\ell(n)).$$

If the truthful revelation is optimal, then

$$u(n) = \max_{m} \; v(p, y(m) + \xi(n)\Pi(p)) - c(m\ell(m)/n). \tag{6}$$

We obtain from the envelope theorem the following first-order condition

$$u'(n) = c_\ell \ell(n)/n + a(p)\xi'(n)\Pi(p). \tag{7}$$

In comparison with the model of Mirrlees (1971), we find a more stringent incentive compatibility condition because of profits. Hence, with only labor income taxes at its disposal the public authority's objective of achieving more equitable outcomes, i.e., having smaller $u'(n)$, is further hindered by unequally distributed profits $\xi'(n)\Pi(p)$. The second-order condition ensuring optimal truth-telling is that labor income schedule $y(n)$ is non-decreasing as in the case without profits (Mirrlees 1976). This is due to the linearity of indirect utility, which implies that dividends do not affect the incentive constraint (for contrast, see the analysis of the non-linear case in Appendix A.2).

We characterize the public authority's problem as finding the combination of price p, income schedule $\tilde{y}(n)$, and labor supply schedule $\ell(n)$ that maximizes[4]

$$\max_{p,\, \tilde{y}(n),\, \ell(n)} \int (v(p, \tilde{y}(n)) - c(\ell(n)))\psi(n) f(n) dn \quad \text{subject to (3), (5), and (7).}$$

It is convenient to change maximization variables $\{p, \tilde{y}(n), \ell(n)\}$ to $\{p, u(n), \ell(n)\}$ where utility is defined by $u(n) = a(p)\tilde{y}(n) - c(\ell(n))$. From the latter expression,

[4] Note that we maximize over p because the price is implicitly determined by equation (5). If we had an explicit price function, we could introduce it into indirect utility and maximize over $(\tilde{y}(n), \ell(n))$ alone.

we can invert disposable income $\tilde{y}$ and express it as $\tilde{y} = r(p, u, \ell) \equiv \frac{u+c(\ell)}{a(p)}$. The maximization problem can then be written as

$$\max_{p,u(n),\ell(n)} \int u(n)\psi(n)f(n)dn \tag{8}$$

$$s.t.$$

$$\int [n\ell(n) - r(p, u(n), \ell(n)) + \xi(n)\Pi(p)]f(n)dn \geq R, \tag{9}$$

$$S(p) - \int x(p, r(p, u(n), \ell(n)))f(n)dn = 0, \tag{10}$$

$$u'(n) - a(p)\xi'(n)\Pi(p) - c_\ell \ell(n)/n = 0. \tag{11}$$

Note that the above problem assumes that dividends cannot be directly taxed. If unconstrained dividend or profit taxation is allowed, the public authority would impose 100% tax rate. The problem of optimal labor income taxation would then reduce to the standard one analyzed by Mirrlees (1971). In Sect. 5.2, we argue that 100% tax rate on profits or dividends is implausible. We present an extension of our main model where firms can enter and exit the market to show that the optimal profit tax must be below the full extraction rate. The influence of firm profits and its unequal distribution in the economy on the optimal income tax policy is the subject of our main analysis that we present in the next sections. In Sect. 3, we provide a solution to the above maximization problem and estimate the change in the optimal marginal tax schedule against the benchmark of the standard Mirrleesian model. In Sect. 4, we show how the same maximization problem can be applied to analyze the optimal income tax policy with oligopolistic markets.

3 Competitive market

We analyze here the public authority's problem introduced in the previous section. We first derive the expression for the optimal income tax schedule in the presence of firm dividends. Then, we estimate numerically the size of the dividend effect on optimal income taxes.

3.1 Optimal income taxation

Before presenting the solution to optimization problem (8) – (11), we introduce some further notation. Let λ be the multiplier corresponding to budget constraint (9), $\varepsilon = S'(p)p/S$ be the price elasticity of supply, and $\varepsilon_h = H'(p)p/H$ be the price elasticity of aggregate Hicksian demand $H(p)$. Denoting the total utility due to profits as $U_\Pi(p) = a(p)\Pi(p)$, we write its price elasticity as $\varepsilon_{U_\Pi} = U'_\Pi(p)\, p/U_\Pi(p)$. Cumulative weights are given by $\Psi(n) = \int_{\underline{n}}^{n} \psi(m)f(m)dm$, the covariance between welfare weights and profit shares by $\text{Cov}(\xi, \psi) = \int(\xi(n) - 1)(\psi(n) - 1)f(n)dn$, and the profit share of total income by $s_\Pi = \Pi(p)/\int \tilde{y}(n)f(n)dn$.

Theorem 1 *In competitive markets, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) - \mathrm{Cov}(\xi, \psi)\frac{a(p)}{\lambda}\frac{\delta_\Pi\,\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h}, \tag{12}$$

where

$$A(n) = \frac{1+\zeta}{\zeta}\frac{1-F(n)}{nf(n)}, \qquad B(n) = \frac{a(p)}{\lambda}\frac{\Psi(n)-F(n)}{1-F(n)}.$$

To analyze optimal marginal income tax formula (12), it is useful to establish the benchmark of comparison – the marginal income tax schedule that arises in the self-confirming policy equilibrium (Rothschild and Scheuer 2013). In this equilibrium, the public authority falsely takes the levels of profits and prices as exogenously given and imposes the standard Mirrleesian tax schedule as determined by $A(n)B(n)$. At the same time, the levels of profits and prices are set to satisfy the market equilibrium condition, which would then falsely confirm the optimality of the self-confirming policy equilibrium tax schedule. As we assume a constant elasticity of labor supply, $\zeta = const$, term $A(n)$ does not depend on endogenous parameters. If the public authority believes that income taxation does not influence prices and profits, it sets $a(p)/\lambda = 1$ (see equation (A.1) in Appendix A.1). Hence, in the benchmark case term $B(n)$ does not depend on endogenous parameters either. We refer to this benchmark case as the "standard case."

Compared to the optimal income tax formula in the standard case, tax formula (12) contains an additional term, which we refer to as the "dividend effect." This term does not depend on ability n and changes ratio $\frac{t}{1-t}$ equally for all levels of income. Noting that elasticities $\varepsilon_{U_\Pi} \geq 0$, $\varepsilon > 0$, $\varepsilon_h \leq 0$, and multiplier $\lambda > 0$, we find that the dividend effect has the opposite sign of covariance $\mathrm{Cov}(\xi, \psi)$.[5] If the public authority has equity concerns ($\psi(n)$ is decreasing) and if agents with higher productivities possess a larger share of profits ($\xi(n)$ is increasing), the covariance is negative and, accordingly, the dividend effect becomes positive. The price level p and the marginal value of public funds λ are still endogenous in the optimum, entering the formula through ratio $a(p)/\lambda$. This ratio is equal to one in the standard case and greater than one in the presence of dividends (see equation (A.1) in Appendix A.1). Overall, we obtain higher optimal marginal income taxes in the economy with a progressive distribution of dividends compared to the standard case.

For intuition, let us consider a change in the tax policy where a small interval of labor incomes are subject to a small marginal tax increase. Using the terminology of Saez (2001), this policy change results in mechanical and substitution effects, captured by

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[5] To obtain $\varepsilon_{U_\Pi} \geq 0$, notice that $U'_\Pi(p) = a'(p)\Pi(p) + a(p)\Pi'(p) \geq 0$, which follows from

$$\Pi'(p) = S(p) = \int x(p, \tilde{y}) f(n)dn = -\frac{a'(p)}{a(p)}\int \tilde{y}(n) f(n)dn \geq -\frac{a'(p)}{a(p)} pS(p) \geq -\frac{a'(p)}{a(p)}\Pi(p).$$

Above, the first equation follows from $\Pi(p) = \int_0^p S(\tilde{p})d\tilde{p}$, the second from the market equilibrium condition, and the third from Roy's identity; the first inequality follows from the agents' individual budget constraints, and the second one from $pS(p) \geq \int_0^p S(\tilde{p})d\tilde{p}$.

standard term $A(n)B(n)$.[6] In our model, an additional effect emerges. The substitution effect changes total income in the economy, which also leads to a change in price p proportional to $1/(\varepsilon - \varepsilon_h)$. This, in turn, creates a pecuniary externality, captured by the price elasticity of utility of profits ε_{U_Π} weighted by the profit share of total income $\jmath_\Pi$. Pecuniary externalities, however, play a role only if profits are unevenly distributed among agents. With the uniform distribution of profits, there is no need for correcting pecuniary externalities, which is a known result in the general equilibrium theory.

From a different perspective, let us consider how a small decrease in price p influences agents' welfare. The price change benefits low-productivity and poorer agents because they can afford more consumption. At the same time, it hurts high-productivity and wealthier agents whose utility is influenced mostly by the resultant decrease in dividend income. Therefore, the price level can serve as an additional instrument to redistribute welfare from high-productivity to low-productivity agents. As the public authority cannot enforce the price level directly, it uses additional marginal income tax to lower labor supply and, in turn, total income and market demand leading to a lower equilibrium price p.[7] Hence, the public authority uses the equilibrium price level through income tax policy to achieve its redistributive objectives.

We find that when restricted to labor income tax policy the public authority cannot generally achieve any constrained Pareto optimal outcome. We demonstrate the robustness of this finding when tax policy restrictions are alleviated. In Sect. 5.2, we consider optimal profit taxation in an extension of our model where firms have idiosyncratic fixed costs and can freely enter and exit the market. We show that the optimal profit tax is below 100% and, as a consequence of positive after-tax profits, the dividend effect continues playing a role for tax policy.[8] In Sect. 5.3, we show that with tax policy based on total income (labor income plus dividends), the market equilibrium condition remains binding and, thus, the dividend effect remains part of the optimal income tax policy.

We now consider an extension of our model to allow for foreign ownership of firm shares and profits. This extension is motivated by empirical evidence that a substantial share of equities is held by foreigners in many countries: the share of foreign equity holdings amounts to 13.6% in the U.S. (U.S. Treasury 2017) and, on average, 38% in European countries (Davydoff et al. 2013). We assume that foreigners have a zero weight in the welfare function and spend their share of profits on the numeraire good only, which leaves the market equilibrium condition intact. Letting $\int \xi(n) f(n) dn =$

[6] Saez (2001) also distinguishes the income effect, which is absent here due to the assumption of linear indirect utility.

