Taxing Profits*

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Abstract

We study the least distortionary way of financing government spending using taxes on profit, capital, and labor income. To this end, we build a multi-sector dynamic general equilibrium model with heterogeneous markups and productivities. Taxable profits comprise both pure rents arising from market power and quasi-rents that reflect returns to entrepreneurial effort. We derive formulas for optimal capital, labor and profit income taxes as well as for optimal corrective product market policies. The quasi-rent share, defined as the share of quasi-rents in total profits, is the main determinant of the optimal profit tax rate. Specifically, a higher quasi-rent share implies a lower optimal profit tax. We establish an analytical relationship that links the quasi-rent share to taxable profit elasticity and use this relationship together with the empirical estimates of this elasticity to discipline the structural parameters of the model that control the quasi-rent share. A quantitative application to the US based on this strategy implies an optimal fiscal profit tax of 46% with sector-specific subsidies correcting insufficient variety creation, yielding combined profit tax rates of 11–43% across sectors. The optimal labor income tax is 43% from period one onward, while it is optimal not to tax capital income from period two onward.

JEL classification: E62, H21, H25

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1 Introduction

A growing body of evidence documents rising markups and profit shares in the United States and other advanced economies over recent decades (Barkai and Benzell, 2018; De Loecker and Eeckhout, 2018; Hall, 2018; Barkai, 2020; Autor et al., 2020; De Loecker et al., 2020). These developments make profit income an increasingly important source of government tax revenue. For example, Clausing (2024a,b) argues that the growing importance of economic rents - the above normal returns that we refer to as pure rents below - strengthens the case for taxation of businesses.

From a revenue-raising perspective, the classical public finance benchmark provides a strong rationale for taxing pure rents: they can be taxed fully without distorting economic activity (Diamond and Mirrlees, 1971; Dasgupta and Stiglitz, 1971). However, in practice, taxable profits rarely consist exclusively of pure rents. Instead, they may also include *quasi-rents*, returns that may appear as rents but are in fact compensation for investment, risk taking, entrepreneurial effort, or costs incurred to start a business. If quasi-rents can be separated from rents, public finance theory would suggest deducting them from the profit tax base and again taxing the remaining pure rents at 100%. When this is not possible, a genuine trade-off emerges: profit taxation extracts pure rents but at the same time dilutes incentives for these productive activities.

In this paper, we study optimal taxation of profit income in a framework in which the profit tax base is naturally a mix of quasi-rents and pure rents. Firms with market power charge prices above marginal costs and earn pure rents. These firms are owned by entrepreneurs whose effort raises firm production and profits. As the owner, the entrepreneur is the residual claimant to sales revenue net of all production costs, the profits, which includes pure rents due to market power and quasi-rents due to returns to entrepreneurial effort. In order to gauge the quantitative significance of optimal profit taxes and how such taxes may differ in the cross section of of firms, we embed this framework into a multi-sector dynamic general equilibrium model that features sectoral heterogeneity in market power and

productivity.

In the resulting model, in each sector, monopolistically competitive intermediate goods firms produce differentiated varieties. A representative firm combines varieties within and across sectors to produce the single final good. The production of each intermediate good variety uses capital and labor, which are rented in competitive factor markets, and the effort of the entrepreneur that owns the firm. In the main body of the paper, we consider a model in which entrepreneurial effort increases profits by creating additional varieties of its output according to a concave technology. This particular way of modeling how effort affects firm output and profits is not required for main qualitative results. To make this point, in the Appendix, we also consider a model in which effort raises output by entering the production function as an input in addition to capital and labor. What is key is that even under full deductibility of the cost of investment, the profit tax base is a mixture of pure rents and returns to entrepreneurial effort. To bypass issues pertaining to redistribution and focus on efficiency, we assume that intermediate goods firms are owned by a continuum of identical households who supply the entrepreneurial effort. The households also supply labor and accumulate and rent capital to firms via competitive markets.

We formulate the optimal policy problem of the government as a Ramsey problem and derive formulas for optimal capital, labor and profit income taxes as well as for optimal product market policies. The formula for the optimal profit tax reveals the centrality of the distinction between pure rents and quasi-rents. Specifically, the share of quasi-rents in total profit income, henceforth called the quasi-rent share, and its responsiveness to entrepreneurial effort directly control the optimal profit tax rate. The formula shows that profit income generated by firms with higher quasi-rent shares should be taxed at lower rates. This formalizes Clausing (2024a,b), who argues for higher tax rates on firms whose profits are more likely to contain substantial pure rents. The formula also reveals that the markup, the rate at which the price of a product exceeds its marginal cost of capital and labor inputs, matters for the optimal profit tax rate only through the quasi-rent share. If the

quasi-rent share as a function of effort is independent of the markup, then the optimal tax rate is orthogonal to the latter. This is perhaps interesting given the importance of markups for discussions related to the rise of market power. Our theory indicates that, for optimal profit tax considerations, it is another variable, the quasi-rent share, that is critical.

Although a clearly defined concept from a theoretical perspective, the quasi-rent share is hard to measure empirically. To circumvent this problem, we establish an analytical relationship that links the quasi-rent share to the elasticity of profit income with respect to the profit tax rate (taxable profit income elasticity in short). We then use this relationship and the empirical estimates of taxable profit elasticity to discipline the structural parameters of our model that control the quasi-rent share, a step we need for the quantitative analysis. The analytical relationship between the quasi-rent share and the taxable profit elasticity is also useful to understand precisely why the quasi-rent share is crucial for the optimal taxation of profit income. This relationship allows us to express the optimal profit tax rate in a standard inverse-elasticity form. Moreover, it also reveals that when the quasi-rent share is larger, profit income is more responsive to the profit tax for two reasons. First, entrepreneurial effort is more sensitive to the profit tax rate when the quasi-rent share is larger. The intuition is straightforward: when a larger fraction of profit income reflects compensation for entrepreneurial effort, profit taxes fall more heavily on the return to effort and are therefore more distortionary. Second, by definition, profit income is also more sensitive to entrepreneurial effort when entrepreneurial effort plays a larger role in profit generation.

In the baseline scenario, we assume separability between labor and entrepreneurial effort in the utility function. Under this assumption and our policy implementation, the optimal labor tax formula reduces to a standard inverse-elasticity rule. The optimal rate on capital income follows the standard the Chamley–Judd result (Chamley, 1986; Judd, 1985): that is, the optimal rate converges to zero in the long run, and if utility is separable over time and between consumption and other inputs and satisfies constant-elasticity of intertemporal

substitution, then optimal capital tax is zero from the second period of transition onward.

The presence of markups distorts the economy via three channels: (i) an aggregate markup that lowers production uniformly across sectors, (ii) misallocation of productive resources across sectors generated by dispersion in markups, and (iii) inefficient entrepreneurial effort. This decomposition follows Edmond et al. (2023) who characterize corrective subsidies in a similar setup when lump-sum taxation is available. We find that production efficiency vis-à-vis capital and labor inputs holds even under distortionary taxation; that is, marginal products of capital and labor are equalized across all firms and sectors in the Ramsey allocation, implying that optimal input subsidies eliminate misallocation across sectors. However, in general, the government finds it optimal to distort the allocation of entrepreneurial effort across sectors to achieve efficient financing of spending. Therefore, production efficiency in the sense of Diamond and Mirrlees (1971) is violated. Our framework has the advantage that it allows us to aggregate the production side of the economy, generalizing the aggregation result of Edmond et al. (2023) to a second-best setup, which facilitates the computation of the Ramsey allocation, and hence optimal policy, substantially.

We quantify the model in a calibration to 20 US sectors, using sectoral markup estimates and an estimated taxable profit elasticity to discipline entrepreneurial incentives. Our baseline assigns the same taxable-profit elasticity to all sectors, implying a common revenue-raising component of the optimal profit tax of 46%. Combined with sector-specific variety creation subsidies, this yields steady-state profit tax rates ranging from 11% to 43% across sectors. The optimal labor income tax is 43%. Both the fiscal and combined profit tax rates, as well as the labor income tax, are equal to their steady-state values by period two, while capital income is untaxed from that date onward. Optimal input subsidies range from approximately 5% to 39% of input costs across sectors. The welfare gains from the optimal Ramsey reform are substantial. To relate our findings to earlier studies, we compare these gains with those from implementing the first-best allocation using lump-sum financing. Accounting for the full transition, optimal policy raises welfare by the equivalent of a

permanent 6.1% increase in consumption, compared with 12.1% when lump-sum financing is available. Requiring distortionary financing therefore reduces the attainable welfare gain by approximately 50%.

Related literature. Our paper contributes to the Ramsey taxation literature that investigates efficient financing of government spending through distortionary taxes.[1] Within this extensive literature, the papers most closely related to ours study optimal taxation in the presence of market power (Guo and Lansing, 1999; Judd, 2002; Atesagaoglu and Yazici, 2025). In all these papers, it is optimal to fully tax profits as they consist exclusively of pure rents. To make the problems interesting, the authors make exogenous restrictions on the profit tax rate that take the form of exogenous upper bounds or equality with the capital tax rate. Coto-Martinez et al. (2007) consider optimal taxation with free entry. Under deductibility of entry costs, profits are driven to zero due to fixed cost of entry, so the profit tax has no impact on the economy. When entry costs are not deductible from taxable profits, the profit tax is used to correct entry but does not provide a source of revenue from pure rents. We contribute to this literature by considering profit taxation in a model in which taxable profits are naturally a mix of pure rents and quasi-rents and by characterizing the optimal profit tax rate that arises from the trade-off between pure rent extraction and entrepreneurial effort incentives. We identify the quasi-rent share and its response to entrepreneurial effort as the key determinants of the optimal revenue-raising tax on profits. An influential backdrop to our analysis is Mirrlees (1972) who also builds a framework where firm profits are a mixture of pure rents and quasi-rents. His focus, however, is to investigate the generality of the production efficiency result of Diamond and Mirrlees (1971).

Our paper is also related to a growing literature that measures the aggregate and welfare implications of product market distortions.[2] Similar to our paper, Edmond et al. (2023) and

[1] For seminal contributions, see Ramsey (1927), Judd (1985), Chamley (1986), Jones et al. (1997), and the survey by Chari and Kehoe (1999).

[2] For analyses of the aggregate implications of market power, see Atkeson and Burstein (2008), Bilbiie et al. (2012), and De Loecker et al. (2020).

Bilbiie et al. (2019) focus on policy implications and welfare costs. Boar and Midrigan (2025) also study optimal product market policies, emphasizing the interaction between market power and redistribution.[3] The main distinction of our paper is that we move away from the assumption of financing firm level subsidies with lump-sum taxes and instead consider the joint design of product market policies and distortionary income tax policy. In this setting, optimal policies retain the corrective components that address markup and variety creation distortions, but add a fiscal profit tax component that distorts entrepreneurial incentives. In this regard, closer to us is Eeckhout et al. (2026), who, in a static Mirrleesian setting, characterize optimal nonlinear labor and profit income taxes in the presence of market power, balancing redistributive objectives, incentive constraints, and corrective motives.

More generally, our paper relates to a large quantitative macroeconomic literature on the optimal taxation of entrepreneurial income (e.g., Brüggemann, 2021; Boar and Midrigan, 2023; İmrohoroğlu et al., 2023; Guvenen et al., 2024; Bhandari et al., 2026). While these studies differ in the policy experiments they consider, even those that address similar questions often reach quite different conclusions. Through the lens of our theory, an important reason is that they differ in the extent to which entrepreneurial profits are pure rents or quasi-rents that compensate owners for their own inputs into the business, such as effort, sweat capital, or, under collateral constraints, wealth. Our framework may therefore help reconcile the different findings in this literature, and it highlights the quasi-rent share as a key statistic for future quantitative work on entrepreneurial taxation.

Outline. The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 characterizes the efficient allocation and the policies that implement it. Section 4 derives optimal policy when lump-sum taxes are unavailable. Section 5 presents the calibration and quantitative results. Section 6 concludes.

[3] A related literature calculates welfare losses from misallocation. For seminal contributions see Guner et al. (2008); Restuccia and Rogerson (2008); and Hsieh and Klenow (2009). A subset of this literature put a particular emphasis on misallocation arising from markup dispersion (Baqaee and Farhi, 2020; Peters, 2020; Bornstein and Peter, 2025; Hubmer and Nord, 2026).

2 Model

We consider an infinite-horizon, discrete-time economy that is populated by a unit measure of identical households indexed by $i \in [0,1]$. There are J production sectors each of which is populated by a unit measure of intermediate goods producing firms also indexed by $i \in [0,1]$. Household i owns and operates firm i in each sector. A representative final goods producer combines intermediate goods to produce the single final good. Finally, there is a benevolent government that needs to finance an exogenous stream of spending.

Representative household. Households live forever. In period zero each household is endowed with $k_0 > 0$ units of physical capital, b_0 units of government debt and J intermediate good firms, one in each sector $j \in \mathcal{J} := \{1, 2, ..., J\}$, which they retain forever. Every period, the household makes consumption, investment and labor supply decisions; they supply capital and labor to firms in competitive factor markets. Each household is also an entrepreneur in that they operate the J intermediate goods firms they own. Specifically, they decide on their supply of entrepreneurial effort in each firm which affects their profit income in a way that is described below. Because households are identical and face strictly concave problems, they make identical decisions in equilibrium. Thus, for notational convenience, we suppress the household index i as long as doing so does not create confusion. We denote by $e_{j,t}$ the effort household exerts in their firm in sector $j \in \mathcal{J}$ and by $\mathbf{e}_t = (e_{1,t}, e_{2,t}, ..., e_{J,t})$ the vector of entrepreneurial effort levels. Preferences are time-separable, with discount factor $\beta \in (0,1)$ and period utility $u(c, l, \mathbf{e})$ where $u_c > 0$, $u_{cc} < 0$, $u_l < 0$, $u_{ll} < 0$, as well as $u_{e_j} < 0$ and $u_{e_j e_j} < 0$ for all $j \in \mathcal{J}$.

The household takes as given the final good prices, the interest rates and the wage rates, $\{p_t, r_t, w_t\}_{t=0}^{\infty}$, as well as taxes on capital income, labor income, and profits, $\{\tau_t^k, \tau_t^l, \{\tau_{j,t}^{\pi}\}_{j=1}^{J}\}_{t=0}^{\infty}$, where the latter may be sector dependent. The household also takes a sequence of lump-sum taxes $\{T_t\}_{t=0}^{\infty}$ as given. Below we show that strictly positive lump-sum taxes are required to decentralize the efficient (first best) allocation as an equilibrium. However, for most of the

analysis that follows we will assume that such lump-sum taxes are inadmissible, i.e. we will restrict attention to $T_t = 0$ for all t.

The problem of the household is

$$\max_{\{c_t, k_{t+1}, l_t, \mathbf{e}_t\}} \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t, \mathbf{e}_t\right)$$

subject to the budget constraint

$$\sum_{t=0}^{\infty} p_t \left(c_t + k_{t+1}\right) \leq \sum_{t=0}^{\infty} p_t \left[(1-\tau_t^l) w_t l_t + R_t k_t + \sum_{j=1}^{J} (1-\tau_{j,t}^{\pi}) \pi_{j,i,t}(e_{j,t}) - T_t\right] + p_0 b_0, \quad (1)$$

where $R_t = 1 + (1-\tau_t^k) r_t$ is the after-tax return on savings.

Using the first-order optimality conditions of the consumer's problem, we can compute the intra- and intertemporal optimality conditions:

The following definitions prove particularly useful.

Quasi-rents, pure rents and quasi-rent share. Quasi-rents in sector j are defined as

$$\pi_{j,t}^q(e_{j,t}) = e_{j,t} \pi'_{j,t}(e_{j,t}) \quad (2)$$

and pure rents in sector-j are defined as

$$\pi_{j,t}^p(e_{j,t}) = \pi_{j,t}(e_{j,t}) - \pi_{j,t}^q(e_{j,t}).$$

The quasi-rent share in total sector-j profits is then given by

$$q_{j,t} = \frac{\pi_{j,t}^q(e_{j,t})}{\pi_{j,t}(e_{j,t})} = \frac{e_{j,t} \pi'_{j,t}(e_{j,t})}{\pi_{j,t}(e_{j,t})}. \quad (3)$$

It equals the elasticity of sector-j profits with respect to entrepreneurial effort.