[7] A decrease in labor supply can also potentially influence the supply curve for good X. This channel is absent in our setting because any change in labor supply is fully absorbed by the sector producing the numeraire good (see Sect. 2.3).

[8] Similarly, we can also argue that the presence of the dividend effect remains robust to the extension of tax policy with dividend taxation as 100% dividend taxation cannot be optimal. This could be established by a dynamic variation of our model, where firms require agents' investments at the first stage and agents receive returns from their investments in the form of dividends at the second stage. The extension of total income taxation examined in Sect. 5.3 can be viewed as a special case of dividend taxation, where for tax purposes the public authority does not discriminate between dividend and labor income. We leave the analysis of optimal dividend taxation outside the scope of this paper. See Chetty and Saez (2005, 2010) or Koethenbuerger and Stimmelmayr (2022) for more on dividend taxation.

$\Xi < 1$ and denoting the price elasticity of profits by $\varepsilon_\Pi = \Pi'(p)\, p/\Pi$, we obtain the following extension of our main result.

Theorem 2 *In competitive markets with foreign ownership, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) + \left((1-\Xi)\frac{\varepsilon_\Pi}{\lambda} - \mathrm{Cov}(\xi, \psi)\frac{a(p)}{\lambda}\right)\frac{\delta_\Pi\, \varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h}, \tag{13}$$

with $A(n)$ and $B(n)$ as in Theorem 1, and $\mathrm{Cov}(\xi, \psi) = \int(\psi(n)-1)(\xi(n)-\Xi)f(n)dn$.

With foreign ownership, we obtain a welfare effect of dividend distribution that goes beyond equity concerns. In the optimal tax formula in (13), the new term contains an additional component, $(1-\Xi)\varepsilon_\Pi/\lambda > 0$, that takes into account the production inefficiency related to foreign ownership. Specifically, the change in the labor supply stemming from a tax policy change now contributes to profits that belong in part to foreigners or, put differently, a share of workers' labor product is lost from the social welfare perspective. This implies that the competitive market equilibrium results in production inefficiency (over-production) and welfare losses, to correct for which the public authority imposes an additional income tax to suppress labor supply and thereby bring the competitive market equilibrium outcome closer to the Pareto frontier.

Lastly, we analyze the optimal tax rate for top income earners using the asymptotic tax rate formula derived by Saez (2001). He argues that the upper tail of the U.S. income distribution is well approximated by a Pareto distribution, which also relates to the upper tail of the productivity distribution. In particular, the Pareto parameter $\overline{a}$ of the income distribution corresponds to the Pareto parameter $\overline{a}(1+\zeta)$ of the productivity distribution for high-productivity agents (see p. 218 in Saez 2001). We denote the asymptotic ratio of social marginal utility to the marginal value of public funds for the top income earners as $\overline{g} = \frac{a(p)}{\lambda}\lim_{n\to\overline{n}}\frac{1-\Psi(n)}{1-F(n)}$. Then, in Theorem 1, term $A(n)$ reduces to $1/(\zeta\overline{a})$, $B(n)$ approaches $1-\overline{g}$, and the top tax rate can be written as

$$t^{top} = \frac{1-\overline{g}+\mathrm{DE}\,\zeta\overline{a}}{\zeta\overline{a}+1-\overline{g}+\mathrm{DE}\,\zeta\overline{a}}, \tag{14}$$

where $\mathrm{DE} = -\mathrm{Cov}(\xi, \psi)\frac{a(p)}{\lambda}\frac{\delta_\Pi\, \varepsilon_{U_\Pi}}{\varepsilon-\varepsilon_h}$ is the dividend effect of the optimal income tax policy. We observe that the optimal tax rate for top earners in a competitive economy with unequal distribution of dividends coincides with the standard one when the public authority puts a smaller social weight on top earners, that is, with ratio $\overline{g}$ reduced to $\overline{g} - \mathrm{DE}\,\zeta\overline{a}$. We also note that, unlike in the standard case, the tax rate for top earners remains strictly positive even if the upper tail of productivity distribution becomes thinner, that is, $\overline{a} \to \infty$.

3.2 Numerical simulations

In this section, we numerically estimate the size of the dividend effect on optimal income taxes. As the model's market for good X we take the U.S. housing market because it is not a perfectly competitive market, while housing is the largest consumption item accounting for about 25% of total household expenditure.[9] In our simulations, we use the housing model estimated by Miles and Sefton (2021), which features the constant elasticity of substitution (CES) utility function

$$u(x_o, x) = \left(e x_o^{1-1/\rho} + (1-e) x^{1-1/\rho}\right)^{\frac{\rho}{\rho-1}}, \tag{15}$$

where x denotes the consumption of housing, x_o denotes the consumption of other goods with their utility weight (relative to housing consumption) given by e, and ρ is the elasticity of substitution between housing and other goods. Drawing on the numerical estimation results of Miles and Sefton (2021), we take $e = 0.85$ and $\rho = 0.6$. In our simulations, this utility specification results in the absolute value of the price elasticity of housing demand of 0.7 and the unit income elasticity of housing demand, which are consistent with elasticity values estimated in the literature (e.g., Albouy et al. 2016).

We model the supply of housing using the constant price elasticity function $S(p) = sp^{\varepsilon}$, where s is a scale parameter and ε is the price elasticity of supply. The estimates of the price elasticity of supply ε vary significantly across countries and even across cities. In particular, Saiz (2010) shows that ε highly depends on geographical and regulatory constraints within U.S. metropolitan areas. Drawing on his estimates for the average U.S. metropolitan area, we take $\varepsilon = 1.75$. We calibrate scale parameter s to match the average share of housing expenditure of 25%, which renders $s = 18.5$. In Appendix A.3, we present the simulation results for inelastic supply $\varepsilon = 0.01$ that better describe housing supply in large U.S. coastal cities (e.g., Boston and San-Francisco) and in countries with a rigid housing planning system (e.g., the UK). We also present results for the price elasticity of supply $\varepsilon = 3$, which is closer to the estimates obtained by Epple and Romer (1991).

Following Saez et al. (2012), we consider the cost function $c(\ell) = \ell^4/4$ with a constant labor supply elasticity of $\zeta = 1/3$. We take the distribution of agent productivities from Mankiw et al. (2009), who proxy it with the distribution of hourly wages in the U.S. Specifically, this distribution consists of several parts. There is a 5% mass of agents with $n = 0$ which matches the percentage of total employees on public disability insurance in the U.S. The productivities of agents between the 5^{th} and 95^{th} percentiles follow the lognormal distribution with mean 2.757 and standard deviation 0.5611. The remaining top 5% levels of productivity follow the Pareto distribution with the shape parameter of 2 obtained from $\overline{a}(1+\zeta)$, where $\overline{a} = 1.5$ is the shape parameter of the Pareto tail of the U.S. income distribution (Saez 2001; Diamond and Saez 2011). We use a standard kernel smoother to merge the log-normal and Pareto parts of the distribution. We set public expenditures at $R = 0$ and use welfare weights $\Psi(n) = 1 - (1 - F(n))^{\imath}$, where $\imath$ is a parameter for redistribution. If $\imath = 1$, the public authority has no equity concerns, and if $\imath > 1$, public authority has equity concerns.

[9] See Consumer Expenditure Survey, 2017, Table 1203. *Income Before Taxes: Annual Expenditure Means, Shares, Standard Errors, and Coefficients of Variation* and Bureau of Economic Analysis, 2016, Table 2.3.5U. *Personal Consumption Expenditures by Major Type of Product and by Major Function.* Similar numbers are also observed in the European Union, for which Eurostat (2016) reports that housing accounts for 24.4% of household expenditure, on average.

Table 1 The Distribution of Dividends in the U.S., 2012 . Source: Saez and Zucman (2016, Table B23)

Distribution of dividends (in %) held by income percentiles:

Bottom 90%	Top 10%	Top 5%	Top 1%	Top 0.5%	Top 0.1%	Top 0.01%
0.4%	99.6%	95.9%	76.0%	67.1%	50.0%	31.2%

The table shows the percentage shares of dividends held by the U.S. population

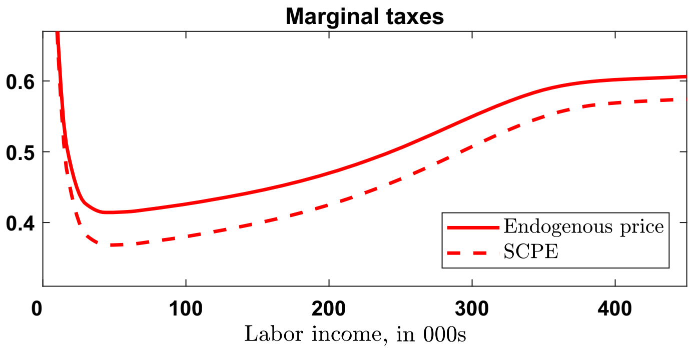

Fig. 1 Optimal income taxation with profits distributed as dividends. *Note:* The solid line presents the optimal marginal income tax rates for an economy with a competitive market and unequal distribution of dividends among agents (see Theorem 2). The dashed line presents the Mirrleesian tax rates in the self-confirming policy equilibrium for the same economy

Following Rothschild and Scheuer (2013), we consider a moderate level of equity concerns given by $\mathfrak{r} = 1.3$.

Drawing on the domestic share of equity holdings in the U.S. (see U.S. Treasury 2017), we set the share of profits that is held by agents in our model at $\Xi = 0.85$. This share should be considered as an upper bound for developed countries, because in Europe, on average, only 62% of equity shares are held by domestic investors; for instance, it is 50% in the UK, 60% in France, and 70% in Germany (Davydoff et al. 2013).[10] We approximate the distribution of dividends by the empirical distribution of dividends across U.S. households in 2012, as presented in Table 1.[11] Lastly, we slightly depart from our theoretical analysis and impose a flat profit tax at 15% (which corresponds to the U.S. dividend tax for most income levels). The proceeds from this tax go to financing government expenditures and are included in the resource constraint.

Figure 1 presents our main simulation results. The solid line shows the optimal marginal income tax schedule with the dividend effect as determined by Theorem 2.

[10] We ignore the presence of the domestic holdings of foreign shares and the influence of domestic taxation policy on foreign countries. This could be a restrictive assumption if international coordination on taxation policy is possible.

[11] The cumulative distribution of dividends is approximated by the functional form $\Xi(n) = \exp(\widehat{b}(-\log F(n))^{\frac{1}{2}})$, where $F(n)$ is the cumulative distribution of agent productivities and $\widehat{b} = -18.1$, which yields the coefficient of determination equal to $R^2 = 0.95$. We take function $\xi(n)$ as the derivative of $\Xi(n)$ under normalization $\int \xi(n) f(n) dn = 0.85$.

The dashed line corresponds to the marginal income tax schedule in the self-confirming policy equilibrium (SCPE). We note that the estimated optimal income tax schedules are of a shape similar to those obtained by previous studies. The high tax rates at the bottom correspond to the phasing-out of the guaranteed income level (Saez 2001; Mankiw et al. 2009). Due to the Pareto tail, at top income levels the optimal marginal income taxes flatten out and are equal to approximately 62% with the dividend effect accounted for and 59% in the SCPE case. Similarly to Mankiw et al. (2009), the minimum of the optimal marginal income tax schedule is achieved at a labor income of around \$50, 000. Our numerical simulations show that the dividend effect adds on average 4.2 percentage points to optimal marginal income tax rates. In Appendix A.3, we show that the size of this effect is robust to other assumptions about the distribution of productivities and also estimate its size for different values of the price elasticity of housing supply.

Lastly, the overall increase in marginal income tax can be attributed to two factors: the presence of progressive distribution of dividends $\xi'(n) > 0$, which leads to a tax correction due to equity concerns, and the presence of foreign ownership $\Xi < 1$, which leads to a tax correction based on efficiency concerns. If we reestimate our model without foreign ownership, that is, by setting $\Xi = 1$, we obtain that the optimal marginal income tax increases on average by four percentage points relative to the SCPE outcome, which implies a rather small effect of foreign ownership for the U.S. case.

4 Oligopolistic competition

In this section, we analyze the public authority's problem of social welfare maximization for the case of oligopolistic market for good X. We consider $M \geq 1$ identical firms with each firm i having a convex cost function $K(X_i)$ of producing X_i units of good X. We denote the inverse aggregate demand function by $p(X)$, where $X = \int x(p, \tilde{y}(n)) f(n) dn$. The assumption $x_p < 0$ ensures that the inverse aggregate demand function $p(X)$ is well defined. We consider only the case without foreign ownership so that $\int \xi(n) f(n) dn = 1$.

We can write firm i's profit as $X_i p(X) - K(X_i)$, where the market clearing condition ensures $\sum_{i=1}^{M} X_i = X$. To model various forms of oligopolistic competition, we assume that when firm i maximizes profits it forms a belief, or *a conjectural variation*, about the other firms' responses to a unit change in its output level,

$$\frac{d(\sum_{j \neq i} X_j)}{dX_i} = \theta, \text{ where } -1 \leq \theta \leq M - 1. \tag{16}$$

The conjectural variation was introduced by Bowley (1924) to capture a wide variety of oligopolistic competition models. For instance, the competitive equilibrium corresponds to $\theta = -1$ when firms expect the rest of the industry to absorb exactly its output expansion; the conjectural variation $\theta = 0$ represents the Cournot-Nash model where each firm expects the output of the other firms in its industry to remain unchanged, and the collusive behavior of firms maximizing their joint profits leads to $\theta = M - 1$.[12]

The first-order condition for the profit maximization problem can be expressed by

$$p(X) - K'(X_i) + (1+\theta)X_i\ p'(X) = 0. \tag{17}$$

We assume that the profit maximization problem is well-behaved and has a unique maximum. For the rest of our analysis, it is convenient to consider the price as an independent variable. We also limit our attention to symmetric equilibria $X_i = X/M$. After the change of variable, the market equilibrium condition then reads as

$$p - K'(X/M) + \frac{(1+\theta)}{M}\frac{X}{X_p} = 0, \tag{18}$$

where $X_p = \int x_p(p, \tilde{y}(n)) f(n) dn$. We note that our assumption of linear indirect utility implies that market demand X is a linear function of aggregate income. Therefore, the price elasticity of market demand is a function of price only, $\varepsilon_d(p) = X_p p/X$. Then the equilibrium condition can be transformed into a condition for the equilibrium markup $m(p)$

$$p - K'(X/M) = -\frac{(1+\theta)}{M}\frac{p}{\varepsilon_d(p)} \equiv m(p). \tag{19}$$

To relate the oligopolistic case to our previous analysis, we rewrite the last equation in terms of the quantity produced by all firms in equilibrium

$$\widetilde{S}(p) \equiv M(K')^{-1}(p - m(p)). \tag{20}$$

To be able to write formula (20), we assume $p - m(p)$ is an increasing function, which also implies $\widetilde{S}'(p) > 0$. This property can be guaranteed in equilibrium, for example, if $\varepsilon_d'(p) \leq 0$.[13] This assumption is trivially satisfied for CES preferences for which we have $\varepsilon_d'(p) = 0$. Note that the market clearing condition has to ensure that the quantity supplied by all firms equals the market demand $\widetilde{S}(p) = X$. We also note that the total firm profit function is given by $\Pi(p) = p\widetilde{S}(p) - MK(\widetilde{S}(p)/M)$ with its derivative $\Pi'(p) = \widetilde{S}(p) + m(p)\widetilde{S}'(p)$. For oligopolistic markets, the public authority's problem can be then expressed as optimization problem (8) – (11) studied for competitive markets after replacing supply $S(p)$ with $\widetilde{S}(p)$ defined in (20).

[12] Perry (1982) gives an excellent overview of various conjectural variation parameters.

[13] If equilibrium price satisfying (19) exists, we have $1 - m'(p) = 1 - \frac{p-K'}{p} - \frac{1+\theta}{M}\frac{p\varepsilon_d'(p)}{\varepsilon_d^2} \geq 0$ if $\varepsilon_d'(p) \leq 0$.

4.1 Optimal income taxation

With oligopolistic competition in the market for good X, the social optimum, determined by the solution to optimization problem (8) – (11), can be implemented by the marginal income tax schedule presented below.

Theorem 3 *With oligopolistic competition, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) - \mathrm{Cov}(\xi, \psi)\frac{a(p)}{\lambda}\frac{\vartheta_\Pi\,\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h} - \frac{m(p)\widetilde{S}'(p)p}{\widetilde{Y}(\varepsilon - \varepsilon_h)}, \tag{21}$$

with $A(n)$ and $B(n)$ as in Theorem 1 and $\widetilde{Y}$ denoting total income in the economy.

In comparison to the case of competitive markets we find that with oligopolistic markets the optimal income taxation formula contains an additional component, which exerts a downward pressure on tax rates. To understand its role, let us again perturb the tax schedule and consider the effect of the pecuniary externality of income change on the market outcome. Relative to the competitive market outcome, in oligopolistic markets there will be a production inefficiency of $m(p)\widetilde{S}'(p)$. Thus, the public authority corrects for this inefficiency by lowering income tax rates in proportion to the monetary value of this inefficiency normalized by the size of the economy. This result can be related to similar findings from the commodity taxation literature, where subsidies are used in order to remedy production inefficiency (see, e.g., Myles 1989).

Importantly, the non-competitive component of the tax formula in (21) works in the direction opposite to that of the dividend effect. However, we also note that the dividend effect becomes stronger in the presence of market power because of larger profits and, consequently, greater inequality of total income distribution. Next, we numerically examine the interplay of these two effects on income tax policy.

4.2 Numerical simulations

We estimate optimal income tax rates for various market structures using the framework introduced in Sect. 3. For comparison reasons, we infer the production cost function $K(\cdot)$ from the specification of the competitive market. Profit maximization in the competitive market has $p - K'(\frac{X}{M_0}) = 0$, where X is equal to the equilibrium market supply $S(p) = sp^{\varepsilon}$ and M_0 is some fixed number of firms. Thus, we obtain the marginal cost function $K'(X_i) = \left(\frac{X_i M_0}{s}\right)^{\frac{1}{\varepsilon}}$, which yields

$$\widetilde{S}(p) = s(p - m(p))^{\varepsilon}$$

where $s = 18.5$ and $\varepsilon = 1.75$, as used in our analysis of the competitive market. It is not clear what is the most realistic number of firms M_0 to consider for our simulations. We take $M_0 = 2$ to have the largest non-competitive effect of profits on optimal income

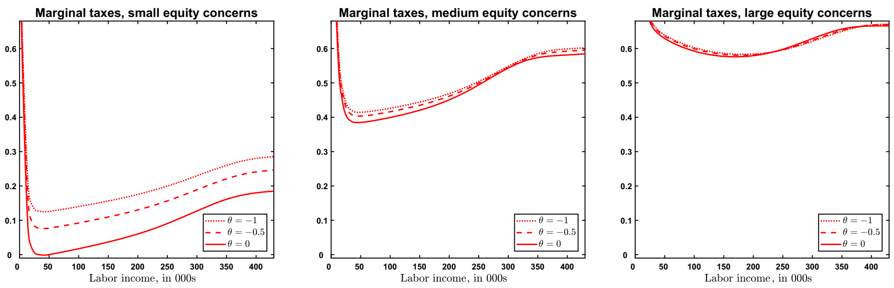

Fig. 2 Optimal income taxation for various market structures and degrees of equity concerns. *Note:* The figure illustrates the optimal marginal income tax schedules for three market structures with $\theta \in \{0, -0.5, -1\}$, where $\theta = 0$ stands for the Cournot-Nash competition model and $\theta = -1$ for perfect competition, and three degrees of equity concerns: $\mathfrak{z} = 1.05$ (small), $\mathfrak{z} = 1.3$ (medium), and $\mathfrak{z} = 2$ (large)

taxation.[14] One should have this in mind when interpreting our simulation results. The non-competitive effect on optimal income taxation will have a smaller magnitude if there is a greater number of firms in the market. All other parameters of the model remain the same as in Sect. 3.