Quasi-rents $\pi_{j,t}^q$ are the hypothetical income the owner would earn if all inframarginal

units of effort generated the same marginal profit as the marginal unit. Since taxes distort behavior only at the margin, the government would ideally extract the pure-rent component through a lump-sum tax, $T_{j,t} = \pi^p_{j,t}$, which would not distort effort. Full extraction of pure rents while preserving the marginal return to entrepreneurial effort would require such a lump-sum component. However, when lump-sum taxes are unavailable, the government raises revenue through taxes on income flows and sine pure- and quasi-rents are part of the same profit flow, these taxes affect the marginal return to entrepreneurial effort. Still, ceteris paribus, a lower quasi-rent share $q_{j,t}$ allows the planner to raise more revenue for a given distortion.

Industrial structure. Each sector $j \in \mathcal{J}$ is populated by a unit measure of intermediate good producers. A firm in a sector is indexed by the household that owns it, $i \in [0, 1]$. Each firm operates an endogenous measure $n_{j,i,t}$ of product lines or varieties. Operating product lines require entrepreneurial effort. Specifically, exerting $e_{j,i,t}$ amount of entrepreneurial effort in sector j allows the firm owner to operate $n_{j,i,t} = \tilde{n}_{j,t}(e_{j,i,t})$ product lines. We assume $\tilde{n}'_{j,t}(\cdot) > 0$ and $\tilde{n}''_{j,t}(\cdot) < 0$. We denote these product lines or varieties by $a \in [0, n_{j,i,t}]$. Intermediate goods producers employ capital and labor to produce differentiated intermediate goods and sell them to the producers of final good whose problem we describe next.

Final good producers. Firms that produce the final good are perfectly competitive and operate a constant elasticity of substitution (CES) production function that combines intermediate goods $y_{j,i,a,t}$, which refers to the a-th product supplied by intermediate good producer i in sector j. This production structure extends those in Dixit and Stiglitz (1977), Ethier (1982) or Benassy (1996) by introducing multiple sectors and product lines. Taking prices of intermediate goods, $\xi_{j,i,a,t}$, as given, the problem of the representative final good

producer is to choose an input bundle $\tilde{y}_t = \{y_{j,i,a,t}\}_{j=1,...,J;i\in[0,1];a\in[0,n_{j,i,t}]}$ to maximize profits:

$$\max_{\tilde{y}_t} \left(y_t - \sum_{j=1}^{J} \int_0^1 \int_0^{n_{j,i,t}} \xi_{j,i,a,t} y_{j,i,a,t} da di \right)$$

$$\text{s.t.} \quad y_t = \left(\sum_{j=1}^{J} y_{j,t}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \tag{4}$$

$$y_{j,t} = N_{j,t}^{\nu_j - \frac{1}{\varepsilon_j - 1}} \left(\int_0^1 \int_0^{n_{j,i,t}} y_{j,i,a,t}^{\frac{\varepsilon_j - 1}{\varepsilon_j}} da di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \tag{5}$$

where $y_{j,t}$ is value-added created by sector j and $N_{j,t} = \int_0^1 n_{j,i,t} di$ is the measure of total product variety in sector j. The parameter ε_j denotes the elasticity of substitution of goods within sector j while γ is the elasticity of substitution of goods across sectors. Following the literature we assume $\varepsilon_j > \gamma > 1$ for all $j \in \mathcal{J}$, that is, goods within any given sector are easier to substitute than goods across different sectors. The parameter $\nu_j \in [0, 1)$ describes spillover effects of additional product varieties on other sector-j firms' productivity. With $\nu_j = \varepsilon_j^{-1}$ laissez-faire entry is efficient, while with $\nu_j > \varepsilon_j^{-1}$ entry is inefficiently low. Notice that the standard Dixit-Stiglitz CES aggregator is a special case in which $\nu_j = \frac{1}{\varepsilon_j - 1}$.

The first-order optimality condition of the final good producer's problem with respect to intermediate good $y_{j,i,a,t}$ gives its demand as a function of price:

$$y_{j,i,a,t} = y_t^{\frac{\varepsilon_j}{\gamma}} y_{j,t}^{1-\frac{\varepsilon_j}{\gamma}} n_{j,t}^{\nu_j(\varepsilon_j - 1) - 1} \xi_{j,i,a,t}^{-\varepsilon_j}, \tag{6}$$

for all $j \in \{1, ..., J\}, i \in [0, 1], a \in [0, n_{j,i,t}]$.

Intermediate goods producers. First, observe that the measure of varieties that firm i provides in sector j, relative to the measure $N_{j,t}$ of all varieties in that sector, is zero. This implies that each firm takes other firms' prices and quantities as given. The problem of the intermediate good firm can be broken down into two steps. In step one, the entrepreneur who owns the firm decides on the effort $e_{j,i,t}$, which determines the measure of product lines

$\tilde{n}_{j,t}(e_{j,i,t})$. In step two, given this measure, intermediate good producer i in sector j chooses $x_{j,i,t} = \{\xi_{j,i,a,t}, y_{j,i,a,t}, k_{j,i,a,t}, l_{j,i,a,t}\}_{a\in[0,n_{j,i,t}(e_{j,i,t})]}$ to maximize their profit as follows:

$$\begin{aligned}
\pi_{j,i,t}(e_{j,i,t}) = \max_{x_{j,i,t}} & \int_0^{\tilde{n}_{j,t}(e_{j,i,t})} \left(\xi_{j,i,a,t} y_{j,i,a,t} - (1-s_{j,t})\left[(r_t+\delta)k_{j,i,a,t} + w_t l_{j,i,a,t}\right]\right) da \\
\text{s.t.} \quad & y_{j,i,a,t} = z_{j,t} F_t(k_{j,i,a,t}, l_{j,i,a,t}) \quad \forall a \in [0, \tilde{n}_{j,t}(e_{j,i,t})], \\
& \xi_{j,i,a,t} = y_t^{\frac{1}{\gamma}} y_{j,t}^{\frac{1}{\varepsilon_j}-\frac{1}{\gamma}} N_{j,t}^{\frac{\nu_j(\varepsilon_j-1)-1}{\varepsilon_j}} y_{j,i,a,t}^{-\frac{1}{\varepsilon_j}} \quad \forall a \in [0, \tilde{n}_{j,t}(e_{j,i,t})].
\end{aligned}$$

Here $k_{j,i,a,t}$ and $l_{j,i,a,t}$ denote, respectively, capital and labor employed in product line a by firm i in sector j, the cost of capital is given by the sum of the interest rate r_t and the depreciation rate $\delta \in (0,1)$, $s_{j,t}$ denotes the sector-specific rate at which inputs are subsidized, and $\xi_{j,i,a,t}$ is the price the firm charges for its a-th product. The first constraint describes the production technology. Output is given by the product of a constant returns to scale production technology $F_t(\cdot)$ and a sector specific productivity $z_{j,t}$. We assume the production technology $F_t(\cdot)$ is common across sectors. The second constraint is equivalent to equation (6) and describes the downward sloping demand curve, now in terms of the price as a function of quantity. Notice that $N_{j,t}$, the measure of all products in sector j, is taken as given by the firm.

The firm's profit-maximization problem is strictly concave in capital and labor inputs and symmetric across products. Hence, the firm makes the same production and pricing decisions for each product a. Denote these by $y_{j,i,t} := y_{j,i,a,t}, k_{j,i,t} := k_{j,i,a,t}, l_{j,i,t} := l_{j,i,a,t}$ and $\xi_{j,i,t} := \xi_{j,i,a,t}$ for all $a \in [0, n_{j,i,t}]$. Using this observation and substituting the constraints of the problem into the objective, the firm's problem becomes one of choosing inputs that maximize profits at the product level:

$$\pi_{j,i,t}(e_{j,i,t}) = \max_{k_{j,i,t}, l_{j,i,t}} \tilde{n}_{j,t}(e_{j,i,t}) \left\{ \begin{array}{c} y_t^{\frac{1}{\gamma}} y_{j,t}^{\frac{1}{\varepsilon_j}-\frac{1}{\gamma}} N_{j,t}^{\frac{\nu_j(\varepsilon_j-1)-1}{\varepsilon_j}} \left[z_{j,t} F_t\left(k_{j,i,t}, l_{j,i,t}\right)\right]^{\frac{\varepsilon_j-1}{\varepsilon_j}} \\ -(1-s_{j,t})\left[(r_t+\delta)k_{j,i,t} + w_t l_{j,i,t}\right] \end{array} \right\}.$$

The first-order conditions are

$$\begin{aligned} r_t + \delta =& \frac{\varepsilon_j - 1}{\varepsilon_j} z_{j,t} F_k(k_{j,i,t}, l_{j,i,t}) \frac{1}{1 - s_{j,t}} \xi_{j,i,t} \quad \text{and} \\ w_t =& \frac{\varepsilon_j - 1}{\varepsilon_j} z_{j,t} F_l(k_{j,i,t}, l_{j,i,t}) \frac{1}{1 - s_{j,t}} \xi_{j,i,t}. \end{aligned} \tag{7}$$

It follows from these first-order conditions that

$$\frac{r_t + \delta}{w_t} = \frac{F_k(k_{j,i,t}, l_{j,i,t})}{F_l(k_{j,i,t}, l_{j,i,t})} = \frac{F_k(k_{j,i,t}/l_{j,i,t}, 1)}{F_l(k_{j,i,t}/l_{j,i,t}, 1)} = \frac{F_k(k_t, l_t)}{F_l(k_t, l_t)},$$

which implies that capital-labor ratios are equalized across as well as within sectors, that is $k_{j,i,t}/l_{j,i,t}$ is independent of j and i. The above equation also implies that the optimal capital-labor ratio in period t is pinned down by input price vector (r_t, w_t). Denote the marginal cost of producing an additional unit of output in sector j in period t by $mc_{j,t}$ Given that production is constant returns to scale, marginal and average costs are equal, that is, $mc_{j,t} = ((r_t + \delta)k_{j,i,t} + w_t l_{j,i,t})/(z_{j,t} F_t(k_{j,i,t}, k_{j,i,t})) = (r_t + \delta)/(z_{j,t} F_t(k_{j,i,t}/l_{j,i,t}), 1) + w_t/(z_{j,t} F_t(1, l_{j,i,t}/k_{j,i,t}))$. This implies marginal cost is a function of input prices and productivity: $mc_{j,t}(r_t, w_t, z_t)$. This notation already reflects the fact that marginal cost is homogeneous within each sector. The optimality conditions given by (7) can be manipulated to show that the marginal cost satisfies $\xi_{j,i,t} = (1 - s_{j,t}) \frac{\varepsilon_j}{\varepsilon_j - 1} mc_{j,t}$, meaning consumers pay a constant markup $\mu_{j,t} = (1 - s_{j,t}) \frac{\varepsilon_j}{\varepsilon_j - 1}$ over the marginal cost of production.

Entrepreneurial profits, quasi-rents and pure rents. The profits of firm i in sector j equal

$$\pi_{j,i,t}(e_{j,i,t}) = \frac{n_{j,i,t}(e_{j,i,t})}{\varepsilon_j} \xi_{j,i,t} y_{j,i,t} = n_{j,i,t}(e_{j,i,t}) \hat{\pi}_t, \tag{8}$$

where $\hat{\pi}_t = \frac{1}{\varepsilon_j} \left((1 - s_{j,t}) mc_{j,t} \frac{\varepsilon_j}{1 - \varepsilon_j} \right)^{1 - \varepsilon_j} y_t^{\frac{\varepsilon_j}{\gamma}} y_{j,t}^{1 - \frac{\varepsilon_j}{\gamma}} N_{j,t}^{\nu_t(\varepsilon_j - 1) - 1}$.

Following the definition introduced earlier, the quasi-rent share is therefore

$$q_{j,t} \equiv \frac{\pi^q_{j,t}}{\pi_{j,t}} = \frac{e_{j,t} n'_{j,t}(e_{j,t})}{n_{j,t}(e_{j,t})}. \tag{9}$$

The remaining share, $1-q_{j,t}$, represents pure rents arising from market power and diminishing returns to entrepreneurial effort.[4]

Lemma 1. ***Aggregate productivity and output.*** *Define the share of production factors employed in sector j by $\phi_{j,t} = \frac{l_{j,t}}{l_t} = \frac{k_{j,t}}{k_t}$. Then, aggregate productivity z_t, and output y_t are given by*

$$y_t = z_t F(k_t, l_t), \qquad \textit{where} \qquad z_t = \left(\sum_{j=1}^{J} \left(z_{j,t} \phi_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}. \tag{10}$$

Proof. Relegated to Appendix A.1. □

Relative sector size. Using the fact that capital-labor ratios are equalized across firms, one can write factor prices as

$$r_t + \delta = \frac{z_{j,t} F_k(k_t, l_t) \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} N_{j,t}^{\nu_j}}{\mu_{j,t}} \quad \text{and} \quad w_t = \frac{z_{j,t} F_l(k_t, l_t) \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} N_{j,t}^{\nu_j}}{\mu_{j,t}}, \tag{11}$$

for any $j \in \mathcal{J}$. Together with Lemma 1, equations (11) deliver a condition for how productive resources - capital and labor - are allocated across sectors: for any two sectors $j, j' \in \mathcal{J}$, we have

$$\frac{\left(z_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \phi_{j,t}^{-\frac{1}{\gamma}}}{\mu_{j,t}} = \frac{\left(z_{j',t} N_{j',t}^{\nu_{j',t}} \right)^{\frac{\gamma-1}{\gamma}} \phi_{j',t}^{-\frac{1}{\gamma}}}{\mu_{j',t}}. \tag{12}$$

Aggregate markup and factor prices. Following Edmond et al. (2023) define aggregate markup as the employment-weighted arithmetic average of sector-level markups, $\mu_{j,t}$, that

[4] If instead variety creation were proportional to entrepreneurial effort, then $e_{j,t} n'_{j,t}(e_{j,t}) / n_{j,t}(e_{j,t}) = 1$ and all profits in our model would be quasi-rents. This corresponds to a constant labor requirement per new variety, analogous to the entry technology in Edmond et al. (2023).

is, $\mathcal{M}_t = \sum_{j=1}^{J} \phi_{j,t}\mu_{j,t}$.

Lemma 2. *The aggregate markup is given by*

$$\mathcal{M}_t = z_t \left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma-1} \right)^{-\frac{1}{\gamma-1}}, \tag{13}$$

where $\eta_{j,t} = \frac{z_{j,t} N_{j,t}^{\nu_j}}{\mu_{j,t}}$. *Factor prices are given by*

$$r_t + \delta = \frac{z_t F_k(k_t, l_t)}{\mathcal{M}_t} \quad \textit{and} \quad w_t = \frac{z_t F_l(k_t, l_t)}{\mathcal{M}_t}. \tag{14}$$

Proof. Relegated to Appendix A.2. □

Equilibrium conditions. The following equations characterize equilibrium labor supply, entrepreneurial effort and capital accumulation behavior.

Lemma 3.

$$-\frac{u_{l,t}}{u_{c,t}} = (1 - \tau_t^l)\frac{z_t F_l(k_t, l_t)}{\mathcal{M}_t}, \tag{15}$$

$$-\frac{u_{e_j,t}}{u_{c,t}} = (1 - \tau_{j,t}^{\pi})\frac{n'_{j,t}(e_{j,i})}{n_{j,t}} \frac{1}{\varepsilon_j} \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} y_{j,t}, \tag{16}$$

$$\frac{u_{c,t}}{\beta u_{c,t+1}} = 1 + (1 - \tau_{t+1}^k) \left(\frac{z_{t+1} F_k(k_{t+1}, l_{t+1})}{\mathcal{M}_{t+1}} - \delta \right). \tag{17}$$

Proof. Relegated to Appendix A.3. □

Government. The government needs to finance an exogenous stream of spending requirements $\{g_t\}_{t=1}^{\infty}$ and the initial debt b_0. Its budget constraint is

$$\sum_{t=0}^{\infty} p_t g_t + p_0 b_0 \leq \sum_{t=0}^{\infty} p_t \left[w_t l_t \tau_t^l + r_t k_t \tau_t^k + \sum_{j=1}^{J} \left(\tau_{j,t}^{\pi} \pi_{j,t} - \left[(r_t + \delta) k_{j,t} + w_t l_{j,t} \right] s_{j,t} \right) \right] + \sum_{t=0}^{T} p_t T_t, \tag{18}$$

where we will eventually restrict lump-sum taxes to be $T_t \leq 0$.