To understand how optimal income tax policy depends on the market structure and to illustrate both the non-competitive and dividend effects, we consider the optimal income tax schedules for various degrees of equity concerns: $\mathfrak{z} = 1.05$ (small), $\mathfrak{z} = 1.3$ (medium), $\mathfrak{z} = 2$ (large). For each case, we also vary the conjectural variation parameter by setting $\theta = -1$ (perfect competition), $\theta = -0.5$, and $\theta = 0$ (Cournot-Nash).

In the case of small equity concerns (the left diagram of Fig. 2), the dividend effect is barely present. With the non-competitive effect dominant, we obtain lower optimal marginal tax rates in less competitive markets to offset larger production inefficiencies. For medium and large degrees of equity concerns (the middle and right diagrams of Fig. 2), the dividend effect starts playing a more important role. Unlike in the case of small equity concerns, we do not observe much variation in tax rates when the market structure changes. Specifically, more market power increases not only the non-competitive effect due to larger production inefficiency, but also the dividend effect due to larger profits. As our simulations show, these increases cancel each other, as the two effects work in the opposite directions. As a result, for a sufficiently high degree of equity concerns the optimal income taxation policy remains stable for various market structures—a result that has not been highlighted in the previous literature.

5 Extensions

In the previous sections, we demonstrate the effect of dividend distribution on income tax policy. In this section, we are interested in the question of whether this effect persists if the public authority also applies other types of taxation. We extend our

[14] Note that the price elasticity of supply $\varepsilon = 1.75$ is inconsistent with the market being monopolistic $M_0 = 1$.

analysis with commodity taxation in Sect. 5.1 and with profit taxation in Sect. 5.2. We explain how our analysis changes if we let the public authority tax total (labor and dividend) income in Sect. 5.3.

5.1 Commodity taxation

Let the public authority impose a commodity tax b (or a subsidy if $b < 0$) paid by producers for every sold unit of good X. We note that there is no loss of generality if the public authority does not impose a commodity tax on the numeraire good, as any production outcome in this case can be replicated with only a commodity tax on good X and a non-linear labor income tax schedule. An individual firm's profits read as $(p-b)X_i - K(X_i)$, and the analogue of the market equilibrium condition in (19) becomes

$$p - b - K'(X/M) = m(p).$$

The equilibrium quantity supplied by all firms can then be defined as

$$\widetilde{S}(p,b) = M(K')^{-1}(p - b - m(p)).$$

Aggregate profits are given by $\Pi(p,b) = (p-b)\widetilde{S}(p,b) - MK(\widetilde{S}(p,b)/M)$ and their partial derivatives by $\Pi_p = \widetilde{S} + m(p)\widetilde{S}_p$ and $\Pi_b = -\widetilde{S} + m(p)\widetilde{S}_b$. The public authority's maximization problem can be written as

$$\max_{p,b,u(n),\ell(n)} \int \psi(n)u(n)f(n)dn$$
$$s.t. \begin{cases} \int (n\ell(n) - r(p,u(n),\ell(n)))\,f(n)dn + \Pi(p,b) + b\widetilde{S}(p,b) \geq R, \\ \\ \widetilde{S}(p,b) - \int x(p, r(p,u(n),\ell(n)))f(n)dn = 0, \\ \\ u'(n) - a(p)\xi'(n)\Pi(p,b) - c_\ell \ell(n)/n = 0. \end{cases} \tag{22}$$

We note that, as before (see Sect. 2.3), the public authority only needs to consider the market clearance condition in the market for good X. Any additional demand for the numeraire good coming from the commodity tax receipts is offset by the corresponding reduction in firm profits and, thus, dividend income. The next theorem presents our results about optimal income and commodity taxation.

Theorem 4 (Commodity taxation) *With income and commodity taxation, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) + \mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\frac{s_X(m'(p) - \delta_\Pi)}{\varepsilon_h}, \tag{23}$$

where $A(n)$ and $B(n)$ as in Theorem 1, and $s_X = p\widetilde{S}(p,b)/\int \tilde{y}(n)f(n)dn$ is the total expenditure share of good X. The optimal commodity tax equals

$$b = -m(p)\left(1 + \mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\right) - p\mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\left(\frac{1-m'(p)}{\varepsilon} - \frac{s_\Pi - m'(p)}{\varepsilon_h}\right). \tag{24}$$

First, we find that with equity concerns and unequally distributed dividends, $\mathrm{Cov}(\xi,\psi) \neq 0$, commodity taxation becomes optimal irrespective of the market structure. Specifically, and in contrast to the seminal result of "uniform commodity tax under nonlinear income taxation" by Atkinson and Stiglitz (1976), we show that it is efficient to address redistributive goals through commodity taxation when profits are unequally distributed. Second, we find that commodity taxation does not eliminate the dividend effect on income tax policy, which, though, takes a different form from those presented in Theorems 1 and 3.

For intuition, consider the case of competitive markets ($m(p) = 0, m'(p) = 0$), where the optimal marginal income tax is determined by

$$\frac{t}{1-t} = A(n)B(n) - \mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\frac{s_X s_\Pi}{\varepsilon_h}$$

and the optimal commodity tax b by

$$b = -p\,\mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\left(\frac{1}{\varepsilon} - \frac{s_\Pi}{\varepsilon_h}\right) > 0$$

as $\mathrm{Cov}(\xi,\psi) < 0$ and $\varepsilon_h < 0$. In line with the commodity taxation literature, the size of the optimal commodity tax inversely depends on the price elasticities of supply and demand, that is, on the producer and consumer tax burden with the latter adjusted for the profit share s_Π of total income. We also note that a larger mismatch between dividend distribution and equity concerns (larger $|\mathrm{Cov}(\xi,\psi)|$) implies a larger optimal commodity tax. With a larger mismatch, the public authority taxes the consumption of good X more heavily in order to extract more producer surplus and, thus, more profits and to redistribute those profits more evenly among the agents.[15] If the commodity tax b results in a higher consumer price p or, in other words, has a positive consumer tax burden, the redistribution of commodity tax proceeds takes place through lower marginal income taxes. More specifically, the dividend effect term of the optimal marginal income tax turns negative with its size related to the consumer tax burden part of the optimal commodity tax. In contrast, if the commodity tax b does not have any consumer tax burden, i.e., if good X is perfectly elastic ($\varepsilon_h \to -\infty$), the dividend effect term vanishes and the optimal marginal income tax coincides with the standard Mirrleesian tax formula.

15 Relatedly, Iwamoto and Konishi (1991) show that in the presence of profits, the optimal commodity tax also depends on the distributional characteristics of production activity.

In the case of oligopolistic markets ($m(p) > 0, m'(p) \neq 0$), the optimal commodity tax also corrects for market inefficiency along the same lines we discussed in Sect. 4. Specifically, the public authority reduces the optimal commodity tax by the amount of firm markup $m(p)$ adjusted by equity concerns. Market power and non-zero markups also have an effect on the consumer and producer tax burden that may affect the size and even the sign of the commodity tax and the dividend effect of income tax policy. Furthermore, the commodity tax does not disappear in the optimum even when profits are equally distributed, $\xi'(n) = 0$. In this case, the optimal tax is the subsidy $b = -m(p)$ that brings the economy to the efficient level of production. This result is similar to the one obtained by Myles (1996), who shows that a combination of ad valorem tax and commodity tax can eliminate the welfare loss that arises from oligopolistic competition.

5.2 Profit taxation

We extend the competitive market model with a unit continuum of firms and free entry.[16] Firms have the same marginal costs of production and, thus, the same individual supply curve $S_i(p) = S(p)$, which is determined by the short-run profit maximization condition of price equal to marginal costs. If firm i enters the market, it supplies $S(p)$ amount of good X and receives an accounting profit of $\pi(p) = \int_0^p S(\tilde{p})d\tilde{p}$. In addition, each firm has firm-specific fixed costs k_i distributed according to distribution function $\mathcal{F}$ over $(0, \infty)$ with positive density f. We think about fixed costs as firm owners' opportunity costs, such as profit opportunities in another country or earnings in the labor market. These costs can also be frictions and risks associated with entering the market that cannot be accounted for in the firm's balance sheet or, put differently, they enter economic but not accounting profits. For convenience, we normalize accounting fixed costs to zero.

At a profit tax rate $\tau \in [0, 1]$, firm i enters the market if and only if

$$(1 - \tau)\pi(p) \geq k_i. \tag{25}$$

Clearly, the 100%-profit tax cannot be optimal, as no firm would enter the market. Let us denote the fixed costs of the marginal firm that enters the market by $k^* = (1 - \tau)\pi(p)$. The market supply is then given by $S(p)\mathcal{F}(k^*)$ and the total after-tax profits by $(1 - \tau)\pi(p)\mathcal{F}(k^*)$. As the firm shares have $\int \xi(n) f(n)dn = 1$, total tax revenue sums to

$$\begin{aligned} TR &= \int [n\ell(n) - \tilde{y}(\ell(n)) + \xi(n)(1 - \tau)\pi(p)\mathcal{F}(k^*) + \tau\pi(p)\mathcal{F}(k^*)] f(n)dn \\ &= \int [n\ell(n) - \tilde{y}(\ell(n)) + \pi(p)\mathcal{F}(k^*)] f(n)dn. \end{aligned}$$

[16] See Scheuer (2014) for a related analysis of optimal profit taxation under endogenous firm formation. See also Gürer (2021), who explores the implications of rising markups for optimal income and profit taxation in a model of monopolistic competition.

In the public authority's maximization problem, it is analytically convenient to express the supply and profits through price p and the share of firms entering the market $\mathcal{F}(k^*) \equiv \mathcal{F}^*$ so that $\widetilde{S}(p, \mathcal{F}^*) = S(p)\mathcal{F}^*$ and $\Pi(\mathcal{F}^*) = \mathcal{F}^{-1}(\mathcal{F}^*)\mathcal{F}^*$. The expression for tax revenue is then $TR = \int [n\ell(n) - \tilde{y}(\ell(n)) + \pi(p)\mathcal{F}^*] f(n)dn$ and the condition that $\tau \geq 0$ can be expressed as $\pi(p) \geq \mathcal{F}^{-1}(\mathcal{F}^*)$ from the profitability condition (25). We drop condition $\tau \leq 1$ as not binding. The public authority's maximization problem with profit taxation reads as

$$\max_{p, \mathcal{F}^*, u(n), \ell(n)} \int u(n)\psi(n) f(n)dn$$
$$s.t. \begin{cases} \int [n\ell(n) - r(p, u(n), \ell(n)) + \pi(p)\mathcal{F}^*] f(n)dn \geq R, \\ S(p)\mathcal{F}^* - \int x(p, r(p, u(n), \ell(n))) f(n)dn = 0, \\ u'(n) - a(p)\xi'(n)\Pi(\mathcal{F}^*) - c_\ell \ell(n)/n = 0, \\ \pi(p) - \mathcal{F}^{-1}(\mathcal{F}^*) \geq 0. \end{cases}$$

Denoting the Lagrange multiplier for $\pi(p) - \mathcal{F}^{-1}(\mathcal{F}^*) \geq 0$ by β, we present the following result.

Theorem 5 (Profit taxation) *In competitive markets with optimal profit taxation, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) - \left(\mathrm{Cov}(\xi, \psi) \frac{a(p)s_\Pi}{\lambda} - \frac{\beta}{\lambda \mathcal{F}^*} \right) \frac{\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h}$$

with $A(n)$ and $B(n)$ as in Theorem 1 and elasticity $\varepsilon_{U_\Pi} = \partial U_\Pi / \partial p \, (p/U_\Pi)$, where $U_\Pi(p, \mathcal{F}^*) = a(p)\Pi(\mathcal{F}^*)$ is the total utility from profits.

Similarly to the problem of commodity and income taxation studied earlier, the public authority can affect market supply through profit tax and market demand through labor income tax. As in Theorem 4 for the case of competitive markets, we obtain that with optimal profit taxation, the dividend effect of optimal income taxation turns negative when $\mathrm{Cov}(\xi, \psi) < 0$ (since with optimal profit taxation we have $\varepsilon_{U_\Pi} < 0$ unlike before, whereas we have $\beta \geq 0$ by the Kuhn-Tucker conditions). The dividend effect again plays the redistributive role of the profit tax revenue.

5.3 Competitive markets: taxing total income

Here, we consider the case when the public authority can tax total (labor and dividend) income $z(n) = n\ell(n) + \xi(n)\Pi(p)$. Under total income taxation, disposable income is given by $\tilde{y}(n) = z(n) - T(z(n))$. Differences in profit shares make it harder for agents to pretend to have different productivity levels compared to the case when taxes are based on labor income only. If an agent of type n wants to pretend to be of type m, he must change working hours to $\ell = (m\ell(m) + (\xi(m) - \xi(n))\Pi(p))/n$, yielding utility

$$U(p, \tilde{y}(m), z(m), n) = v(p, \tilde{y}(m)) - c((z(m) - \xi(n)\Pi(p))/n).$$

Letting $u(n) \equiv U(p, \tilde{y}(n), z(n), n)$, for truthful revelation to be optimal we have

$$u(n) - U(p, \tilde{y}(n), z(n), n) = 0 \geq u(m) - U(p, \tilde{y}(n), z(n), m), \tag{26}$$

which leads to the following first-order condition:

$$u'(n) = U_n = c_\ell \frac{\ell(n) + \xi'(n)\Pi(p)}{n}. \tag{27}$$

The latter condition coincides with the standard one when profits are zero $\Pi(p) = 0$ or $\xi'(n) = 0$. Also, notice that the standard single-crossing condition is satisfied when total income is taxed:

$$\frac{\partial}{\partial n \partial m} c((z(m) - \xi(n)\Pi(p))/n) < 0.$$

Hence, the second-order condition for truth-telling coincides with the one in the standard case; that is, $z(n)$ must be increasing. The first-order condition for maximizing (26) implies $v_y \tilde{y}'(n) - c_\ell z'(n)/n = 0$ or that total income $z(n)$ is increasing if and only if disposable income $\tilde{y}(n)$ is increasing, as we had before.

The maximization problem of the public authority can be written as follows

$$\max_{p, u(n), \ell(n)} \int u(n)\psi(n) f(n) dn$$
$$s.t. \begin{cases} \int [n\ell(n) - r(p, u(n), \ell(n)) + \xi(n)\Pi(p)] f(n) dn \geq R, \\ S(p) - \int x(p, r(p, u(n), \ell(n))) f(n) dn = 0, \\ u'(n) - c_\ell \frac{\ell(n) + \xi'(n)\Pi(p)}{n} = 0. \end{cases}$$

The first-order conditions of the above problem give us the following result.

Theorem 6 (Total income taxation) *In competitive markets with total income taxation, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) + \int_{\underline{n}}^{\overline{n}} (\Psi(m) - F(m)) \frac{\xi'(m) c_\ell(\ell(m))}{\lambda m} dm \frac{\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h} \frac{\jmath_\Pi}{1 - \jmath_\Pi},$$

where

$$A(n) = \left(\frac{1 + \zeta + \xi'(n)\Pi(p)/\ell(n)}{\zeta} \right) \frac{1 - F(n)}{n f(n)}, \quad B(n) = \frac{a(p)}{\lambda} \frac{\Psi(n) - F(n)}{1 - F(n)}.$$

When tax is based on total income, it becomes more difficult for high earners to deviate due to their higher profits; hence, incentive compatibility becomes a lesser problem. Unlike in Theorem 1, the standard incentive term $A(n)$ is now influenced by the distribution of profits. With progressive distribution of profits $\xi'(n) > 0$, the public authority can impose more progressive income taxes, also used as a means of taxing profits after accounting for the labor incentives captured by labor supply $\ell(n)$ in $A(n)$. As $\xi'(n) > 0$ and $\varepsilon_{U_\Pi} \geq 0$, the last term in the optimal income tax formula is again positive when the public authority puts more weight on lower income earners ($\Psi(n) - F(n) \geq 0$). Overall, the optimal income tax is again larger compared to the standard Mirrleesian formula.

6 Conclusion

In this paper, we argue that a redistributive labor income tax policy needs to consider the distribution of the profit share of workers' product of labor or, put differently, the distribution of dividends. We study how the distribution of dividends affects the optimal income taxation policy under different market structures and in the presence of other forms of taxation. In a Mirrleesian framework, we establish that a progressive distribution of dividends creates a positive dividend effect on labor income tax rates. In oligopolistic markets, market power not only increases the dividend effect, but also creates an additional non-competitive effect on income tax policy, which works in the direction opposite of the dividend effect. Using numerical simulations, we show that for a sufficiently high degree of equity concerns, the non-competitive effect is offset by the increase in the dividend effect, resulting in the invariance of the optimal income tax schedule to different market structures. In general, our numerical simulations show that the dividend effect can be of a considerable size and, thus, of relevance for tax policy design. Future research could expand the model in different directions. An important expansion would be a dynamic model with an endogenously determined distribution of dividends. Another expansion could be into the domain of a larger product space and more general demand structure. It could provide additional insights on the role of the distribution of dividends for income and commodity tax policy.

A Appendix

A.1 Proofs

Proof of Theorem 1 Let λ, γ, and $\mu(n)$ be multipliers corresponding to constraints (9), (10), and (11), respectively. After integration by parts and taking the transversality condition $\mu(\underline{n}) = \mu(\overline{n}) = 0$ into account, we express the Lagrangian of the maximization problem as

$$\int \Big\{ \big[u(n)\psi(n) + \lambda\big(n\ell(n) - r(p, u(n), \ell(n)) + \xi(n)\Pi(p) - R\big) \\ + \gamma\big(S(p) - x(p, r(p, u(n), \ell(n)))\big)\big] f(n) - \mu'(n)u(n) \\ - \mu(n)\big(v_y \xi'(n)\Pi(p) + c_\ell \ell(n)/n\big)\Big\} dn.$$

Note that $r_u = 1/v_y$, $r_\ell = c_\ell/v_y$, and $r_p = -v_p/v_y = x$. Let $H(p)$ denote the aggregate Hicksian demand function and its slope $H'(p) = \int(x_p + x_y x)f(n)dn$. Given $a(p) = v_y$, the first-order conditions can then be written as

$$u(n): \left[\psi(n) - \frac{\lambda + \gamma x_y}{a(p)}\right] f(n) - \mu'(n) = 0, \tag{A.1}$$

$$\ell(n): \left[\lambda n - \frac{(\lambda + \gamma x_y)c_\ell}{a(p)}\right] f(n) - \mu(n)(c_\ell + c_{\ell\ell}\ell(n))/n = 0, \tag{A.2}$$

$$p: \gamma(S'(p) - H'(p)) - (a(p)\Pi(p))' \int \mu(n)\xi'(n)dn = 0. \tag{A.3}$$

The linearity of indirect utility implies that expression $(\lambda + \gamma x_y)/a(p)$ is constant and it is equal to 1, which is obtained by integrating first-order condition (A.1) and using the transversality conditions $\mu(\underline{n}) = \mu(\overline{n}) = 0$. The same first-order condition yields the formula $\mu(n) = \Psi(n) - F(n)$, where $\Psi(n) = \int_{\underline{n}}^{n} \psi(m)f(m)dm$, $n \in [\underline{n}, \overline{n}]$, are cumulative weights. Taking this expression into account and integrating by parts, we obtain

$$\int \mu(n)\xi'(n)dn = -\mathrm{Cov}(\xi, \psi), \tag{A.4}$$

where covariance $\mathrm{Cov}(\xi, \psi) = \int(\xi(n)-1)(\psi(n)-1)f(n)dn$. Noting that individual utility maximization implies the optimal marginal income tax $t(n\ell) = 1 - c_\ell/(nv_y)$, we find from first-order condition (A.2)

$$\frac{t}{1-t} = \left(1 + \frac{\ell c_{\ell\ell}}{c_\ell}\right)\frac{a(p)\mu(n)}{\lambda n f} + \frac{\gamma}{\lambda}x_y. \tag{A.5}$$

Next, we show that $1 + \ell c_{\ell\ell}/c_\ell = (1+\zeta)/\zeta$, where ζ is the elasticity of compensated labor supply.[17] Denoting net wage $w = (1-t)n$ and implicitly differentiating the individual utility maximization condition $v_y w - c_\ell(\ell) = 0$ with respect to w, we obtain $\partial\ell/\partial w = v_y/c_{\ell\ell}$. Thus, we find $\zeta = w/\ell\,(\partial\ell/\partial w) = c_\ell/(\ell c_{\ell\ell})$ or, after rearrangement, $1 + \ell c_{\ell\ell}/c_\ell = (1+\zeta)/\zeta$.