Resource feasibility. Aggregate resource feasibility requires that for all $t \geq 0$

$$c_t + k_{t+1} + g_t = y_t + (1 - \delta)k_t. \tag{19}$$

Definition 1. ***Tax-distorted market equilibrium.*** *Given initial capital and government debt (k_0, b_0) and given a stream of government expenditures $\{g_t\}_{t=0}^{\infty}$, a tax-distorted market equilibrium is a policy $\{\tau_t^k, \tau_t^l, \{\tau_{j,t}^{\pi}, s_{j,t}\}_{j=1}^{J}, T_t\}_{t=0}^{\infty}$, an allocation $\{c_t, k_{t+1}, l_t, \{\phi_{j,t}, e_{j,t}\}_{j=1}^{J}\}_{t=0}^{\infty}$, prices $\{p_t, r_t, w_t\}_{t=0}^{\infty}$ and profits $\{\{\pi_{j,t}\}_{j=1}^{J}\}_{t=0}^{\infty}$ such that given policy and prices: (i) the allocation solves the representative household's problem; (ii) all firms maximize profits; (iii) markets for final and intermediate goods, capital and labor clear; (iv) the government's budget constraint is satisfied.*

3 Efficient Allocation

In this section we consider the problem of a benevolent social planner who directly chooses all the economic activity subject to the same resource constraints as in the decentralized economy. We call the solution to this problem the efficient allocation (and first best, interchangeably) and characterize its properties. A comparison of the efficient allocation with the (laissez-faire) market equilibrium allocation enables us to see the channels through which market power distorts outcomes in the market economy. We also provide an implementation result: a set of firm level policies that implement the efficient allocation in the market economy with lump-sum taxes. The first-best policies that implement the efficient allocation will serve as a benchmark for comparison after we characterize the Ramsey allocation and optimal policies under distortions.

First-best planning problem. The economic activity chosen by the planner consists of aggregate levels of consumption, labor supply, investment which determines the capital stock, the distribution of aggregate capital and labor into sectors and entrepreneurial effort (which determines the number of product varieties) in each sector. The planner chooses an infinite stream of these activities to maximize the utility of the representative consumer subject to the resource constraints:

$$\max_{c_t,k_{t+1},l_t,\{\phi_{j,t},e_{j,t}\}_{j=1}^{J}} \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t, \mathbf{e}_t\right) \qquad \text{s.t.} \quad \forall t \geq 0,$$

$$c_t + k_{t+1} + g_t = \left(\sum_{j=1}^{J} \left(z_{j,t}\phi_{j,t}N_{j,t}^{\nu_j}\right)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}} F(k_t, l_t) + (1-\delta)k_t, \tag{20}$$

$$\sum_{j=1}^{J} \phi_{j,t} = 1, \qquad \text{with } \phi_{j,t} \geq 0 \text{ for all } j \in \mathcal{J}, \tag{21}$$

$$N_{j,t} = n_{j,t}(e_{j,t}) \qquad \forall j \in \mathcal{J}, \tag{22}$$

where (20) is obtained by plugging the expression for aggregate productivity computed in Lemma 1 into (19) and (21) simply means sectoral shares have to add up to one.

The first-order conditions of the planning problem imply that in the efficient allocation, for all $j, j' \in \mathcal{J}$ and $t \geq 0$, we have

$$-\frac{u_{l,t}}{u_{c,t}} = z_t F_l(k_t, l_t) \tag{23}$$

$$\frac{u_{c,t}}{\beta u_{c,t+1}} = 1 + z_{t+1}F_k(k_{t+1}, l_{t+1}) - \delta \tag{24}$$

$$\frac{\partial y_t}{\partial \phi_{j,t}} = \frac{\partial y_t}{\partial \phi_{j',t}} \quad \text{and} \tag{25}$$

$$-\frac{u_{e_j,t}}{u_{c,t}} = \frac{n'_{j,t}(e_{j,t})}{n_{j,t}} \nu_j \left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} y_{j,t}. \tag{26}$$

Conditions (23) and (24) are standard intra- and intertemporal optimality conditions that describe efficient behavior of aggregate consumption, investment and labor. Comparing these conditions with their counterparts in the laissez-faire market economy, (15) and (17)

with taxes set to zero, reveals that the aggregate markup $\mathcal{M}_t$ acts like a uniform output tax, reducing the overall scale of production, and hence, reducing the use of all inputs in all sectors relative to the efficient allocation.

Condition (25) characterizes efficient allocation of factors of production across sectors and implies that sectoral allocation of inputs is efficient when marginal return to increasing the share of inputs going into any two sectors is equalized. One can show that

$$\frac{\partial y_t}{\partial \phi_{j,t}} = \left(\sum_{j=1}^{J} \left(z_{j,t} \phi_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{1}{\gamma-1}} \left(z_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \phi_{j,t}^{-\frac{1}{\gamma}} F(k_t, l_t). \tag{27}$$

Thus (25) implies

$$\left(z_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \phi_{j,t}^{-\frac{1}{\gamma}} = \left(z_{j',t} N_{j',t}^{\nu_{j',t}} \right)^{\frac{\gamma-1}{\gamma}} \phi_{j',t}^{-\frac{1}{\gamma}}. \tag{28}$$

Observe that, under laissez faire, the equilibrium condition which describes how capital and labor are allocated across sectors, (12) with subsidies set to zero, is not aligned with (28). This implies that laissez-faire equilibrium features misallocation across sectors relative to the efficient allocation. Intuitively, intermediate goods firms use their market power to increase their profits by setting their prices above their marginal costs which implies they keep their size of operation smaller than the efficient levels. The level of this distortion depends on the level of markups in each sector, which in the model is controlled by ε_j. The dispersion in markups across sectors gives rise to misallocation of productive factors.

Condition (26) characterizes the efficient number of product varieties (entry). Comparing it with the laissez-fare version of the equilibrium condition (16) reveals that this number is inefficiently high if $1/\varepsilon_j > \nu_j$ and inefficiently low if $1/\varepsilon_j < \nu_j$. Intuitively, in the monopolistic competition model with free entry, the private and social benefits of entry do not coincide for two reasons. First, when a new firm enters a sector, they do not internalize the negative impact of their entry on the demand of incumbent firms. This *business-stealing* effect implies

there is too much entry in equilibrium. The business-stealing effect is decreasing in the competitiveness of the sector (ε_j), and hence, increasing in the markup, since the more market power each firm possesses the larger is the negative impact their entry has on incumbent firms. Second, as can be seen from the sectoral production function given by (4), an increase in the number of varieties increases the marginal product of incumbent firms in that sector. New entrants do not take into account this positive production externality their variety creates for existing firms. This effect, which is called the *complementarity* effect, implies there is too little entry in equilibrium. The complementarity effect is increasing in the taste for variety parameter ν_j. Overall, whether there is too little or too much entry in equilibrium relative to efficient level of entry depends on which effect dominates.[5]

Proposition 1. *The set of tax instruments* $\{T_t, \tau_t^l, \tau_{t+1}^k, \{s_{j,t}, \tau_{j,t}^\pi\}_{j=1}^J\}_{t=0}^\infty$ *implements the efficient allocation if and only if:*

(a) Input subsidies generate a homogenous markup across sectors, i.e.

$$(1 - s_{j,t})\frac{\varepsilon_j}{\varepsilon_j - 1} = \mu_{j,t} = \mathcal{M}_t \quad \forall j \in \mathcal{J}, \forall t \geq 0. \tag{29}$$

(b) Labor, capital and profit income taxes satisfy

$$1 - \tau_t^l = \mathcal{M}_t, \qquad \forall t \geq 0, \tag{30}$$

$$1 - \tau_t^k = \frac{z_t F_{k,t} - \delta}{\frac{z_t F_{k,t}}{\mathcal{M}_t} - \delta}, \quad \forall t \geq 1, \tag{31}$$

$$1 - \tau_{j,t}^\pi = \varepsilon_j \nu_j, \qquad \forall j \in \mathcal{J}, \forall t \geq 0. \tag{32}$$

(c) Lump sum taxes are given by $T_0 = g_0 + y_0 \sum_{j=1}^J \phi_{j,0}\nu_{j,0} + b_0 - \tau_0^k r_0 k_0$ *and* $T_t = g_t + y_t \sum_{j=1}^J \phi_{j,t}\nu_j \ \forall t \geq 1$ *or by any other sequence* $\{\hat{T}_t\}_{t=0}^\infty$ *that has equivalent net present value.*

[5]See Coto-Martinez et al. (2007) for a similar discussion of entry efficiency in a single-sector model that distinguishes returns to specialization from market power.

Proof. Relegated to Appendix A.4 □

The laissez-faire equilibrium features three sources of inefficiency. The optimal profit taxes given by (32) correct the entry distortion. Sectoral input subsidies (29) remove the markup dispersion which creates misallocation of inputs across sectors. They may be set to $s_{j,t} = 1/\varepsilon_j$ in which case $\mu_{j,t} = \mathcal{M}_t = 1$. In that case the input subsidies also remove the distortion emanating from the aggregate markup and labor and capital income taxes are set to zero, $\tau_t^l = \tau_t^k = 0$. However, input subsidies may as well be set in a way to generate a homogenous markup $\mu_{j,t} = \mathcal{M}_t \neq 1$. In the latter case, the aggregate distortion is handled at the consumer side through appropriate adjustments in labor and capital income taxes.

4 Optimal Taxation

This section considers our primary optimal policy analysis, that is, the problem of a government that uses distortionary taxation to finance a given stream of public spending and initial debt. Specifically, the government uses sector-specific profit taxes and input subsidies, together with taxes on capital and labor income, both to meet its financing needs and to correct product market distortions. Lump-sum taxes are ruled out. The government commits at the time of reform to a sequence of policies that maximizes the representative household's welfare, taking into account the effects of its policy choice on market equilibrium.

Under the assumptions outlined so far, given initial conditions (k_0, b_0) and a stream of government spending $\{g_t\}_{t=0}^{\infty}$, the government chooses jointly taxes and product market policies, $\{\tau_{t+1}^k, \tau_t^l, \{\tau_{j,t}^{\pi}, s_{j,t}\}_{j=1}^J\}_{t=0}^{\infty}$, to maximize the welfare of the representative consumer subject to the requirement that the tax system, the allocation $\{c_t, k_{t+1}, l_t, \{\phi_{j,t}, e_{j,t}\}_{j=1}^J\}_{t=0}^{\infty}$, the price system $\{p_t, r_t, w_t\}_{t=0}^{\infty}$ and profits $\{\{\pi_{j,t}\}_{j=1}^J\}_{t=0}^{\infty}$ constitute a market equilibrium. We refer to this optimal policy problem as the Ramsey problem.[6]

[6]It is well-known that in optimal tax problems of this sort the government would like to set the tax rate on capital income in the very first period as high as possible since this tax is effectively a lump-sum tax on first period capital income. To make the problem interesting, we follow the literature and set the initial capital tax rate to an exogenous value, τ_0^k.

We follow the primal approach in characterizing, and later quantitatively solving for, optimal product market policies and income taxes. To do so, we first prove Proposition 2 which establishes that the resource feasibility constraints together with another constraint, called the implementability constraint, completely characterize the set of allocations that can be achieved as a tax-distorted market equilibrium allocation. This result then allows us to rewrite the Ramsey tax problem as a planning problem in which the planner chooses directly the allocation subject to these constraints.

Proposition 2. *If an allocation* $\{c_t, k_{t+1}, l_t, \{\phi_{j,t}, e_{j,t}\}_{j=1}^J\}_{t=0}^\infty$ *is part of a tax-distorted market equilibrium, then it satisfies resource feasibility constraints* (20)–(21) *and the implementability constraint*

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c,t} c_t + u_{l,t} l_t + \sum_{j=1}^{J} \frac{u_{e_j,t} e_{j,t}}{q_{j,t}} \right] = u_{c,0} W_0, \tag{33}$$

where $q_{j,t}$ *is the quasi-rent share defined in* (9) *and* $W_0 = [1 + (1 - \tau_0^k) r_0] k_0 + b_0$ *denotes initial wealth. Conversely, suppose an allocation* $\{c_t, k_{t+1}, l_t, \{\phi_{j,t}, e_{j,t}\}_{j=1}^J\}_{t=0}^\infty$ *satisfies equations* (20), (21), *and* (33). *Then, prices, product-market policies, and taxes can be constructed such that this allocation, together with those prices and policies, constitutes a tax-distorted market equilibrium.*

Proof. Relegated to Appendix A.5. □

Ramsey problem. Initial capital and debt (k_0, b_0), the initial capital income tax τ_0^k, and government spending $\{g_t\}_{t=0}^\infty$ are given. At the initial date, input subsidies are set to eliminate markup distortions, $s_{j,0} = 1/\varepsilon_{j,0}$ for all $j \in \mathcal{J}$.[7] By Proposition 2, the Ramsey problem can be written as a choice of allocations subject to resource feasibility and the

[7] Analogously to fixing τ_0^k, fixing initial input subsidies rules out their use as an indirect levy on inherited capital. A negative subsidy acts as a tax on firms' inputs, reducing the return received by capital owners and allowing the government to tax inherited capital indirectly despite the fixed capital income tax rate.

implementability constraint:

$$\max_{\{c_t,k_{t+1},l_t,\{\phi_{j,t},e_{j,t}\}_{j=1}^{J}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t, \mathbf{e}_t\right) \tag{34}$$
$$\text{subject to } (20)-(22) \text{ and } (33).$$

The following proposition characterizes the policies that implement an interior solution to this problem. We denote the Ramsey allocation and the optimal taxes that implement it by a superscript star (*). Define $\sigma_{c,t} \equiv -\frac{u_{c,t}}{c_t u_{cc,t}}, \sigma_{l,t} \equiv \frac{u_{l,t}}{l_t u_{ll,t}}, \sigma_{e_j,t} \equiv \frac{u_{e_j,t}}{e_{j,t} u_{e_j e_j,t}}, \mathcal{E}_{q_{j,t},e_{j,t}} \equiv \frac{\partial \ln q_{j,t}}{\partial \ln e_{j,t}}$. Let λ denote the multiplier on the implementability constraint.

Proposition 3. *Suppose preferences are additively separable: $u(c,l,\mathbf{e}) = U(c) - V(l) - \sum_{j=1}^{J} W_j(e_j)$. Given the initial capital income tax τ_0^k and initial input subsidies $s_{j,0} = 1/\varepsilon_{j,0}$ for all $j \in \mathcal{J}$, the remaining policy instruments $\{\tau_t^l, \tau_{t+1}^k, \{\tau_{j,t}^{\pi}\}_{j=1}^{J}\}_{t=0}^{\infty}$ and $\{\{s_{j,t}\}_{j=1}^{J}\}_{t=1}^{\infty}$ that implement an interior Ramsey optimum satisfy the following conditions:*

(a) Input subsidies are identical to those under first best as described by (29)*.*

(b) Capital income taxes satisfy

$$1 - \tau_t^{k*} = \frac{\dfrac{1+\lambda^*(1-{\sigma_{c,t}^*}^{-1})}{1+\lambda^*(1-{\sigma_{c,t-1}^*}^{-1})}(1 + z_t F_{k,t}^* - \delta) - 1}{z_t F_{k,t}^*/\mathcal{M}_t - \delta} \qquad t \geq 2. \tag{35}$$

The capital tax for period one satisfies (A.31) *in the Appendix A.6.*

(c) Labor income taxes satisfy

$$1 - \tau_t^{l*} = \frac{1+\lambda^*(1-{\sigma_{c,t}^*}^{-1})}{1+\lambda^*\left(1+{\sigma_{l,t}^*}^{-1}\right)}\mathcal{M}_t \qquad t \geq 1. \tag{36}$$

The labor tax for period zero satisfies (A.29) *in Appendix A.6.*

(d) Profit taxes satisfy, for all $j \in \mathcal{J}$ and $t \geq 1$,

$$1 - \tau_{j,t}^{\pi *} = \frac{1 + \lambda^* (1 - {\sigma_{c,t}^*}^{-1})}{1 + \lambda^* \dfrac{1 + {\sigma_{e_j,t}^*}^{-1} - \mathcal{E}_{q_{j,t},e_{j,t}}^*}{q_{j,t}^*}} \varepsilon_j \nu_j. \tag{37}$$

The profit tax for period zero satisfies (A.30) *in Appendix A.6.*

Proof. Relegated to Appendix A.6. □

The multiplier λ^* captures the magnitude of the fiscal motive for distortionary taxation at the optimum. When $\lambda^* = 0$, the policy formulas reduce to those implementing the efficient allocation.

Optimal input subsidies. Optimal input subsidies satisfy the same condition as in the efficient allocation: they eliminate markup dispersion and the associated misallocation across sectors. Setting $s_{j,t} = 1/\varepsilon_j$ also eliminates the aggregate markup distortion, so that $\mathcal{M}_t = 1$. For other common markup levels, the capital and labor tax formulas include corresponding adjustments.

Optimal capital income taxes. With $\mathcal{M}_t = 1$, equation (35) has the standard Ramsey form: capital taxation depends on changes in the consumption elasticity across adjacent dates. In a steady state, the optimal capital tax is therefore zero. As it is well known, if one further assumes that the utility function has the constant elasticity of intertemporal substitution form, that is $U(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$ for some $\sigma > 0$, then the optimal capital rate is zero also along the transition from $t = 2$ onward (see, for example, Chari et al. (2020)). The exceptional period one tax reflects the initial-wealth term in the implementability constraint.

Optimal labor income taxes. In (36), the factor $\mathcal{M}_t$ adjusts for any aggregate markup distortion left uncorrected by input subsidies. The remaining fraction captures the fiscal motive for labor taxation. The fiscal motive is increasing in λ^*, which represents government's

spending needs. It is decreasing in the Frisch elasticity of labor supply since with higher elasticity labor income taxation is more distortionary.

Optimal profit taxes. The optimal net-of-profit-tax rate in (37) can be expressed as the product of two components, $1-\tau^{\pi}_{j,t} = (1-\tau^{f}_{j,t})(1+s^{n}_{j,t})$. The component $1+s^{n}_{j,t} = \nu_j \varepsilon_j$ corrects the entry distortion by aligning private variety-creation incentives with their social benefit and coincides with the efficient net-of-profit-tax rate (32).

The component

$$1-\tau^{f}_{j,t} = \frac{1+\lambda^{*}(1-\sigma^{*\,-1}_{c,t})}{1+\lambda\dfrac{1+\sigma^{*\,-1}_{e_j,t}-\mathcal{E}^{*}_{q_{j,t},e_{j,t}}}{q^{*}_{j,t}}} \tag{38}$$

captures the revenue-raising (or fiscal) motive of profit taxation and is our main focus. To develop an understanding of the fiscal component, first consider the case in which profits are all quasi-rents, that is $q_{j,t}=1$ in some sector j. In our model, this would occur if the variety creation function was linear in entrepreneurial effort. In this case, the fiscal component becomes $1-\tau^{f}_{j,t} = \frac{1+\lambda(1-\sigma^{-1}_{c,t})}{1+\lambda(1+\sigma^{-1}_{e_j,t})}$. This has the same interpretation as the (fiscal component of the) labor tax: all else equal, a higher Frisch elasticity of entrepreneurial effort implies a lower fiscal profit tax because effort responds more strongly to taxation.

When $q_{j,t}<1$, profits also contain pure rents. The formula (38) implies that, the presence of pure rents strengthens the fiscal motive for profit taxation: other things equal, the smaller is the share of quasi-rents in profits, the higher is the optimal fiscal profit tax. Intuitively, the entrepreneur's effort decision depends on marginal profits, and hence the quasi-rents, whereas the government taxes total profit income. A larger pure-rent component, therefore, allows the government to raise more revenue relative to the marginal compensation required to induce entrepreneurial effort. When the quasi-rent share varies with effort, its elasticity, $\mathcal{E}_{q_{j,t},e_{j,t}}$, also matters for optimal tax rate. All else equal, a quasi-rent share that rises with effort reduces the optimal fiscal profit tax, whereas a share that falls with effort increases it.

Relation to taxable profit elasticity. To get a deeper understanding of why the quasi-rent share and its elasticity are relevant for the optimal profit tax rate, we now relate these variables to taxable profit elasticity. First, define

$$\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}} \equiv \left.\frac{\partial \ln \pi_{j,t}}{\partial \ln(1-\tau^{\pi}_{j,t})}\right|_{u_{c,t}}$$

as the elasticity of taxable profit income with respect to the net of the tax rate at constant marginal utility of consumption. To be precise, this is defined as a micro elasticity meaning that it captures the changes in the profit income of an entrepreneur stemming from their individual reaction to the tax change (general equilibrium effects are not accounted for).

Proposition 4. *For $t \geq 1$,*

$$\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}} = \frac{q_{j,t}}{1+\sigma^{-1}_{e_j,t} - \mathcal{E}_{q_{j,t},e_{j,t}} - q_{j,t}}. \tag{39}$$

Proof. Relegated to Appendix A.7. □

The fiscal component of the optimal profit tax rate can now be expressed in terms of the responsiveness of taxable profits to the net-of-tax rate.

Corollary 1. *For $t \geq 1$, the optimal profit tax satisfies*

$$1-\tau^{f}_{j,t} = \frac{1+\lambda^{*}(1-{\sigma^{*}_{c,t}}^{-1})}{1+\lambda^{*}\left[1+{\mathcal{E}^{*}_{\pi_{j,t},1-\tau^{\pi}_{j,t}}}^{-1}\right]}. \tag{40}$$

The formula given by (40) makes transparent the point that the quasi-rent share and its elasticity are important for the optimal profit tax rate because they impact elasticity of taxable profits. To see how, observe that the taxable profit elasticity can be further broken

down into

$$\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}} = \mathcal{E}_{\pi_{j,t},e_{j,t}}\mathcal{E}_{e_{j,t},1-\tau^{\pi}_{j,t}} \tag{41}$$

$$= q_{j,t}\frac{1}{1+\sigma^{-1}_{e_j,t} - \mathcal{E}_{q_{j,t},e_{j,t}} - q_{j,t}}. \tag{42}$$

In words, the taxable profit elasticity is the product of two elasticities: one that measures the sensitivity of profits with respect to entrepreneurial effort, $\mathcal{E}_{\pi_{j,t},e_{j,t}}$, and another one that measures the sensitivity of entrepreneurial effort with respect to the net of the tax rate, $\mathcal{E}_{e_{j,t},1-\tau^{\pi}_{j,t}}$. It is easy to see that, all else equal, both components are increasing in the quasi-rent share. Therefore, a higher fraction of quasi-rents increases the responsiveness of profit income to profit tax rate both because it implies a larger sensitivity of profit income to entrepreneurial effort and because it implies a larger response of the entrepreneur's effort to the tax rate. That profits are more sensitive to effort when the quasi-rent share is larger is almost definitional. The sensitivity of entrepreneurial effort increases with quasi-rent share as with a higher quasi-rent share more of the tax falls on effort.

Two extremes are worth a discussion. As the constant quasi-rent share approaches one, pure rents vanish and the taxable-profit elasticity approaches $\sigma_{e_j,t}$. When profits are proportional to effort, their response to taxation is governed entirely by the curvature of effort costs. The fiscal component of the optimal profit tax then has the same form as that of the labor tax, and the two would coincide if the elasticities of entrepreneurial effort and labor supply are equal. At the opposite extreme, when the stock of varieties is fixed and requires no entrepreneurial effort, all profits are pure rents. The taxable-profit elasticity is zero, and a 100% profit tax raises revenue without changing effort or production. This recovers the classical public finance benchmark in which pure rents can be fully taxed without distorting production (Diamond and Mirrlees, 1971; Dasgupta and Stiglitz, 1971).

A positive elasticity of the quasi-rent share with respect to effort implies, ceteris paribus, a higher taxable-profit elasticity than in the constant-share case, weakening the fiscal motive

for profit taxation. A negative elasticity implies the reverse.

Production efficiency. Diamond and Mirrlees (1971) famously showed that, under fairly general conditions, optimal tax systems maintain production efficiency as long as production does not generate pure profits. Dasgupta and Stiglitz (1971) showed that when there are pure profits and full confiscation of these profits is not allowed, then production efficiency result breaks down while Dasgupta and Stiglitz (1972) established that when unrestricted taxation of profits is allowed, production efficiency emerges again. In our environment, firms generate pure profits and, like in Dasgupta and Stiglitz (1972), profit taxation is unrestricted. However, unlike their setup, here it is not optimal to tax pure profits away completely as this would completely discourage entrepreneurial effort. We find that, in general, although there is no exogenous restriction on profit taxes, production efficiency theorem of Diamond and Mirrlees (1971) is still violated. This is in line with Mirrlees (1972).

Specifically, there are three primary factors of production in our environment: capital, labor and entrepreneurial effort. Production efficiency, as benchmarked by the first-best allocation, implies that the allocation of these primary production factors across sectors should be determined only according to a comparison of marginal physical benefits and costs. The Ramsey allocation features an efficient allocation of capital and labor across sectors, conditional on the allocation of entrepreneurial effort. To see this, note that the sectoral shares, $\phi_{j,t}$, enter the Ramsey problem (34) only through the feasibility constraints (20) and (21), exactly like in the first-best planning problem. Therefore, the first-order optimality conditions with respect to sectoral shares would be identical to the ones in the case of first best, given by (25), and show that capital and labor are allocated to equate their marginal returns across sectors. This is also evident from the fact that input subsidies are identical in the first best and the Ramsey allocation.

The allocation of entrepreneurial effort across sectors, on the other hand, violates production efficiency in general. To see this, observe that entrepreneurial effort enters the Ramsey

problem also through the implementability constraint, (33). This implies that the first-order optimality condition with respect to entrepreneurial effort includes terms beyond simply physical returns. Consequently, unlike the first best, entreprenerial effort is not allocated across with only physical benefits and costs in mind. This can be seen by comparing the first-order optimality conditions for entrepreneurial effort in the first-best allocation (26) and in the Ramsey allocation (A.25).

5 Quantitative Analysis

We calibrate the model's initial steady state under pre-reform policy to key moments of the U.S. economy. We then compute the Ramsey allocation and the policies that implement it, and compare the resulting transition with the transition to the efficient allocation.

5.1 Calibration

We calibrate the model at an annual frequency to an initial steady state with $J = 20$ sectors based on two-digit NAICS industries. To construct sector-specific markups μ_j, we use the replication package of De Loecker et al. (2020). Applying the sample restrictions implemented in the replication code yields 3,988 firm observations for 2016. We reconstruct firm-level markups as the estimated output elasticity of the variable input multiplied by the ratio of sales to cost of goods sold, using the production-elasticity estimates supplied in the replication package. Following Edmond et al. (2023), we aggregate firm-level markups within each sector using the sales-weighted harmonic mean.[8] With zero pre-reform input subsidies, sector-specific demand elasticities satisfy $\varepsilon_j = \mu_j/(\mu_j - 1)$. Table 1 reports the markup targets and implied demand elasticities.

Table 2 summarizes the remaining parameters. We adopt the conventional Dixit–Stiglitz restriction on the sector-specific variety exponents, $\nu_j = 1/(\varepsilon_j - 1)$. Given the pre-reform

[8] Table 15.1 of the Online Appendix to De Loecker et al. (2020) reports sales-weighted arithmetic averages. For a given sample and sales weights, the arithmetic mean is weakly greater than the harmonic mean.

Table 1: Sector markups and demand elasticities.

NAICS	Sector	Markup μ_j	Demand elasticity ε_j
11	Agriculture, Forestry, Fishing and Hunting	1.617	2.621
21	Mining, Quarrying, and Oil and Gas Extraction	1.301	4.320
22	Utilities	1.249	5.020
23	Construction	1.122	9.213
31	Manufacturing I	1.595	2.681
32	Manufacturing II	1.407	3.454
33	Manufacturing III	1.258	4.877
42	Wholesale Trade	1.094	11.684
44–45	Retail Trade	1.050	20.957
48–49	Transportation and Warehousing	1.220	5.542
51	Information	1.613	2.632
52	Finance and Insurance	1.322	4.106
53	Real Estate and Rental and Leasing	1.645	2.550
54	Professional, Scientific, and Technical Services	1.173	6.782
56	Administrative, Support, and Waste Services	1.404	3.473
61	Educational Services	1.548	2.826
62	Health Care and Social Assistance	1.087	12.463
71	Arts, Entertainment, and Recreation	1.220	5.538
72	Accommodation and Food Services	1.064	16.690
81	Other Services (except Public Administration)	1.187	6.338

Notes: Markups are sales-weighted harmonic averages of reconstructed firm-level markups for 2016. NAICS 44–45 and 48–49 are each pooled into one sector. Demand elasticities are computed from unrounded markups under zero pre-reform input subsidies.

markup targets, this implies $\nu_j = \mu_j - 1$, with values ranging from 0.0501 to 0.6453. We set the elasticity of substitution across sectors to $\gamma = 1.5$.

Preferences are additively separable in consumption, labor supply, and entrepreneurial effort in each sector:

$$u(c, l, \mathbf{e}) = \frac{c^{1-1/\sigma_c}}{1-1/\sigma_c} - \frac{l^{1+1/\sigma_l}}{1+1/\sigma_l} - \sum_{j=1}^{J} \frac{e_j^{1+1/\sigma_{e_j}}}{1+1/\sigma_{e_j}}.$$

We set the intertemporal elasticity of substitution to $\sigma_c = 0.5$ and the Frisch elasticities of labor supply and entrepreneurial effort to $\sigma_l = \sigma_{e_j} = 1$ for all j. The coefficients on the labor and sectoral effort disutility terms are set to one.

We parameterize the variety-creation technology as $n_j(e_j) = e_j^{\theta}$, with a common curvature

Table 2: Parameters and calibration targets.

Parameter	Description	Value	Source/target
Set parameters			
J	Number of sectors	20	NAICS 2-digit industries
σ_c	IES	0.500	Standard value
σ_l	Frisch elasticity of labor supply	1.000	Benchmark value
σ_{e_j}	Frisch elasticity of entrepreneurial effort	1.000	Benchmark value
σ_{kl}	Capital–labor substitution	0.600	Oberfield and Raval (2021)
γ	Cross-sector substitution	1.500	Benchmark value
ν_j	Variety exponent	$1/(\varepsilon_j - 1)$	Dixit–Stiglitz specification
δ	Annual depreciation rate	0.057	BEA private fixed-asset data
Calibrated parameters			
ε_j	Within-sector dem. elast.	Table 1	De Loecker et al. (2020)
θ	Variety-creation curvature	0.821	$\mathcal{E} = 0.697$; Kennedy et al. (2026)
β	Discount factor	0.960	$K/Y = 2.399$; BEA
α	Production share parameter	0.504	$wL/Y = 0.514$; BEA NIPA
z_j	Sector productivity	Figure 1	Sector value-added shares; BEA
Pre-reform policy parameters			
τ^l	Labor income tax rate	0.242	BEA/IRS; see notes
τ^k	Capital income tax rate	0.262	BEA/IRS; see notes
τ_j^π	Combined profit tax rate	0.262	Restricted to τ^k
s_j	Input subsidy	0.000	Baseline approximation
s_j^n	Variety-creation subsidy	0.000	Baseline approximation
g	Government spending	0.172	BEA national accounts

Notes: Initial output is normalized to $Y = 1$. NIPA denotes BEA National Income and Product Accounts. The capital-output target uses the year-end net stock of private fixed assets at current replacement cost divided by GDP; the labor-share target uses employee compensation divided by GDP. Both refer to 2024. The labor tax numerator includes employment-related employer and employee social-insurance contributions and 66.12% of personal income-tax receipts. Its denominator is employee compensation, including employer contributions to pension, insurance, and government social-insurance programs. The allocation share is the wage share of reported income in IRS data. Proportional allocation assumes equal average effective personal income-tax rates across income sources; federal-return income shares are also applied to state and local receipts. With $s_j^n = 0$ before the reform, the fiscal and combined profit tax rates coincide. The common capital and profit tax numerator includes corporate income-tax receipts, personal income taxes allocated to capital and business income, self-employment social-insurance contributions, and state and local property taxes. The denominator is net operating surplus, including owner-occupied housing, with property taxes added back because they are deducted in measuring operating surplus. Dividends enter the personal tax allocation but are not added again to the income base. Government spending includes government consumption expenditures and gross investment. Fiscal amounts refer to 2024; personal income-tax allocation shares use 2023 IRS data.

parameter $0 < \theta < 1$ across sectors. We discipline θ using the Frisch taxable-profit elasticity introduced in Proposition 4. Under this technology, the quasi-rent share is constant and equal to θ, so

$$\mathcal{E} \equiv \mathcal{E}_{\pi_j, 1-\tau_j^\pi} = \frac{\theta}{1 + \sigma_{e_j}^{-1} - \theta} = \frac{\theta}{2 - \theta}, \qquad \theta = \frac{2\mathcal{E}}{1 + \mathcal{E}}.$$

This elasticity holds prices, sector aggregates, all other tax rates, and the marginal utility of consumption fixed. We use the average taxable-profit elasticity of 0.697 estimated by Kennedy et al. (2026) as the target in every sector, implying $\theta = 0.8214$. The implied quasi-rent and pure-rent shares are $\pi_j^q/\pi_j = \theta = 82.14\%$ and $\pi_j^p/\pi_j = 1-\theta = 17.86\%$. These shares are implications of the functional form and elasticity target, rather than separate calibration targets.