From first-order condition (A.3) and equation (A.4) we find multiplier

$$\gamma = -\mathrm{Cov}(\xi, \psi)\frac{(a(p)\Pi(p))'}{S'(p) - H'(p)}.$$

Using the definitions of price elasticities ε, ε_h, and ε_{U_Π} and that $S(p) = H(p)$, we can express multiplier γ as

[17] The compensated elasticity of labor supply coincides with the uncompensated one in the absence of income effects (linear indirect utility).

$$\gamma = -\mathrm{Cov}(\xi, \psi) \frac{a(p)\Pi(p)}{S(p)} \frac{\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h}$$
$$= -\mathrm{Cov}(\xi, \psi) \frac{a(p)s_\Pi}{x_y} \frac{\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h},$$

where to obtain the last expression we use that $S(p) = x_y \int \tilde{y}(n) f(n) dn$ due to the linearity of indirect utility. Substituting the derived expression for γ together with $\mu(n) = \Psi(n) - F(n)$ in (A.5), we obtain the tax formula in Theorem 1. □

Proof of Theorem 2 The public authority's optimization problem for competitive markets with foreign ownership is the same as without foreign ownership (8)–(11). The first-order conditions with respect $u(n)$ and $\ell(n)$ remain unchanged. The first order condition with respect to price p is slightly different due to $\int \xi(n) f(n) dn = \Xi < 1$

$$p: \ \lambda(-S(p) + \Xi\Pi'(p)) + \gamma(S'(p) - H'(p)) - (a(p)\Pi(p))' \int \mu(n)\xi'(n)dn = 0.$$

Given that $\Pi'(p) = S(p)$, the statement of the theorem follows from the same steps as in the proof of Theorem 1. □

Proof of Theorem 3 With an oligopolistic market for good X, the first-order conditions with respect to $u(n)$ and $\ell(n)$ remain the same as with competitive markets. The first-order condition with respect to price p is

$$p: \ \lambda(-\widetilde{S}(p) + \Pi'(p)) + \gamma(\widetilde{S}'(p) - H'(p)) - (a(p)\Pi(p))' \int \mu(n)\xi'(n)dn = 0.$$

Given that $\Pi'(p) = \widetilde{S}(p) + m(p)\widetilde{S}'(p)$, the statement of the theorem follows from the same steps as in the proof of Theorem 1. □

Proof of Theorem 4 The first-order conditions with respect to $u(n)$ and $\ell(n)$ remain the same as before (see (A.1) and (A.2)). The conditions with respect to price p and commodity tax b are

$$p: \lambda(m(p) + b)\widetilde{S}_p + \gamma(\widetilde{S}_p - H'(p)) - (a(p)\Pi(p, b))'_p \int \mu(n)\xi'(n)dn = 0, \tag{A.6}$$

$$b: \lambda(m(p) + b)\widetilde{S}_b + \gamma\widetilde{S}_b - a(p)\Pi_b(p, b) \int \mu(n)\xi'(n)dn = 0. \tag{A.7}$$

Recalling that $\int \mu(n)\xi'(n)dn = -\mathrm{Cov}(\xi, \psi)$ (see (A.4)) and $\widetilde{S}_p = -(1 - m'(p))\widetilde{S}_b$, we multiply the second equation by $1 - m'(p)$ and add the two equations to obtain

$$\gamma(-H'(p)) + \mathrm{Cov}(\xi, \psi)\Big(a'(p)\Pi + a\Pi_p + a\Pi_b(1 - m'(p))\Big) = 0$$

or, given that $\Pi_p = \widetilde{S} + m(p)\widetilde{S}_p$ and $\Pi_b = -\widetilde{S} + m(p)\widetilde{S}_b$,

$$\gamma = -\mathrm{Cov}(\xi, \psi)\frac{a'(p)\Pi(p,b) + a(p)m'(p)\widetilde{S}(p,b)}{-H'(p)}. \tag{A.8}$$

Therefore, the corrective term is equal to

$$\frac{\gamma}{\lambda}x_y = -\frac{\mathrm{Cov}(\xi,\psi)}{\lambda}\frac{a'(p)\Pi(p,b) + a(p)m'(p)\widetilde{S}(p,b)}{-H'(p)}\left(-\frac{a'(p)}{a(p)}\right)$$

Our notation is $\Pi(p,b) = s_\Pi \int \tilde{y}(n) f(n)dn$ and $\widetilde{S}(p,b) = \int x(p, r(p, u(n), \ell(n))) f(n)dn = -\frac{a'(p)}{a(p)} \int \tilde{y}(n) f(n)dn$, $\varepsilon_h = pH'(p)/H(p)$. Therefore,

$$a'(p)\Pi(p,b) = s_\Pi a'(p) \int \tilde{y}(n) f(n)dn = -s_\Pi a(p)\widetilde{S}(p,b)$$

and

$$\begin{aligned}\frac{\gamma}{\lambda}x_y &= -\frac{\mathrm{Cov}(\xi,\psi)}{\lambda}\frac{a(p)\widetilde{S}(p,b)(-s_\Pi + m'(p))}{H'(p)}\frac{a'(p)}{a(p)} \\ &= \mathrm{Cov}(\xi,\psi)\frac{a(p)}{\lambda}\frac{s_X(m'(p) - s_\Pi)}{\varepsilon_h},\end{aligned}$$

where to obtain the last expression we use the expenditure share of good X given by $s_X = px_y \int \tilde{y}(n) f(n)dn / \int \tilde{y}(n) f(n)dn = -pa'(p)/a(p)$. The tax formula then follows from algebraic transformations similar to those in Theorem 1. To obtain the expression for b, we substitute the expression for γ in (A.8) into (A.7). □

Proof of Theorem 5 (Profit taxation) We obtain the following first-order conditions with respect to price p and the share of firms $\mathcal{F}^*$

$$p : \gamma(S'(p)\mathcal{F}^* - H'(p)) + a'(p)\Pi(\mathcal{F}^*)\mathrm{Cov}(\xi,\psi) + \beta S(p) = 0, \tag{A.9}$$
$$\mathcal{F}^* : \lambda\pi(p) + \gamma S(p) + a(p)\Pi'(\mathcal{F}^*)\mathrm{Cov}(\xi,\psi) - \beta/\mathcal{F}'(k^*) = 0, \tag{A.10}$$

where k^* is the fixed costs of the marginal firm entering the market. The first-order conditions with respect to utility $u(n)$ and $\ell(n)$ remain the same as in the initial problem. Equation (A.9) together with $x_y = -\frac{a'(p)}{a(p)}$ and $H(p) = S(p)\mathcal{F}^*$ imply

$$\frac{\gamma}{\lambda}x_y = \frac{a'(p)\Pi(\mathcal{F}^*)\mathrm{Cov}(\xi,\psi) + \beta S(p)}{\varepsilon - \varepsilon_h}\frac{a'(p)}{a(p)}\frac{p}{S(p)\mathcal{F}^*}$$

Now, ε_{U_Π} reduces to $a'(p)p/a(p)$ and $a'(p)\Pi(\mathcal{F}^*) = -s_\Pi a(p)S(p)\mathcal{F}^*$. This results in the following expression for the corrective term in the tax formula

$$\frac{\gamma}{\lambda}x_y = \left(-\mathrm{Cov}(\xi,\psi)\frac{a(p)s_\Pi}{\lambda} + \frac{\beta}{\lambda\mathcal{F}^*}\right)\frac{\varepsilon_{U_\Pi}}{\varepsilon - \varepsilon_h}. \tag{A.11}$$

The remaining tax formula then follows from algebraic transformations similar to those used in proving Theorem 1. □

Proof of Theorem 6 (Total income taxation) The first-order conditions with respect to labor $\ell(n)$ and price p are, respectively, given by

$$\ell(n): \left[\lambda n - \frac{(\lambda + \gamma x_y)c_\ell}{v_y}\right] f(n) - \mu(n)\Big(c_\ell + c_{\ell\ell}(\ell(n) + \xi'(n)\Pi(p))\Big)/n = 0,$$

$$p: \gamma(S'(p) - H'(p)) - \Pi'(p) \int \mu(n) \frac{\xi'(n)c_\ell}{n} dn = 0.$$

The first-order condition with respect to $u(n)$ remains intact,

$$u(n): \left[\psi(n) - \frac{\lambda + \gamma x_y}{a(p)}\right] f(n) - \mu'(n) = 0.$$

From the condition with respect to $\ell(n)$, we obtain

$$\frac{t}{1-t} = \left(\frac{1 + \zeta + \xi'(n)\Pi(p)/\ell(n)}{\zeta}\right) \frac{\mu(n) v_y}{\lambda n f(n)} + \frac{\gamma}{\lambda} x_y.$$

From the first-order condition with respect to p we obtain

$$\frac{\gamma}{\lambda} x_y = -\frac{\int_{\underline{n}}^{\overline{n}} \mu(m) \frac{\xi'(m)c_\ell(\ell(m))}{\lambda m} dm}{\varepsilon - \varepsilon_h} \frac{a'(p)p}{a(p)}$$

Using $U_\Pi = a(p)\Pi(p)$, and $(a(p)\Pi(p))' = -a'(p)(1 - s_\Pi)\tilde{Y}$ we obtain

$$\frac{\gamma}{\lambda} x_y = \int_{\underline{n}}^{\overline{n}} \mu(m) \frac{\xi'(m)c_\ell(\ell(m))}{\lambda m} dm \frac{\varepsilon_\Pi}{\varepsilon - \varepsilon_h} \frac{s_\Pi}{1 - s_\Pi}$$

The tax formula then follows from similar algebraic transformations as used before. □

A.2 Competitive markets: non-linear indirect utility

In this section, we consider the general case of non-linear indirect utility. Let us again denote an agent's utility from revealing his productivity type truthfully as

$$u(n) \equiv U(p, y(n) + \xi(n)\Pi(p), \ell(n)) = v(p, y(n) + \xi(n)\Pi(p)) - c(\ell(n)).$$

If revealing the agent's type truthfully is optimal then

$$u(n) = \max_m \; v(p, y(m) + \xi(n)\Pi(p)) - c(m\ell(m)/n). \tag{A.12}$$

The envelope theorem implies the following first-order condition

$$u'(n) = c_\ell \ell(n)/n + v_{yy}\xi'(n)\Pi(p). \tag{A.13}$$

We note that the single-crossing condition does not generally hold when the indirect utility is non-linear. Hence, we need to derive the second-order condition when truth-telling is optimal.