Production combines capital and labor according to

$$F(k, l) = \left[\alpha k^{(\sigma_{kl}-1)/\sigma_{kl}} + (1 - \alpha) l^{(\sigma_{kl}-1)/\sigma_{kl}}\right]^{\sigma_{kl}/(\sigma_{kl}-1)},$$

with $\sigma_{kl} = 0.6$, following Oberfield and Raval (2021).

Employee compensation divided by GDP gives a labor share of 51.37%. This is lower than conventional measures that impute labor income to the self-employed, because our model includes returns to entrepreneurial effort in profits. The net stock of private fixed assets, valued at current replacement cost and divided by GDP, gives a capital-output ratio of 2.399. Private fixed-asset depreciation divided by the corresponding year-end capital stock gives an annual depreciation rate of $\delta = 5.68\%$. These capital measures include residential capital. Together with the markup targets, these aggregate targets imply an annual pretax net capital return of $r = 5.68\%$. At the pre-reform capital income tax rate, the household's Euler equation then implies $\beta = 0.9598$.

We calibrate the sector-specific productivities z_j to match sectoral value-added shares, normalized across the $J = 20$ sectors included in the model. We use BEA value-added data for 2024 to divide the manufacturing share among NAICS industries 31, 32, and 33.

We normalize initial output to $Y = 1$. The parameters β, α, and z_j are jointly calibrated to the capital-output ratio, labor share, $J-1$ independent sector value-added shares, and this output normalization. The calibrated production share parameter is $\alpha = 0.5045$. Figure 1 relates sector value-added shares to the calibrated productivities.

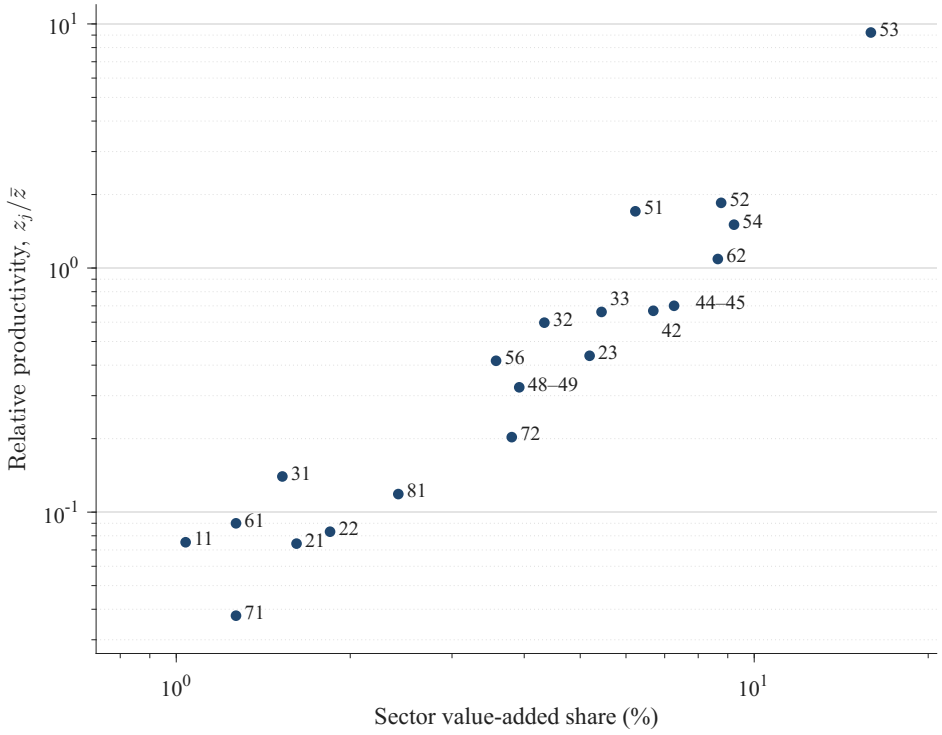

Figure 1: Sector value-added shares and calibrated productivities.

Notes: The horizontal axis shows sector value-added shares based on BEA data, in percent. The vertical axis shows $z_j/\bar{z}$, where $\bar{z}$ is the unweighted mean of calibrated sector productivities. Both axes use logarithmic scales. Labels identify two-digit NAICS industries; 44–45 and 48–49 denote pooled sectors.

We approximate pre-reform tax rates using revenue-to-income ratios constructed from BEA fiscal and income data and IRS income-source shares. We allocate personal income-tax receipts in proportion to reported income by source. Combining the wage-attributable receipts with employment-related social-insurance contributions gives labor tax revenue of \$3,634.7 billion. Dividing by employee compensation of \$15,049.1 billion yields $\tau^l = 24.15\%$.

Capital income and entrepreneurial profits are not separately identified in observed tax receipts: both corporate and personal income taxes apply to income combining these two components. We therefore impose a common pre-reform rate, $\tau^k = \tau_j^\pi = 26.18\%$, which

allows us to use their combined revenue and income base without an additional allocation between the two model tax bases. This rate is based on combined capital and business tax revenue of $2,107.1 billion and a broad income base of $8,047.5 billion.[9]

We use zero input subsidies and zero variety-creation subsidies as the pre-reform baseline, $s_j = s_j^n = 0$. Government spending is set to the 2024 BEA ratio of government consumption expenditures and gross investment to GDP, so $g = 0.172$ under the output normalization. Government investment enters as a resource use; the model has no separate public-capital stock. Government debt is implied by the stationary budget constraint. The initial calibration yields a debt-to-GDP ratio of 104.09%, compared with 96.76% for U.S. federal debt held by the public in the fourth quarter of 2024. The comparison is approximate because the debt benchmark covers only the federal government, whereas the tax and spending data used to calibrate the model also include state and local governments.

5.2 Optimal Policy

Starting from the calibrated steady state, we compute the Ramsey allocation and implement it using input subsidies and taxes on profits, labor income, and capital income. We choose the implementation with $\mathcal{M}_t = 1$ from $t = 0$ onward and retain the predetermined initial capital income tax of 26.18%. As in the analytical section, we decompose the combined profit tax into a variety-creation subsidy and a fiscal component:

$$1 - \tau_{j,t}^{\pi} = (1 - \tau_{j,t}^{f})(1 + s_{j,t}^{n}).$$

This decomposition preserves the net-of-profit-tax rate and therefore the allocation implemented by the single profit-tax instrument.

[9]Consistent with the model's treatment of entrepreneurial income as profits, the tax base includes proprietors' returns to their own effort. The revenue measure also includes personal income-tax receipts allocated to capital gains.

Input subsidies and variety correction. The left panel of Figure 2 plots optimal input subsidies against pre-reform markups, $\mu_j^{\text{pre}} = \varepsilon_j/(\varepsilon_j - 1)$. The subsidies increase with pre-reform markups, ranging from 4.77% in Retail Trade (44–45) to 39.22% in Real Estate and Rental and Leasing (53). They direct larger corrections toward sectors with greater market power, a principle that also underlies the firm subsidies studied by Edmond et al. (2023) and Boar and Midrigan (2025). In our model, these input subsidies eliminate both markup dispersion and the aggregate markup distortion.

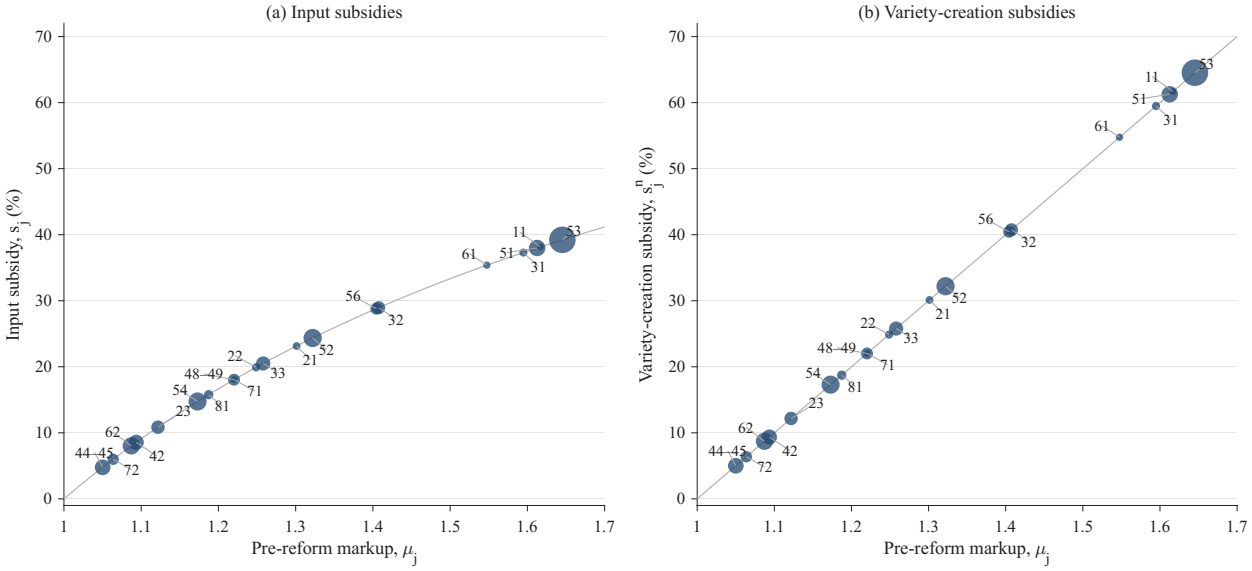

Figure 2: Optimal subsidies and pre-reform markups.

Notes: Each point represents a sector. The left panel shows input subsidies, $s_j = 1 - 1/\mu_j^{\text{pre}}$; the right panel shows variety-creation subsidies, $s_j^n = \mu_j^{\text{pre}} - 1$. Subsidies are reported in percent and are constant from the reform onward. Markups are the pre-reform targets reported in Table 1. Labels identify two-digit NAICS industries; 44–45 and 48–49 denote pooled sectors. Dot areas are proportional to sector value-added shares in the post-reform Ramsey steady state.

The right panel of Figure 2 depicts optimal variety-creation subsidies against pre-reform markups. Under the Dixit–Stiglitz restriction $\nu_j = 1/(\varepsilon_j - 1)$, optimal variety-creation subsidies increase linearly with pre-reform markups:

$$s_j^n = \varepsilon_j \nu_j - 1 = \nu_j = \mu_j^{\text{pre}} - 1.$$

They range from 5.01% in Retail Trade to 64.53% in Real Estate and Rental and Leasing.

These subsidies apply to operating profits before the fiscal profit tax and are distinct from subsidies to firms' input costs.

Fiscal profit taxes. All sectors have the same taxable-profit elasticity in the baseline, $\mathcal{E} = 0.697$, and the same quasi-rent share, $q_j = \theta = 0.8214$. Equation (40) therefore implies a common fiscal profit tax for $t \geq 1$, denoted by τ_t^f, despite differences in markups and variety-creation subsidies. The fiscal profit tax rises from 26.18% in the pre-reform steady state to 46.06% at $t = 1$ and remains at that rate thereafter, including in the new steady state. Its constancy over time follows from the constant consumption and taxable-profit elasticities. Its cross-sector uniformity follows from the common elasticity target; sector-specific elasticity estimates would instead imply sector-specific fiscal rates.

The combined tax rate on operating profits is

$$\tau_{j,t}^{\pi} = 1 - (1 - \tau_t^f)(1 + s_j^n), \qquad t \geq 1.$$

In the new steady state, it ranges from 11.25% in Real Estate and Rental and Leasing to 43.36% in Retail Trade. Thus, a sector can receive a substantial variety-creation subsidy while still paying a positive combined profit tax. The combined rate decreases with the pre-reform markup in this calibration because the fiscal rate is common and the variety-creation subsidy increases with that markup.

Labor and capital income taxes. The labor income tax rises from its pre-reform value of 24.15% to 42.72% at $t = 1$ and remains at that rate thereafter. Capital income is untaxed from $t = 2$ onward, in accordance with the constant-IES result in Proposition 3. Table 3 reports the capital and labor income tax rates and the fiscal profit tax in the new steady state. With constant consumption, labor-supply, and taxable-profit elasticities, these fiscal tax rates are constant from $t = 1$ onward, apart from the exceptional period-one capital tax.

In this calibration, the Frisch elasticities of labor and entrepreneurial effort are both one,

Table 3: Optimal fiscal tax rates in the new steady state.

Tax	New steady state
Capital income tax τ^k	0.00
Labor income tax τ^l	42.72
Fiscal profit tax τ^f	46.06

Notes: All rates are percentages. The fiscal profit tax is common across sectors and excludes the variety-creation subsidy. Since $\mathcal{M} = 1$, the labor income tax coincides with its fiscal component.

while the constant quasi-rent share is below one. The difference between the fiscal tax rates therefore reflects the presence of pure rents. Equivalently, the taxable-profit elasticity of 0.697 is below the labor-supply elasticity of one. With $\mathcal{M}_t = 1$ and a constant intertemporal elasticity of substitution, the optimal capital income tax is zero from $t = 2$ onward.

The initial periods are exceptional. At $t = 0$, the labor tax is -52.84% and the fiscal profit tax is -46.36%. Combined with the variety-creation subsidies, the latter implies negative combined profit tax rates in every sector. The period-one capital income tax is 577.50%. This is a rate on net capital income, not on the capital stock, and the Ramsey problem imposes no upper bound of 100% on it. These initial policies reflect the initial-wealth terms in the implementability constraint. The distinction between exceptional initial taxes and subsequent tax rates is familiar from Ramsey models with commitment, in which the planner exploits the inelastic supply of inherited assets.

Cross-sector reallocation. The reform changes the allocation of activity across sectors through both the allocation shares ϕ_j and entrepreneurial effort. Figure 3 plots sectoral allocation shares, ϕ_j, against pre-reform markups. Blue points denote the pre-reform steady state and red points the post-reform Ramsey steady state. Point sizes are proportional to sectoral value added, measured in pre-reform GDP units. Higher-markup sectors generally receive larger allocation shares after the reform, whereas lower-markup sectors receive smaller shares.

Figure 4 shows the percentage change in entrepreneurial effort between the pre-reform

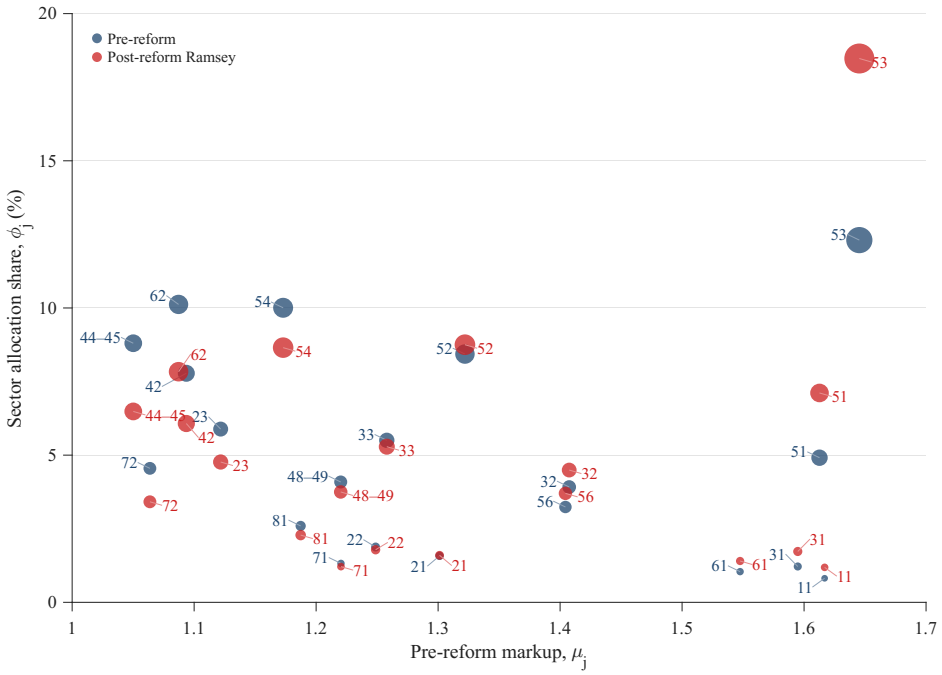

Figure 3: Sector allocation shares before and after the reform.

Notes: The horizontal axis shows pre-reform sector markups. The vertical axis reports allocation shares ϕ_j in percent. Blue dots and labels denote the pre-reform steady state; red dots and labels denote the post-reform Ramsey steady state. Labels identify two-digit NAICS industries; 44–45 and 48–49 denote pooled sectors. Dot areas are proportional to sector value added, measured in units of pre-reform GDP in both steady states.

and post-reform Ramsey steady states. Aggregate entrepreneurial effort falls by 3.27%, but sectoral responses differ substantially: effort rises by 13.51% in Real Estate and Rental and Leasing but falls by 20.48% in Retail Trade. Together, the figures show that the aggregate response reflects a reallocation of entrepreneurial activity toward sectors with higher pre-reform markups.

Transition dynamics. Figure 5 compares the transition under Ramsey policy with the first-best transition, which allows for lump-sum taxes. Both transitions start from the same calibrated pre-reform steady state and are shown from $t = 1$ through $t = 50$; all quantities are expressed as percentage deviations from their pre-reform steady-state values. The first-best allocation generates substantially larger increases in output, consumption, and capital in both the short and the long run. Under first-best policy, all three variables remain above their pre-reform levels throughout the displayed transition. Under Ramsey policy, capital

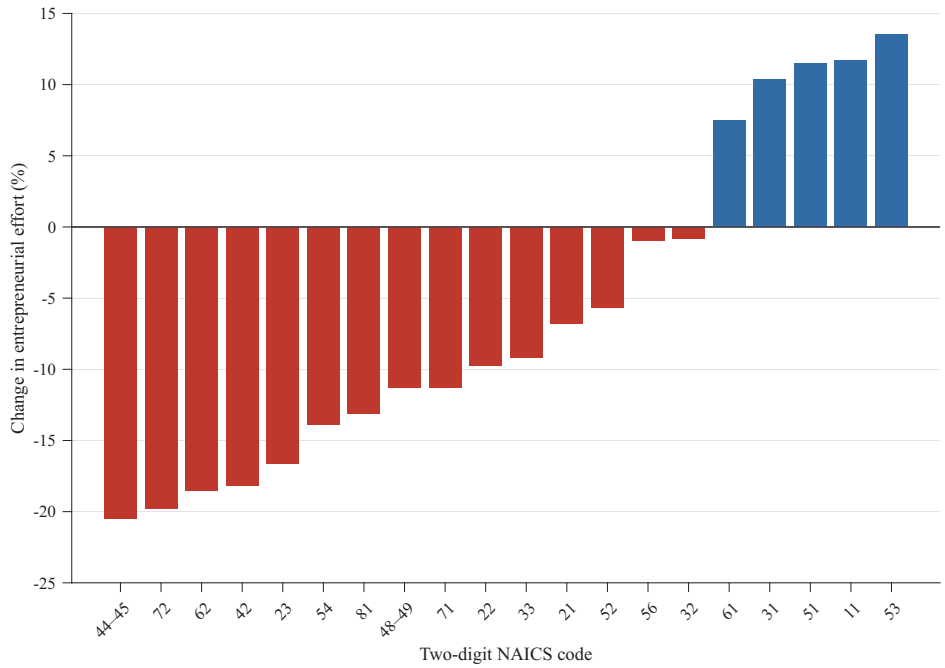

Figure 4: Sectoral reallocation of entrepreneurial effort.

Notes: Bars show the percentage change in sectoral entrepreneurial effort between the pre-reform and post-reform Ramsey steady states. Sectors are ordered by the size of the change. Labels identify two-digit NAICS industries; 44–45 and 48–49 denote pooled sectors.

and consumption are initially below their pre-reform levels and gradually increase toward their higher long-run levels. In the new Ramsey steady state, output is 12.74% higher, consumption 10.50% higher, and capital 40.19% higher than before the reform.

The need to finance government spending with distortionary taxes also dampens wage work and entrepreneurial effort under Ramsey policy relative to the first best. Under both policies, wage work and entrepreneurial effort begin the displayed transition above their pre-reform levels and then gradually decline. Under first-best policy, they settle above their pre-reform levels, whereas under Ramsey policy their long-run levels are slightly lower than before the reform. In the new Ramsey steady state, wage work falls by 2.14%, aggregate entrepreneurial effort by 3.27%, and total hours by 2.93% relative to the pre-reform steady state.

Welfare comparison. Table 4 reports consumption-equivalent welfare gains, accounting for the full transition paths of consumption, labor supply, and entrepreneurial effort in each

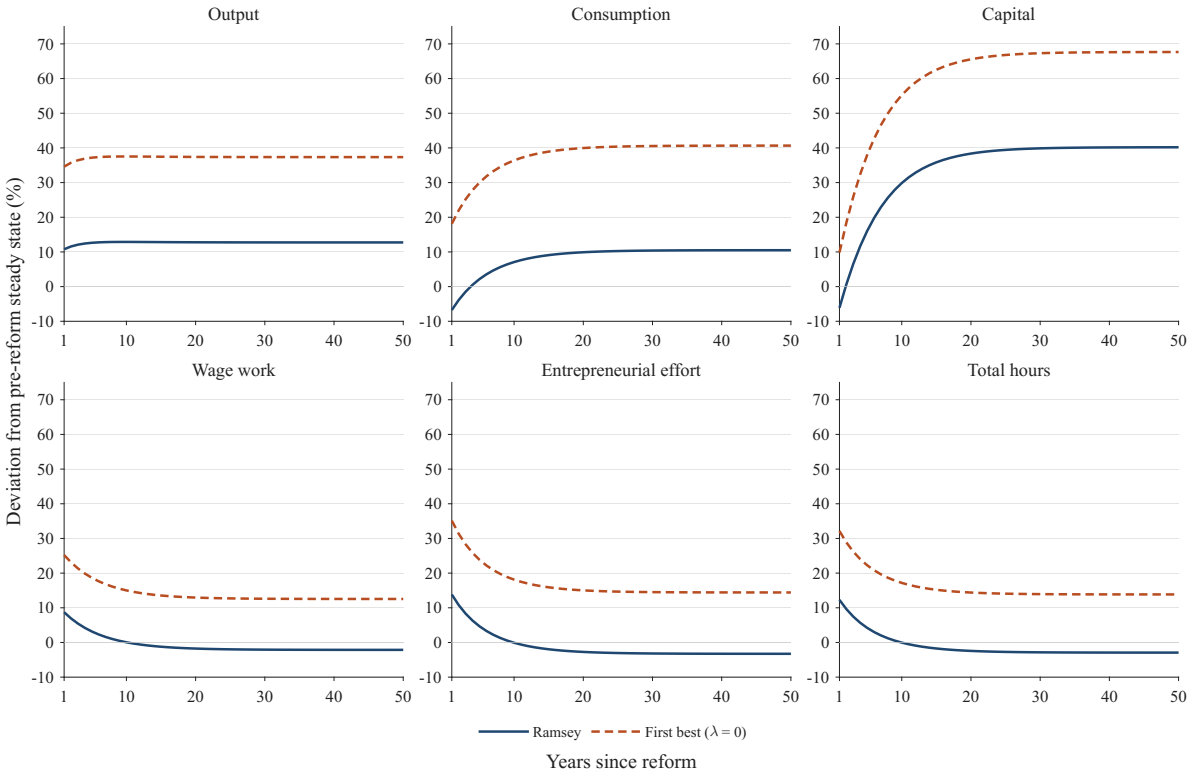

Figure 5: Transition dynamics under Ramsey and first-best policy.

Notes: Both transitions start from the same calibrated pre-reform steady state, with the reform occurring at $t = 0$. The figure reports the paths from $t = 1$ through $t = 50$; all quantities are expressed as percentage deviations from their pre-reform steady-state values. The same vertical scale is used across panels. The first-best allocation corresponds to $\lambda = 0$ and allows lump-sum financing. Government spending follows the same path in both cases. The impact responses at $t = 0$ are omitted to make the subsequent adjustment easier to see.

sector, together with the steady-state continuation. The gain is 6.132% under Ramsey policy and 12.106% under the first-best allocation.

Table 4: Welfare gains under Ramsey and first-best policy.

	Ramsey	First best
Consumption-equivalent variation (%)	6.132	12.106

Notes: The consumption-equivalent variation is the constant percentage increase in pre-reform steady-state consumption that, with labor supply and each sector's entrepreneurial effort held at their pre-reform levels, delivers the same lifetime utility as the corresponding policy transition.

These results highlight the importance of the financing assumptions underlying assessments of the welfare costs of markups. For example, Edmond et al. (2023) quantify the gains from eliminating markup distortions using corrective subsidies financed by lump-sum taxes.

Our comparison shows that the gains attainable when such financing is unavailable can be substantially smaller: within our model, requiring the government to use distortionary taxes reduces the welfare gain by about 49%. Thus, gains measured relative to an efficient allocation are not attainable under the fiscal constraints considered here. Nevertheless, the gains from reform remain substantial.

6 Conclusion

This paper studies the joint design of product-market policies and distortionary taxes in a multi-sector economy with market power and endogenous variety creation. Profits combine pure rents with quasi-rents that remunerate entrepreneurial effort, so profit taxation raises revenue while also affecting productive incentives. The quasi-rent share and its responsiveness to effort determine the taxable-profit elasticity and thereby the fiscal motive for profit taxation.

Optimal policy combines this fiscal component with corrective policies addressing markup and variety-creation distortions. Although input subsidies restore the efficient allocation of capital and employed labor across sectors, the Ramsey planner generally distorts the allocation between employment and entrepreneurial effort to reduce the cost of raising revenue.

In our U.S. calibration, optimal policy combines a common fiscal profit tax of 46% with sector-specific variety-creation subsidies, yielding combined profit tax rates of 11–43%. Accounting for the full transition, the reform generates a consumption-equivalent welfare gain of 6.1%. When corrective policies are financed with distortionary taxes, about half of the welfare gains attainable under lump-sum financing remain.

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A Proofs

A.1 Proof of Lemma 1

Proof. The definition of $y_{j,t}$ and a symmetric equilibrium give

$$\begin{aligned} y_{j,t} =& N_{j,t}^{\nu_j - \frac{1}{\varepsilon_j - 1}} \left(\int_0^1 \int_0^{n_{j,i,t}} y_{j,i,n,t}^{\frac{\varepsilon_j - 1}{\varepsilon_j}} dn di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}} \\ =& N_{j,t}^{\nu_j - \frac{1}{\varepsilon_j - 1}} \left(\int_0^1 N_{j,t} \left(z_{j,t} F\left(\frac{k_{j,t}}{N_{j,t}}, \frac{l_{j,t}}{N_{j,t}} \right) \right)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}} \\ =& z_{j,t} N_{j,t}^{\nu_j} \left(\int_0^1 \left(F\left(\phi_{j,t} k_t, \phi_{j,t} l_t \right) \right)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}} \\ =& \phi_{j,t} z_{j,t} F\left(k_t, l_t \right) N_{j,t}^{\nu_j}. \end{aligned} \tag{A.1}$$

The expression for aggregate output then follows directly from its definition. □

A.2 Proof of Lemma 2

Proof. Defining

$$\eta_{j,t} = \frac{z_{j,t} N_{j,t}^{\nu_j}}{\mu_{j,t}}$$

equations (11) are equivalent to

$$y_{j,t} = \eta_{j,t}^{\gamma} \left(\frac{F_k(k_t, l_t)}{r_t + \delta} \right)^{\gamma} y_t = \eta_{j,t}^{\gamma} \left(\frac{F_l(k_t, l_t)}{w_t} \right)^{\gamma} y_t. \tag{A.2}$$

The definition of aggregate output from equation (4) then implies

$$y_t = \left(\frac{F_k(k_t, l_t)}{r_t + \delta} \right)^{\gamma} y_t \left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma - 1} \right)^{\frac{\gamma}{\gamma - 1}} = \left(\frac{F_l(k_t, l_t)}{w_t} \right)^{\gamma} y_t \left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma - 1} \right)^{\frac{\gamma}{\gamma - 1}}. \tag{A.3}$$

We therefore have

$$r_t + \delta = F_k(k_t, l_t) \left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma-1} \right)^{\frac{1}{\gamma-1}} \quad \text{and} \quad w_t = F_l(k_t, l_t) \left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma-1} \right)^{\frac{1}{\gamma-1}}.$$

What remains to be shown is that

$$\sum_{j=1}^{J} \phi_{j,t} \mu_{j,t} = \frac{z_t}{\left(\sum_{j'=1}^{J} \eta_{j',t}^{\gamma-1} \right)^{\frac{1}{\gamma-1}}}.$$

Plugging in the expression for z_t from Lemma 1 as well as the definition for $\eta_{j,t} = \frac{z_{j,t} n_{j,t}^{\nu_j}}{\mu_{j,t}}$ this is equivalent to

$$\sum_{j=1}^{J} \phi_{j,t} \mu_{j,t} = \frac{\left(\sum_{j=1}^{J} \left(z_{j,t} \phi_{j,t} N_{j,t}^{\nu_j} \right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}}{\left(\sum_{j'=1}^{J} \left(\frac{z_{j',t} N_{j',t}^{\nu_{j',t}}}{\mu_{j',t}} \right)^{\gamma-1} \right)^{\frac{1}{\gamma-1}}}. \tag{A.4}$$

To see that this equation indeed holds note first that

$$\frac{y_{j,t}}{y_t} = \frac{\eta_{j,t}^{\gamma}}{\left(\sum_{j=1}^{J} \eta_{j,t}^{\gamma-1} \right)^{\frac{\gamma}{\gamma-1}}} = \frac{\phi_{j,t} z_{j,t} N_{j,t}^{\nu_j}}{\left(\sum_{j'=1}^{J} \left(\phi_{j',t} z_{j',t} N_{j',t}^{\nu_{j',t}} \right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}},$$

where the first equation follows from equations (A.2) and (A.3), and the second equation follows from Lemma 1. The second equation implies that

$$\eta_{j,t}^{\gamma} = \phi_{j,t} z_{j,t} N_{j,t}^{\nu_j} \Omega_t \quad \text{for some } \Omega_t > 0.$$

Hence $\frac{\eta_{j,t}^{\gamma}}{\phi_{j,t} z_{j,t} N_{j,t}^{\nu_j}}$ must be constant across all j. Together with $\sum_{j=1}^{J} \phi_{j,t} = 1$ this implies that

$$\phi_{j,t} = \frac{\frac{\eta_{j,t}^{\gamma}}{z_{j,t} N_{j,t}^{\nu_j}}}{\sum_{j'=1}^{J} \frac{\eta_{j',t}^{\gamma}}{z_{j',t} N_{j',t}^{\nu_{j',t}}}} = \frac{\left(z_{j,t} N_{j,t}^{\nu_j} \right)^{\gamma-1} \mu_{j,t}^{-\gamma}}{\sum_{j'=1}^{J} \left(z_{j',t} N_{j',t}^{\nu_{j',t}} \right)^{\gamma-1} \mu_{j',t}^{-\gamma}},$$

where the latter equation again follows from the definition of $\eta_{j,t}$. Plugging the latter expression for $\phi_{j,t}$

into equation (A.4) then proves the result. □

A.3 Proof of Lemma 3

Proof. Households' optimality conditions are:

$$-\frac{u_{l,t}}{u_{c,t}} = (1-\tau_t^l)w_t, \tag{A.5}$$

$$-\frac{u_{e_j,t}}{u_{c,t}} = (1-\tau_{j,t}^{\pi})\pi'_{j,t}(e_{j,t}) \quad \forall j, \tag{A.6}$$

$$u_{c,t} = \beta u_{c,t+1}\left(1+(1-\tau_{t+1}^k)r_{t+1}\right). \tag{A.7}$$

Using Lemma 2 in (A.5) and (A.7) immediately delivers (15) and (17). To achieve (16), observe first that in a symmetric equilibrium, we have $n_{j,i,t} = n_{j,t}$. Since the mass of firms in every sector is one, $N_{j,t} = n_{j,t}$. Denote the level of capital and labor allocated to sector j by $k_{j,t}$ and $l_{j,t}$. Then, we have $k_{j,t} = n_{j,t}k_{j,i,t}$ and $l_{j,t} = n_{j,t}l_{j,i,t}$. The definition of sectoral output (5) implies $y_{j,i,t} = y_{j,t}N_{j,t}^{-(\nu_j+1)}$. Denoting the price of sector j's composite good by $\xi_{j,t}$, the common price charged for each individual product satisfies $\xi_{j,i,t} = \xi_{j,t}N_{j,t}^{\nu_j}$. From equation (8) it then follows that each firm i in sector j makes the same profit $\pi_{j,i,t} = \pi_{j,t} = \frac{1}{\varepsilon_j}\xi_{j,t}y_{j,t}$. Furthermore, the final good producer's optimality condition (6) can be used to show that the price of sector-j's composite goods equals $\xi_{j,t} = \left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}}$. Since the mass of firms in each sector is one, total sector-j profits also equal $\pi_{j,t}$ and are therefore given by

$$\pi_{j,t} = \frac{1}{\varepsilon_j}\left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} y_{j,t}. \tag{A.8}$$

Furthermore, we can express the derivative of entrepreneurial profit with respect to effort as

$$\pi'_{j,i,t}(e_{j,i,t}) = \frac{n'_{j,t}(e_{j,i,t})}{n_{j,t}}\frac{1}{\varepsilon_j}\left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} y_{j,t}. \tag{A.9}$$

Plugging (A.9) in (A.6) delivers (16).