Proposition A1 *Condition (A.13) ensures that truth-telling is an optimal solution of (A.12) if and only if schedule* $\{y(n), \ell(n)\}$ *satisfies for each n*

$$\left[\frac{c_{\ell\ell}\ell(n) + c_\ell}{n}\frac{v_y}{c_\ell} + v_{yy}\xi'(n)\Pi(p)\right] y'(n) \geq 0. \tag{A.14}$$

Proof Let us assume that $y(n)$ and $\ell(n)$ are differentiable. We also denote U_y, U_z, and U_n to be the partial derivatives of function U with respect to its first, second, and third arguments, respectively. The second-order condition for maximization (A.12) is

$$u''(n) - U_{nn} - (U_{yy}\xi'(n)\Pi(p) + 2U_{yn})\xi'(n)\Pi(p) - U_y\xi''(n)\Pi(p) \geq 0. \tag{A.15}$$

Taking the derivative of (A.13) with respect to n we obtain

$$\begin{aligned} u''(n) = U_{nn} &+ U_{ny}(y'(n) + \xi'(n)\Pi(p)) + U_{nz}(n\ell(n))' \\ &+ (U_{yn} + U_{yy}(y'(n) + \xi'(n)\Pi(p)) \\ &+ U_{yz}(n\ell(n))')\xi'(n)\Pi(p) + U_y\xi''(n)\Pi(p). \end{aligned}$$

Hence, condition (A.15) is equivalent to

$$U_{ny}y'(n) + U_{nz}(n\ell(n))' + (U_{yy}y'(n) + U_{yz}(n\ell(n))')\xi'(n)\Pi(p) \geq 0.$$

Given our separable utility specification, this reduces to

$$\frac{c_{\ell\ell}\ell(n) + c_\ell}{n^2}(n\ell(n))' + v_{yy}y'(n)\xi'(n)\Pi(p) \geq 0.$$

Maximization problem (A.12) implies $v_y y'(n) - c_\ell(n\ell(n))'/n = 0$, which allows rewriting the previous inequality in the form of (A.14). □

Note that the first term in (A.14) is always positive because the cost function $c(\ell)$ is increasing and convex. Hence, the second-order condition reduces to income schedule $y(n)$ being non-decreasing if either profits are zero $\Pi(p) = 0$ or profits are equally distributed $\xi'(n) = 0$. When both $\Pi(p) > 0$ and $\xi'(n) > 0$ the second term in (A.14) is negative because the indirect utility function is concave.

Assuming the second-order condition (A.14) is satisfied, we express the public authority's maximization problem as

$$\max_{p,u(n),\ell(n)} \int u(n)\psi(n)f(n)dn$$

$$s.t.$$

$$\int [n\ell(n) - r(p, u(n), \ell(n)) + \xi(n)\Pi(p)]f(n)dn \geq R,$$

$$S(p) - \int x(p, r(p, u(n), \ell(n)))f(n)dn = 0,$$

$$u'(n) - v_y(p, r(p, u(n), \ell(n)))\xi'(n)\Pi(p) - c_\ell \ell(n)/n = 0.$$

Having the same notation for Lagrange multipliers as before, we write the first-order conditions as

$$u(n) : \left[\psi(n) - \frac{\lambda + \gamma x_y}{v_y}\right] f(n) - \mu'(n) - \mu(n)\frac{v_{yy}}{v_y}\xi'(n)\Pi(p) = 0, \tag{A.16}$$

$$\ell(n) : \left[\lambda n - \frac{(\lambda+\gamma x_y)c_\ell}{v_y}\right] f(n) - \mu(n)\frac{v_{yy}c_\ell}{v_y}\xi'(n)\Pi(p) - \mu(n)(c_\ell + c_{\ell\ell}\ell(n))/n = 0, \tag{A.17}$$

$$p : \gamma(S'(p) - H'(p)) - \int \mu(n)\xi'(n)((v_{yp} + v_{yy}x)\Pi(p) + v_y\Pi'(p))dn = 0. \tag{A.18}$$

To calculate the optimal marginal income tax, we consider the individual utility maximization problem $\max_\ell (v(p, n\ell - T(n\ell) + \xi(n)\Pi(p)) - c(\ell))$ as before. The first-order condition with respect to ℓ yields $t(n\ell) = 1 - c_\ell/(v_y n)$. Using equation (A.17) we can then write

$$\frac{t}{1-t} = \frac{\mu(n)v_y}{\lambda n f}\frac{1+\zeta^u(n)}{\zeta^c(n)} + \frac{\gamma x_y}{\lambda} + \frac{\mu(n)v_{yy}\xi'(n)\Pi(p)}{\lambda f}, \tag{A.19}$$

where $\zeta^u(n)$ is the elasticity of the uncompensated labor supply, $\zeta^c(n)$ is the elasticity of the compensated labor supply, and we exploited that $1 + \ell c_{\ell\ell}/c_\ell = (1 + \zeta^u(n))/\zeta^c(n)$.

Lagrange multiplier $\mu(n)$ is determined by first-order linear differentiation equation (A.16)

$$\mu'(n) + C(n)\mu(n) = D(n).$$

where $C(n) = \frac{v_{yy}^{(n)}}{v_y^{(n)}}\xi'(n)\Pi(p)$ and $D(n) = \left(\psi(n) - \frac{\lambda+\gamma x_y^{(n)}}{v_y^{(n)}}\right) f(n)$ and superscript (n) means that functions are evaluated at productivity n. Taking into account the transversality condition $\mu(\underline{n}) = \mu(\overline{n}) = 0$, we find its solution given by

$$\mu(n) = -\int_n^{\overline{n}} E_{mn}D(m)dm = \int_n^{\overline{n}} E_{mn}\left(\frac{\lambda + \gamma x_y^{(m)}}{v_y^{(m)}} - \psi(m)\right) f(m)dm,$$

where $E_{mn} = \exp(\int_n^m C(m')dm') = \exp(\Pi(p)\int_n^m \frac{v_{yy}^{(m')}}{v_y^{(m')}}\xi'(m')dm')$.

Lagrange multiplier γ is then determined by equation (A.18). Denoting $G(n,p) = (v_{yp}^{(n)} + v_{yy}^{(n)} x^{(n)})\Pi(p) + v_y^{(n)}\Pi'(p)$, we have

$$\gamma(S'(p) - H'(p)) = \int_{\underline{n}}^{\overline{n}} G(n,p)\xi'(n) \int_n^{\overline{n}} E_{mn}\left(\frac{\lambda + \gamma x_y^{(m)}}{v_y^{(m)}} - \psi(m)\right) f(m) dm dn.$$

Therefore,

$$\gamma = \frac{\int_{\underline{n}}^{\overline{n}} G(n,p)\xi'(n) \int_n^{\overline{n}} \lambda E_{mn}/v_y^{(m)}(1 - \frac{\psi(m)v_y^{(m)}}{\lambda}) f(m) dm dn}{S'(p) - H'(p) - \int_{\underline{n}}^{\overline{n}} G(n,p)\xi'(n) \int_n^{\overline{n}} E_{mn} x_y^{(m)}/v_y^{(m)} f(m) dm dn}.$$

Substituting the above expressions in (A.19), we obtain the following result.

Theorem A1 *In competitive markets, the optimal marginal income tax is determined by*

$$\frac{t}{1-t} = A(n)B(n) + \frac{\gamma}{\lambda}\left(x_y^{(n)} + A(n)v_y^{(n)} \frac{\int_n^{\overline{n}} x_y^{(m)} E_{mn}/v_y^{(m)} f(m) dm}{1 - F(n)}\right),$$

where

$$A(n) = \left(\frac{1 + \zeta^u(n)}{\zeta^c(n)} + n\frac{v_{yy}^{(n)}}{v_y^{(n)}}\xi'(n)\Pi(p)\right)\frac{1 - F(n)}{nf(n)},$$

$$B(n) = \frac{v_y^{(n)}}{1 - F(n)} \int_n^{\overline{n}} \frac{E_{mn}}{v_y^{(m)}}\left(1 - \frac{\psi(m)v_y^{(m)}}{\lambda}\right) f(m) dm,$$

$$\gamma = \frac{\int_{\underline{n}}^{\overline{n}} \xi'(n) G(n,p) \int_n^{\overline{n}} \lambda E_{mn}/v_y^{(m)}(1 - \frac{\psi(m)v_y^{(m)}}{\lambda}) f(m) dm dn}{S'(p) - H'(p) - \int_{\underline{n}}^{\overline{n}} \xi'(n) G(n,p) \int_n^{\overline{n}} E_{mn} x_y^{(m)}/v_y^{(m)} f(m) dm dn}.$$

Note that the optimal marginal tax formula is more complicated and depends on many endogenous variables in contrast to the case of linear indirect utility. The dividend effect now depends on the income level when the indirect utility is non-linear. We can check that the formula reduces to the one of Theorem 1 when $v(p, y) = a(p)y$. In this case, x_y and v_y do not depend on productivity, $(\lambda + \gamma x_y)/v_y = 1$, $E_{mn} = 1$, and $G(n, p) = (v_y(p)\Pi(p))'_p$.

A.3 Numerical simulations: further results

Here, we provide additional numerical simulations of the effect of dividend distribution on optimal income tax rates. Within the same framework of the U.S. housing market, we study the robustness of the dividend effect to different forms of housing supply and to income distribution.