□

A.4 Proof of Proposition 1

Proof. It follows immediately from the comparison of (26) with equilibrium condition (16) that $(1-\tau_{j,t}^{\pi}) = \nu_j\varepsilon_j$ aligns the equilibrium variety-creation condition with the efficient one.

The partial derivative of y_t with respect to $\phi_{j,t}$ is

$$\frac{\partial y_t}{\partial \phi_{j,t}} = \frac{\partial z_t}{\partial \phi_{j,t}} F(k_t, l_t) \tag{A.10}$$

$$= z_t^{\frac{1}{\gamma}} \left(z_{j,t} N_{j,t}^{\nu_j}\right)^{\frac{\gamma-1}{\gamma}} \phi_{j,t}^{-\frac{1}{\gamma}} F(k_t, l_t). \tag{A.11}$$

Notice that by 28, (A.11) does not depend on j. This, together with the restriction that $\sum_{j=1}^{J} \phi_{j,t} = 1$, implies

$$\phi_{j,t} = \frac{\left(z_{j,t} N_{j,t}^{\nu_j}\right)^{\gamma-1}}{\sum_{j'=1}^{J} \left(z_{j',t} N_{j',t}^{\nu_j}\right)^{\gamma-1}}.$$

Plugging into equation (10) gives an expression for efficient aggregate output (and productivity)

$$y_t = \underbrace{\left(\sum_{j=1}^{J} \left(z_{j,t} N_{j,t}^{\nu_j}\right)^{\gamma-1}\right)^{\frac{1}{\gamma-1}}}_{z_t} F(k_t, l_t),$$

which no longer depends on $\phi_{j,t}$. Hence, we have

$$\phi_{j,t} = \left(\frac{z_{j,t} N_{j,t}^{\nu_j}}{z_t}\right)^{\gamma-1} \tag{A.12}$$

and

$$y_{j,t} = \phi_{j,t} z_{j,t} F(k_t, l_t) N_{j,t}^{\nu_j} = \left(\frac{z_{j,t} N_{j,t}^{\nu_j}}{z_t}\right)^{\gamma} y_t \tag{A.13}$$

In equilibrium, we have by equation (11)

$$\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{1}{1 - \tau_{j,t}^x} z_{j,t} n_{j,t}^{\nu_j} \left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} = \frac{\varepsilon_{1,t} - 1}{\varepsilon_{1,t}} \frac{1}{1 - \tau_{1,t}^x} z_{1,t} n_{1,t}^{\nu_{1,t}} \left(\frac{y_{1,t}}{y_t}\right)^{-\frac{1}{\gamma}}. \tag{A.14}$$

By Lemma 1

$$\left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} = \left(\frac{\phi_{j,t} z_{j,t} N_{j,t}^{\nu_j}}{z_t}\right)^{-\frac{1}{\gamma}} = \frac{z_t}{z_{j,t}} N_{j,t}^{-\nu_j},$$

where we used the expression (A.12) for $\phi_{j,t}$. This then implies

$$\frac{\varepsilon_j - 1}{\varepsilon_j}\frac{1}{1 - s_{j,t}} = \frac{\varepsilon_{1,t} - 1}{\varepsilon_{1,t}}\frac{1}{1 - s_{1,t}}.$$

This is equivalent to $\mu_{j,t} = \mu_{1,t}$, implying that all

$$\mu_{j,t} = \mathcal{M}_t \quad \forall j \in \mathcal{J}.$$

Hence optimal input subsidies need to satisfy

$$1 - s_{j,t} = \frac{\varepsilon_j - 1}{\varepsilon_j}\mathcal{M}_t \quad \forall j \in \mathcal{J}.$$

The first-order optimality conditions of the planning problem with respect to c_t, l_t, k_{t+1} are

$$\begin{aligned}
\beta^t u_{c,t} - \mu_t &= 0, \\
\beta^t u_{h,t} + \mu_t z_t F_l(k_t, l_t) &= 0, \\
-\mu_t + \mu_{t+1}(z_t F_{k,t} + 1 - \delta) &= 0
\end{aligned}$$

Together these imply that in the efficient allocation

$$\begin{aligned}
-\frac{u_{l,t}}{u_{c,t}} &= z_t F_l(k_t, l_t), \\
u_{c,t} &= \beta u_{c,t+1}(z_{t+1} F_{k,t+1} + 1 - \delta).
\end{aligned} \tag{A.15}$$

Comparing these with the equilibrium conditions (15) and (17) proves (30) and (31).

To obtain the value for lump-sum taxes T_t use the government budget constraint (18)

$$\begin{aligned}
\sum_{t=0}^{\infty} p_t g_t + p_0 b_0 \leq \sum_{t=0}^{\infty} p_t \left[w_t l_t \tau_t^l + r_t k_t \tau_t^k + \sum_{j=1}^{J} \left(\tau_{j,t}^{\pi} \pi_{j,t} - \left[(r_t + \delta) k_{j,t} + w_t l_{j,t} \right] s_{j,t} \right) \right] \\
+ \sum_{t=0}^{T} p_t T_t.
\end{aligned}$$

The households' first order optimality condition with respect to c_t implies

$$\frac{\beta u_{c,t+1}}{u_{c,t}} = \frac{p_{t+1}}{p_t} \tag{A.16}$$

and normalizing $p_0 = 1$ then gives for all $t \geq 0$

$$p_t = \beta^t \frac{u_{c,t}}{u_{c,0}}. \tag{A.17}$$

Plugging these prices, equilibrium factor prices (14), labor taxes (30), capital taxes (31), input subsidies (29) and variety-correction rates and fiscal profit taxes (32) into the government budget constraint and multiplying by $u_{c,0}$ gives

$$\sum_{t=0}^{\infty} \beta^t u_{c,t} g_t + u_{c,0} b_0 \leq \sum_{t=0}^{\infty} \beta^t u_{c,t} \left[\sum_{j=1}^{J} \pi_{j,t} \left(1 - \varepsilon_j \nu_j\right) - \left[z_t F_{k,t} k_{j,t} + z_t F_{l,t} l_{j,t}\right] \frac{1}{\varepsilon_j} + T_t \right],$$

which is equivalent to

$$\sum_{t=0}^{\infty} \beta^t u_{c,t} g_t + u_{c,0} b_0 \leq \sum_{t=0}^{\infty} \beta^t u_{c,t} \left[\sum_{j=1}^{J} \pi_{j,t} \left(1 - \varepsilon_j \nu_j\right) - y_t \frac{\phi_{j,t}}{\varepsilon_j} + T_t \right].$$

Plugging in (A.8) for profits $\pi_{j,t}$ and using equation (A.12) gives

$$\sum_{t=0}^{\infty} \beta^t u_{c,t} g_t + u_{c,0} b_0 \leq \sum_{t=0}^{\infty} \beta^t u_{c,t} \left[-y_t \sum_{j=1}^{J} \phi_{j,t} \nu_j + T_t \right],$$

which is equivalent to (e) and hence completes the proof. □

A.5 Proof of Proposition 2

Proof. We first show that an equilibrium allocation satisfies (20), (21), and (33). Market clearing for the final good at each date implies

$$c_t + k_{t+1} + g_t = y_t + (1 - \delta) k_t \qquad \text{for all } t \geq 0,$$

which is (20). The definition of sectoral factor shares and factor-market clearing imply $\sum_{j=1}^{J} \phi_{j,t} = 1$, which is (21).

The households' first order optimality condition with respect to c_t implies

$$\frac{\beta u_{c,t+1}}{u_{c,t}} = \frac{p_{t+1}}{p_t} \tag{A.18}$$

and normalizing $p_0 = 1$ and canceling the discounted capital terms using the Euler condition and the maintained transversality condition gives for all $t \geq 0$

$$p_t = \beta^t \frac{u_{c,t}}{u_{c,0}}. \tag{A.19}$$

Plugging prices (A.19) into the household budget constraint (1) gives

$$\sum_{t=0}^{\infty} \beta^t u_{c,t} \left(c_t + k_{t+1}\right) = \sum_{t=0}^{\infty} \beta^t u_{c,t} \left[(1-\tau_t^l) w_t l_t + \left[1 + (1-\tau_t^k) r_t\right] k_t + \sum_{j=1}^{J} (1-\tau_{j,t}^{\pi}) \pi_{j,t}\right] + u_{c,0} b_0,$$

which is equivalent to

$$\begin{aligned}\sum_{t=0}^{\infty} \beta^t u_{c,t} \left[c_t + k_{t+1} - (1-\tau_t^l) w_t l_t - \sum_{j=1}^{J} (1-\tau_{j,t}^{\pi}) \pi_{j,t}\right] = &\sum_{t=1}^{\infty} \beta^t u_{c,t} \left[1 + (1-\tau_t^k) r_t\right] k_t \\ &+ u_{c,0} \left[\left(1 + (1-\tau_0^k) r_0\right) k_0 + b_0\right]\end{aligned}$$

Using the household's optimality conditions (A.5)–(A.7) to substitute out net labor income, profit income after both instruments, and the after-tax capital return gives

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c,t} c_t + u_{l,t} l_t + \sum_{j=1}^{J} u_{e_j,t} \frac{n_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})}\right] = u_{c,0} \left[\left(1 + (1-\tau_0^k) r_0\right) k_0 + b_0\right].$$

Using the definition of $q_{j,t}$,

$$\sum_{j=1}^{J} \frac{n_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})} = \sum_{j=1}^{J} \frac{e_{j,t}}{q_{j,t}}.$$

Consequently,

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c,t} c_t + u_{l,t} l_t + \sum_{j=1}^{J} \frac{u_{e_j,t} e_{j,t}}{q_{j,t}} \right] = u_{c,0} W_0,$$

which is the implementability constraint (33).

To prove the other direction, suppose that an allocation satisfies (20), (21), and (33). We will show that this allocation, together with properly constructed prices and taxes, constitutes a tax-distorted market equilibrium.

By equation (A.1) and (10), the allocation directly implies sectoral output $y_{j,t}$ and aggregate output y_t, respectively. By (A.8) sector j profits are given by

$$\pi_{j,t} = \frac{1}{\varepsilon_j} \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} y_{j,t}.$$

The equilibrium condition (16) determines the combined profit retention factor once wages and labor taxes are constructed.

Furthermore, from equations (11) we have

$$\begin{aligned} r_t + \delta =& \frac{\varepsilon_j - 1}{\varepsilon_j} z_{j,t} F_k(k_t, l_t) \frac{1}{1 - s_{j,t}} \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} N_{j,t}^{\nu_j} \quad \text{and} \\ w_t =& \frac{\varepsilon_j - 1}{\varepsilon_j} z_{j,t} F_l(k_t, l_t) \frac{1}{1 - s_{j,t}} \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} N_{j,t}^{\nu_j}. \end{aligned}$$

Let input subsidies $s_{j,t}$ for all $j \in \{1, 2, ..., J\}$ and for all $t \geq 0$ be given by

$$1 - s_{j,t} = \frac{\varepsilon_j - 1}{\varepsilon_j} \frac{z_{j,t}}{z_t} \left(\frac{y_{j,t}}{y_t} \right)^{-\frac{1}{\gamma}} N_{j,t}^{\nu_j}.$$

Then factor prices are

$$\begin{aligned} r_t + \delta =& z_t F_k(k_t, l_t) \quad \text{and} \\ w_t =& z_t F_l(k_t, l_t). \end{aligned}$$

This construction normalizes factor prices by setting the aggregate markup to one. The initial return used in W_0 in (33) must be the same constructed return, $r_0 = z_0 F_k(k_0, l_0) - \delta$. With τ_0^k given, a different

initial factor-price normalization must also be reflected in W_0; it cannot be changed independently of the implementability constraint.

Next, set final good prices $\{p_t\}_{t=1}^{\infty}$ using (A.19). Use (17) to construct capital income taxes $\{\tau_t^k\}_{t=1}^{\infty}$ and (15) to construct labor income taxes $\{\tau_t^l\}_{t=0}^{\infty}$. By design the allocation then satisfies household and firm optimality conditions.

Furthermore using the constructed taxes and prices, and reversing the substitution $\sum_j e_{j,t}/q_{j,t} = \sum_j n_{j,t}(e_{j,t})/n'_{j,t}(e_{j,t})$, in the implementability condition (33) we get that the allocation also satisfies the household budget constraint (1). Combining it with the resource constraint (20) gives the government budget constraint, which completes the proof. □

A.6 Proof of Proposition 3

Proof. With additively separable preferences, $u(c,l,\mathbf{e}) = U(c) - V(l) - \sum_{j=1}^{J} W_j(e_j)$, we have $u_{cl,t} = u_{ce_j,t} = u_{e_jl,t} = 0$ for all j, and $u_{e_je_m,t} = 0$ for $j \neq m$. Use the definitions of $\sigma_{c,t}$, $\sigma_{l,t}$, $\sigma_{e_j,t} = u_{e_j,t}/(e_{j,t}u_{e_je_j,t})$, and $q_{j,t}$. Primes on the variety-creation technology denote derivatives with respect to entrepreneurial effort. The government solves

$$\max_{\{c_t,k_{t+1},l_t,\{\phi_{j,t},e_{j,t}\}_{j=1}^{J}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t, \mathbf{e}_t\right)$$

subject to

$$\begin{aligned} c_t + k_{t+1} + g_t &= \left(\sum_{j=1}^{J} \left(z_{j,t}\phi_{j,t}n_{j,t}(e_{j,t})^{\nu_j}\right)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}} F(k_t,l_t) + (1-\delta)k_t, \\ \sum_{j=1}^{J} \phi_{j,t} &= 1 \\ \sum_{t=0}^{\infty} \beta^t \left[u_{c,t}c_t + u_{l,t}l_t + \sum_{j=1}^{J} u_{e_j,t}e_{j,t}q_{j,t}^{-1}\right] &= u_{c,0}\left[\left(1 + (1-\tau_0^k)r_0\right)k_0 + b_0\right]. \end{aligned}$$

Here k_0 and b_0 are given, τ_0^k is fixed, and $W_0 \equiv [1 + (1-\tau_0^k)r_0]k_0 + b_0$ denotes initial wealth. At date zero, the fixed subsidies $s_{j,0} = 1/\varepsilon_{j,0}$ imply $\mathcal{M}_0 = 1$. The initial sectoral shares must additionally satisfy the equilibrium restrictions (A.22) at these fixed subsidies; these restrictions are imposed in the government's problem. Let λ multiply the implementability constraint written as its left-hand side minus $u_{c,0}W_0$, and let μ_t multiply date-t resources net of uses.

For $t \geq 1$, the first order condition with respect to $\phi_{j,t}$ is

$$\mu_t \frac{\partial y_t}{\partial \phi_{j,t}} = \xi_t, \tag{A.20}$$

where ξ_t is the Lagrange multiplier on the constraint $\sum_{j=1}^{J} \phi_{j,t} = 1$.

The partial derivative of y_t with respect to $\phi_{j,t}$ is

$$\begin{aligned}\frac{\partial y_t}{\partial \phi_{j,t}} =& \frac{\partial z_t}{\partial \phi_{j,t}} F(k_t, l_t) \\ =& z_t^{\frac{1}{\gamma}} \left(z_{j,t} n_{j,t} (e_{j,t})^{\nu_j}\right)^{\frac{\gamma-1}{\gamma}} \phi_{j,t}^{-\frac{1}{\gamma}} F(k_t, l_t).\end{aligned}$$

Together with the restriction that $\sum_{j=1}^{J} \phi_{j,t} = 1$ this implies

$$\phi_{j,t} = \frac{\left(z_{j,t} n_{j,t} (e_{j,t})^{\nu_j}\right)^{\gamma-1}}{\sum_{j'=1}^{J} \left(z_{j',t} n_{j',t} (e_{j',t})^{\nu_{j',t}}\right)^{\gamma-1}}.$$

At $t = 0$, the same share formula follows from the equilibrium restrictions (A.22) with $s_{j,0} = 1/\varepsilon_{j,0}$. Substituting these initial shares into the problem, and plugging into equation (10) gives an expression for aggregate output (and productivity)

$$y_t = \underbrace{\left(\sum_{j=1}^{J} \left(z_{j,t} n_{j,t} (e_{j,t})^{\nu_j}\right)^{\gamma-1}\right)^{\frac{1}{\gamma-1}}}_{z_t} F(k_t, l_t),$$

where the optimal sectoral shares have been substituted out. Hence we have that

$$\phi_{j,t} = \left(\frac{z_{j,t} n_{j,t} (e_{j,t})^{\nu_j}}{z_t}\right)^{\gamma-1}. \tag{A.21}$$

By equation (11) we must have for all $j \in \mathcal{J}$

$$\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{1}{1 - s_{j,t}} z_{j,t} n_{j,t} (e_{j,t})^{\nu_j} \left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} = \frac{\varepsilon_{1,t} - 1}{\varepsilon_{1,t}} \frac{1}{1 - s_{1,t}} z_{1,t} n_{1,t} (e_{1,t})^{\nu_{1,t}} \left(\frac{y_{1,t}}{y_t}\right)^{-\frac{1}{\gamma}}. \tag{A.22}$$

By Lemma 1

$$\left(\frac{y_{j,t}}{y_t}\right)^{-\frac{1}{\gamma}} = \left(\frac{\phi_{j,t} z_{j,t} n_{j,t}(e_{j,t})^{\nu_j}}{z_t}\right)^{-\frac{1}{\gamma}} = \frac{z_t}{z_{j,t}} n_{j,t}(e_{j,t})^{-\nu_j},$$

where we used the expression (A.21) for $\phi_{j,t}$. Hence, (A.22) is equivalent to

$$\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{1}{1 - s_{j,t}} = \frac{\varepsilon_{1,t} - 1}{\varepsilon_{1,t}} \frac{1}{1 - s_{1,t}}$$

for all $j \in \mathcal{J}$. Consequently,

$$(1 - s_{j,t}) \frac{\varepsilon_j}{\varepsilon_j - 1} = \mathcal{M}_t \quad \forall j \in \mathcal{J}.$$

For compactness in the proof, define

$$\begin{aligned}
C_t &\equiv 1 - \frac{1}{\sigma_{c,t}}, \\
L_t &\equiv 1 + \frac{1}{\sigma_{l,t}}, \\
E_{j,t} &\equiv 1 + \frac{1}{\sigma_{e_j,t} q_{j,t}}, \\
R_{j,t} &\equiv \frac{\partial}{\partial e_{j,t}} \left(\frac{e_{j,t}}{q_{j,t}}\right) - 1 = \frac{1}{q_{j,t}} - 1 - \frac{e_{j,t}}{q_{j,t}^2} \frac{\partial q_{j,t}}{\partial e_{j,t}}.
\end{aligned}$$

The date-t implementability term is $I_t = u_{c,t} c_t + u_{l,t} l_t + \sum_{j=1}^{J} \frac{u_{e_j,t} e_{j,t}}{q_{j,t}}$. Additive separability implies

$$\frac{\partial I_t}{\partial c_t} = u_{c,t} C_t, \qquad \frac{\partial I_t}{\partial l_t} = u_{l,t} L_t, \qquad \frac{\partial I_t}{\partial e_{j,t}} = u_{e_j,t}(E_{j,t} + R_{j,t}).$$

Denote the marginal output gain from entrepreneurial effort by

$$Y_{e_j,t} \equiv \frac{\partial y_t}{\partial e_{j,t}} = \left(\frac{y_{j,t}}{y_t}\right)^{-1/\gamma} y_{j,t} \frac{n'_{j,t}(e_{j,t})}{n_{j,t}(e_{j,t})} \nu_j.$$

For $t \geq 1$, the first order conditions with respect to c_t, l_t and $e_{j,t}$ are, respectively,

$$1 + \lambda C_t = \frac{\mu_t}{\beta^t u_{c,t}}, \tag{A.23}$$

$$1 + \lambda L_t = -\frac{\mu_t}{\beta^t u_{l,t}} z_t F_{l,t}, \tag{A.24}$$

$$1 + \lambda E_{j,t} + \lambda R_{j,t} = -\frac{\mu_t}{\beta^t u_{e_j,t}} Y_{e_j,t}. \tag{A.25}$$

The first-order condition with respect to k_{t+1} is given by

$$\mu_t = (1 + z_{t+1} F_{k,t+1} - \delta)\mu_{t+1} \qquad (t \geq 0). \tag{A.26}$$

For $t \geq 1$, substituting (A.23) into (A.26) gives

$$u_{c,t}(1 + \lambda C_t) = \beta u_{c,t+1}(1 + \lambda C_{t+1})(1 + z_{t+1} F_{k,t+1} - \delta).$$

Comparing with (17) and indexing the tax by its payment date,

$$1 - \tau_t^k = \frac{\dfrac{1 + \lambda(1 - \sigma_{c,t}^{-1})}{1 + \lambda(1 - \sigma_{c,t-1}^{-1})}(1 + z_t F_{k,t} - \delta) - 1}{z_t F_{k,t}/\mathcal{M}_t - \delta} \qquad (t \geq 2).$$

This is (35).

Substituting (A.23) into (A.24) and (A.25) renders

$$1 + \lambda L_t = -\frac{u_{c,t}}{u_{l,t}}(1 + \lambda C_t) z_t F_{l,t},$$

$$1 + \lambda E_{j,t} + \lambda R_{j,t} = -\frac{u_{c,t}}{u_{e_j,t}}(1 + \lambda C_t) Y_{e_j,t}.$$

Comparing with (15) and (16) yields

$$1 - \tau_t^l = \frac{1 + \lambda C_t}{1 + \lambda L_t}\mathcal{M}_t,$$

$$1 - \tau_{j,t}^{\pi} = \frac{1 + \lambda C_t}{1 + \lambda E_{j,t} + \lambda R_{j,t}}\varepsilon_j \nu_j.$$

Equivalently, for $t \geq 1$,

$$1 - \tau_t^l = \frac{1 + \lambda(1 - \sigma_{c,t}^{-1})}{1 + \lambda\left(1 + \sigma_{l,t}^{-1}\right)}\mathcal{M}_t,$$
$$1 - \tau_{j,t}^{\pi} = \frac{1 + \lambda(1 - \sigma_{c,t}^{-1})}{1 + \lambda\left(\dfrac{1}{q_{j,t}} - \dfrac{e_{j,t}}{q_{j,t}^2}\dfrac{\partial q_{j,t}}{\partial e_{j,t}} + \dfrac{1}{\sigma_{e_j,t} q_{j,t}}\right)}\varepsilon_j \nu_j.$$

These are (36) and (37).

The initial wealth term changes the period-zero consumption condition. Define

$$\widehat{C}_0 \equiv C_0 - \frac{u_{cc,0}}{u_{c,0}} W_0 = 1 - \frac{1}{\sigma_{c,0}} + \frac{W_0}{\sigma_{c,0} c_0}.$$

The first-order conditions with respect to c_0, l_0 and $e_{j,0}$ are, respectively,

$$1 + \lambda \widehat{C}_0 = \frac{\mu_0}{u_{c,0}},$$
$$1 + \lambda\left[L_0 - \frac{u_{c,0}}{u_{l,0}}\frac{\partial W_0}{\partial l_0}\right] = -\frac{\mu_0}{u_{l,0}} z_0 F_{l,0},$$
$$1 + \lambda\left[E_{j,0} + R_{j,0} - \frac{u_{c,0}}{u_{e_j,0}}\frac{\partial W_0}{\partial e_{j,0}}\right] = -\frac{\mu_0}{u_{e_j,0}} Y_{e_j,0}.$$

Substituting out μ_0 gives

$$1 + \lambda\left[L_0 - \frac{u_{c,0}}{u_{l,0}}\frac{\partial W_0}{\partial l_0}\right] = -\frac{u_{c,0}}{u_{l,0}}(1 + \lambda \widehat{C}_0) z_0 F_{l,0}, \tag{A.27}$$

and

$$1 + \lambda\left[E_{j,0} + R_{j,0} - \frac{u_{c,0}}{u_{e_j,0}}\frac{\partial W_0}{\partial e_{j,0}}\right] = -\frac{u_{c,0}}{u_{e_j,0}}(1 + \lambda \widehat{C}_0) Y_{e_j,0}. \tag{A.28}$$

Comparing (A.27) with (15) gives

$$1 - \tau_0^l = \frac{1 + \lambda\left[\widehat{C}_0 - \dfrac{\partial W_0 / \partial l_0}{z_0 F_{l,0}}\right]}{1 + \lambda L_0}\mathcal{M}_0, \tag{A.29}$$

while comparing (A.28) with (16) gives

$$1-\tau^{\pi}_{j,0}=\frac{1+\lambda\left[\widehat{C}_0-\dfrac{\partial W_0/\partial e_{j,0}}{Y_{e_j,0}}\right]}{1+\lambda E_{j,0}+\lambda R_{j,0}}\varepsilon_{j,0}\nu_{j,0}. \tag{A.30}$$

Here $Y_{e_j,0}=q_{j,0}\pi_{j,0}\varepsilon_{j,0}\nu_{j,0}/e_{j,0}$. The wealth derivatives remain because W_0 depends on the initial interest rate, even under additive separability. For a given initial markup $\mathcal{M}_0$, they are obtained from

$$\begin{aligned}
W_0&=\left[1+(1-\tau^k_0)\left(\frac{z_0F_{k,0}}{\mathcal{M}_0}-\delta\right)\right]k_0+b_0,\\
\frac{\partial W_0}{\partial l_0}&=\frac{(1-\tau^k_0)k_0}{\mathcal{M}_0}\,z_0F_{kl,0},\\
\frac{\partial W_0}{\partial e_{j,0}}&=\frac{(1-\tau^k_0)k_0}{\mathcal{M}_0}\,F_{k,0}\frac{\partial z_0}{\partial e_{j,0}},\qquad \frac{\partial z_0}{\partial e_{j,0}}=z_0\phi_{j,0}\nu_{j,0}\frac{n'_{j,0}(e_{j,0})}{n_{j,0}(e_{j,0})}.
\end{aligned}$$

Thus the condition $s_{j,0}=1/\varepsilon_{j,0}$ sets $\mathcal{M}_0=1$ and eliminates the initial markup distortion but does not eliminate the wealth corrections.

Finally, substituting $\mu_0=u_{c,0}(1+\lambda\widehat{C}_0)$ and $\mu_1=\beta u_{c,1}(1+\lambda C_1)$ into the capital condition at $t=0$ and comparing with (17) yields

$$1-\tau^k_1=\frac{\dfrac{1+\lambda(1-\sigma^{-1}_{c,1})}{1+\lambda\left(1-\sigma^{-1}_{c,0}+W_0/(\sigma_{c,0}c_0)\right)}(1+z_1F_{k,1}-\delta)-1}{z_1F_{k,1}/\mathcal{M}_1-\delta}. \tag{A.31}$$

This completes the proof. □

A.7 Proof of Proposition 4

Proof. Throughout the proof, prices, sector aggregates, all other tax rates, and the marginal utility of consumption $u_{c,t}$ are held fixed. Household choices are allowed to adjust. Under separable preferences, labor supply and entrepreneurial effort in all other sectors remain unchanged, while entrepreneurial effort in sector j adjusts.

Under additive separability, the labor-supply condition

$$-u_{l,t}=u_{c,t}(1-\tau^l_t)w_t$$

implies that labor supply remains unchanged. The optimality condition for entrepreneurial effort in sector

j is

$$-u_{e_j,t} = u_{c,t}(1-\tau^{\pi}_{j,t})\kappa_{j,t}n'_{j,t}(e_{j,t}),$$

where $\kappa_{j,t} = \pi_{j,t}/n_{j,t}(e_{j,t})$ denotes profits per variety. The firm's profit-maximization problem implies that $\kappa_{j,t}$ remains constant when prices and sector aggregates are held fixed.

Differentiating with respect to $1-\tau^{\pi}_{j,t}$ gives

$$-u_{e_{j,t}e_{j,t}}\frac{\partial e_{j,t}}{\partial(1-\tau^{\pi}_{j,t})} = u_{c,t}\kappa_{j,t}n'_{j,t}(e_{j,t}) + u_{c,t}(1-\tau^{\pi}_{j,t})\kappa_{j,t}n''_{j,t}(e_{j,t})\frac{\partial e_{j,t}}{\partial(1-\tau^{\pi}_{j,t})},$$

which is equivalent to

$$\mathcal{E}_{e_{j,t},1-\tau^{\pi}_{j,t}} = \frac{\sigma_{e_j,t}}{1-\sigma_{e_j,t}\frac{e_{j,t}n''_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})}},$$

Because profits per variety are constant and $q_{j,t} = \mathcal{E}_{\pi_{j,t},e_{j,t}}$ we have

$$\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}} = \mathcal{E}_{\pi_{j,t},e_{j,t}}\mathcal{E}_{e_j,1-\tau^{\pi}_{j,t}} = q_{j,t}\mathcal{E}_{e_j,1-\tau^{\pi}_{j,t}}$$

and hence

$$\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}} = \frac{1}{\frac{1}{q_{j,t}\sigma_{e_j,t}} - \frac{1}{q_{j,t}}\frac{e_{j,t}n''_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})}}.$$

Finally, log-differentiating $q_{j,t} = e_{j,t}n'_{j,t}(e_{j,t})/n_{j,t}(e_{j,t})$ with respect to sectoral effort gives

$$\mathcal{E}_{q_{j,t},e_{j,t}} = 1 + \frac{e_{j,t}n''_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})} - q_{j,t}.$$

Therefore

$$\begin{aligned}\frac{1+\sigma^{-1}_{e_j,t} - \mathcal{E}_{q_{j,t},e_{j,t}}}{q_{j,t}} &= 1 + \frac{1}{q_{j,t}\sigma_{e_j,t}} - \frac{1}{q_{j,t}}\frac{e_{j,t}n''_{j,t}(e_{j,t})}{n'_{j,t}(e_{j,t})} \\ &= 1 + \frac{1}{\mathcal{E}_{\pi_{j,t},1-\tau^{\pi}_{j,t}}}.\end{aligned}$$

□