Table 2 The optimal vs Mirrleesian marginal income tax

	$\varepsilon = 0.01$	$\varepsilon = 1.75$	$\varepsilon = 3$
Δt	16.2%	4.2%	2.7%

The average change between the optimal marginal income tax rates and the Mirrleesian tax rates that arises in self-confirming policy equilibrium for various elasticities of housing supply

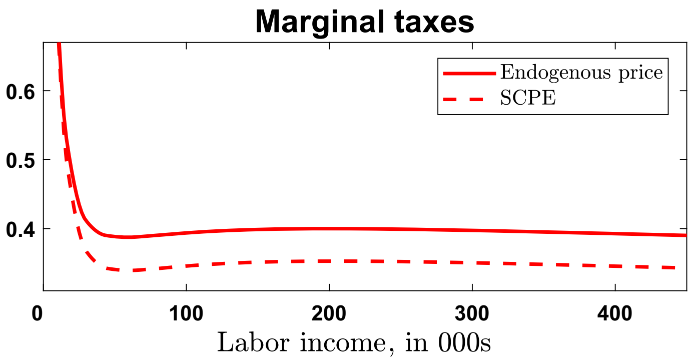

Fig. 3 Optimal income taxation with lognormal distribution of productivities. *Note:* The solid line presents the optimal marginal income tax rates for an economy with a competitive market (see Theorem 2). The dashed line presents the Mirrleesian tax rates in the self-confirming policy equilibrium for the same economy

In Sect. 3.2 we consider the competitive market with supply function $S = sp^{\varepsilon}$ and price elasticity $\varepsilon = 1.75$ which corresponds to the price elasticity of the average U.S. metropolitan area (Saiz 2010). However, as also noted earlier, the price elasticity of housing supply widely differs across various countries and regions and, therefore, we reestimate the size of the dividend effect for the cases of (i) inelastic supply $\varepsilon = 0.01$ and (ii) elastic supply with $\varepsilon = 3$. The first case better describes housing supply in large U.S. coastal cities (e.g., Boston, San-Francisco) and in countries with a rigid housing planning system, e.g., the UK (see Hilbert and Schöni 2016). In the second case, we draw on the estimates of the price elasticity of the U.S. housing supply obtained by Epple and Romer (1991).

Table 2 reports the average change between the optimal marginal income tax rate (as in Theorem 1) and Mirrleesian tax rate that arises in self-confirming policy equilibrium for various supply elasticities of housing.[18] For the case of inelastic supply $\varepsilon = 0.01$, we note a massive increase in the size of the dividend effect compared to $\varepsilon = 1.75$ from Sect. 3.2. Intuitively, with fixed supply any change in aggregate demand is solely translated into price change, which calls for stronger price corrective measures on the part of the public authority. In contrast, in the case of an elastic supply of housing, $\varepsilon = 3$, we see a reduction in the size of the dividend effect compared to $\varepsilon = 1.75$ as changes in demand lead to smaller changes in price.

[18] We calibrate parameter s of supply function $S(p) = sp^{\varepsilon}$ in order to match the average expenditure share of housing of 25%. In particular, we have $s = 15.5$ for $\varepsilon = 0.01$, $s = 18.5$ for $\varepsilon = 1.75$, and $s = 21.7$ for $\varepsilon = 3$.

Lastly, we also reestimate the dividend effect for the lognormal distribution of agent productivities with the parameter values of mean $m = 2.757$ and standard deviation $\sigma = 0.5611$. We adjust parameter $s = 16.2$ of supply function $S(p) = sp^{\varepsilon}$, $\varepsilon = 1.75$, in order to match the average housing expenditure share of 25%. Figure 3 presents our findings. Compared to the lognormal-Pareto case, the removal of Pareto tail leads to a decline of marginal tax rates at high income levels, which is in line with the previous literature (Saez 2001). At the same time, the average change between the optimal marginal income tax rates and Mirrleesian tax rates in SCPE becomes equal to 4.4%, which is slightly larger than what we obtain in Sect. 3.2.

References

Ábrahám, Á., Koehne, S., Pavoni, N.: Optimal income taxation when asset taxation is limited. J. Public Econ. **136**, 14–29 (2016)

Albouy, D., Ehrlich, G., Liu, Y.: Housing demand, cost-of-living inequality, and the affordability crisis. NBER Working Paper No. 22816 (2016)

Atkinson, A.B., Stiglitz, J.E.: The design of tax structure: direct versus indirect taxation. J. Public Econ. **6**, 55–75 (1976)

Atkinson, A.B., Stiglitz, J.E.: Lectures on Public Economics. Princeton University Press (2015)

Barkai, S.: Declining labor and capital shares. J. Financ. **75**, 2421–2463 (2020)

Bowley, A.L.: Mathematical Groundwork of Economics. California Press, Oxford (1924)

Chetty, R., Saez, E.: Dividend taxes and corporate behavior: evidence from the 2003 dividend tax cut. Q. J. Econ. **120**, 791–833 (2005)

Chetty, R., Saez, E.: Dividend and corporate taxation in an agency model of the firm. Am. Econ. J. Econ. Policy **2**, 1–31 (2010)

Conesa, J.C., Kitao, S., Krueger, D.: Taxing capital? Not a bad idea after all! Am. Econ. Rev. **99**, 25–48 (2009)

da Costa, C.E., Maestri, L.J.: Optimal Mirrleesian taxation in non-competitive labor markets. Econ. Theory **68**, 845–886 (2019). https://doi.org/10.1007/s00199-018-1147-3

Davydoff, D., Fano, D., Qin, L.: Who owns the European Economy? Evolution of the Ownership of EU-listed Companies Between 1970 and 2012. European Savings Institute and INSEAD, Report for the European Commission and the Financial Services User Group (2013)

Dasgupta, P., Stiglitz, J.: On optimal taxation and public production. Rev. Econ. Stud. **39**, 87–103 (1972)

De Loecker, J., Eeckhout, J., Unger, G.: The rise of market power and the macroeconomic implications. Q. J. Econ. **135**, 561–644 (2020)

Diamond, P.A., Mirrlees, J.A.: Optimal taxation and public production I: production efficiency. Am. Econ. Rev. **61**, 8–27 (1971)

Diamond, P., Saez, E.: The case for a progressive tax: from basic research to policy recommendations. J. Econ. Perspect. **25**, 165–190 (2011)

Epple, D., Romer, T.: Mobility and redistribution. J. Political Econ. **99**, 828–858 (1991)

Eurostat: Expenditure of households by consumption purpose: a quarter of household expenditure allocated to housing. News release 236/2016, 29 November 2016 (2016)

Gürer, E.: Rising markups and optimal redistributive taxation. Int. Tax Public Financ. **29**, 1227–1259 (2022)

Hilbert, C., Schöni, O.: Housing policies in the United Kingdom, Switzerland, and the United States: lessons learned. Cityscape **18**, 291–332 (2016)
Iwamoto, Y., Konishi, H.: Distributional considerations of producers' profit in a commodity tax design problem. Econ. Lett. **35**, 423–428 (1991)
Kaplow, L.: Market power and income taxation. Am. Econ. J. Econ. Policy **13**, 329–54 (2021)
Koethenbuerger, M., Stimmelmayr, M.E.: The efficiency costs of dividend taxation with managerial firms. Econ. J. **132**, 1123–1149 (2022)
Mankiw, N.G., Weinzierl, M.C., Yagan, D.: Optimal taxation in theory and practice. J. Econ. Perspect. **23**, 147–174 (2009)
Miles, D., Sefton, J.: House prices and growth with fixed land supply. Econ. J. **131**, 1815–1848 (2021)
Mirrlees, J.A.: An exploration in the theory of optimum income taxation. Rev. Econ. Stud. **38**, 175–208 (1971)
Mirrlees, J.A.: On producer taxation. Rev. Econ. Stud. **39**, 105–111 (1972)
Mirrlees, J.A.: Optimal tax theory: a synthesis. J. Public Econ. **6**, 327–358 (1976)
Munk, K.J.: Optimal taxation and pure profit. Scand. J. Econ. 1–19 (1978)
Munk, K.J.: Optimal taxation with some non-taxable commodities. Rev. Econ. Stud. **47**, 755–765 (1980)
Myles, G.D.: Ramsey tax rules for economies with imperfect competition. J. Public Econ. **38**, 95–115 (1989)
Myles, G.D.: Imperfect competition and the optimal combination of ad valorem and specific taxation. Int. Tax Public Financ. **3**, 29–44 (1996)
Perry, M.K.: Oligopoly and consistent conjectural variations. Bell J. Econ. **13**, 197–205 (1982)
Rothschild, C., Scheuer, F.: Redistributive taxation in the Roy model. Q. J. Econ. **128**, 623–668 (2013)
Saez, E.: Using elasticities to derive optimal income tax rates. Rev. Econ. Stud. **68**, 205–229 (2001)
Saez, E., Slemrod, J., Giertz, S.: The elasticity of taxable income with respect to marginal tax rates: a critical review. J. Econ. Lit. **50**, 3–50 (2012)
Saez, E., Zucman, G.: Wealth inequality in the United States since 1913: evidence from capitalized income tax data. Q. J. Econ. **131**, 519–578 (2016)
Saiz, A.: The geographic determinants of housing supply. Q. J. Econ. **125**, 1253–1296 (2010)
Scheuer, F.: Entrepreneurial taxation with endogenous entry. Am. Econ. J. Econ. Policy **6**, 126–63 (2014)
Scheuer, F., Werning, I.: Mirrlees meets Diamond-Mirrlees: Simplifying Nonlinear Income Taxation. NBER Working Paper No 22076 (2016)
Stiglitz, J.E., Dasgupta, P.: Differential taxation, public goods, and economic efficiency. Rev. Econ. Stud. **38**, 151–174 (1971)
Tarasov, A., Zubrickas, R.: Optimal income taxation under monopolistic competition. Econ. Theory **76**, 495–523 (2023). https://doi.org/10.1007/s00199-022-01463-z
U.S. Treasury: United States Holdings of Foreign Securities as of June 30, 2016 (2017). Retrieved from http://ticdata.treasury.gov/Publish/shla2016r.pdf
Zubrickas, R.: Loss aversion, labor supply, and income taxation. Scand. J. Econ. **124**, 579–598 (2022)
Zubrickas, R.: The relative income effect and labor supply. J. Econ. Behav. Organ. **209**, 176–184 (2023)