Monopsony Power and Creative Destruction

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Isabella Maassen, Filip Mellgren, Jonas Overhage

Abstract

In the U.S., the last decades have seen a rise in concentration and decrease in economic growth. Over the same time period, shifts in labor market power and income tax regimes have occured. This paper connects these developments. We identify labor supply elasticities as an important factor for market concentration. Higher elasticities further the expansion of large, productive firms. We argue that this expansion may increase efficiency in production while at the same time decreasing it in innovation. We show that income taxation plays into this, with decreases in progressivity increasing market concentration. Embedding monopsonic labor markets in a model of economic growth, we quantify these effects. We identify key channels through which historical tax reforms affected output and present evidence that a more progressive tax regime increases long-run productivity growth.

1 Introduction

Market power and its effects have seen significant attention in research over recent years. Often, studies of market power restrict themselves to product markets. Motivated by the observation that wages in US manufacturing are increasingly marked-down below the marginal revenue product of labor (Chen et al., 2022), we seek to expand this scope and consider labor market power as well. We present a channel through which firms labor supply elasticity shapes growth and productivity. This paper microfounds this labor supply elasticity, and links it to tax policy in the presence of monopsonistic labor markets. We develop an endogenous growth model along the Schumpetarian tradition that features both product- and labor market power, firm heterogeneity, and flexible income taxes. Using our model, we quantify the relation between monopsony power, income taxation and aggregate outcomes.

Compared to endogenous growth models without monopsony, a key mechanism in our model that influences long-run aggregate output is that monopsony increases the cost of operating large firms, as wages increase with employment. The introduction of progressive income taxes exacerbates this effect by further lowering firms' labor supply elasticity with respect to the gross wage. These factors entering the labor supply elasticity introduce a convexity of operating costs, which limits firm sizes while simultaneously decreasing marginal cost dispersion and limiting market concentration.

To quantitatively understand how a progressive tax policy might influence aggregate output when labor markets are monopsonistic, we calibrate the model to match the U.S data and quantify the quantifiy the relation between the resulting labor supply elasticities and aggregate outcomes. By matching to the data, we uncover a tradeoff between the efficiency of research- and production activity. We can furthermore quantify the role of labor supply elasticities. Our findings include that: (1) When a shift in the supply elasticity is induced through preference changes, a 1% higher labor supply elasticity is associated with 0.34% higher current output, while at the same time lowering productivity growth by 0.76%. (2) A 1% increase in tax progressivity decreases the supply elasticity with respect to gross wage by around 1%. (3) A shift to a low base – high progressivity tax schedule is associated with around 10% lower current output while increasing productivity growth by around 50%.

We follow Boppart and Li, 2021, and decompose aggregate output into its main components. The decomposition allows us to separate out distinct channels that arise within our framework. Specifically, we can partial out effects on growth, average process efficiency, misallocation, and employment, and show that each of these channels are affected by changes in the tax regime under monopsonistic labor markets. Using this decomposition, we argue that large tax cuts in the 1980s, which featureed cuts in progressivity, mainly affected output by increasing concentration, TFPQ and labor market participation, but had little – or even negative – effects on long-run TFP growth.

Our study of monopsony in a growth model is motivated by the recent surge in papers empirically documenting the presence of monopsonistic labor markets and its consequences for firm size and productivity. For US manufacturing, Chen et al., 2022, use a production function approach in data from the Census of Manufactures and the Annual Surveys of Manufactures. They document substantial wage markdowns that are widespread and have been increasing since the year 2000. Similarly, Kirov and Traina, 2023, use US Census data and find that wage markdowns have been increasing since 1970, and more sharply since 2002. Berger et al., 2022, establish evidence of labor market power in the US, and using a general equilibrium model find that aggregate output is about 20.9% lower, compared to a perfectly competitive benchmark. Bachmann et al., 2022 find that the variation of the labor market power within Germany can account for about 10% lower aggregate labor productivity in East Germany and compared to West Germany. Compared to these papers, our paper contributes by developing a structural model that can be used to study the interaction between labor- and product market power as well as tax policy.

The growth model in this paper builds on seminal work by Aghion and Howitt, 1992 and Klette and Kortum, 2004. In particular, we base our model on Aghion et al., 2019. To this class of models, our main contribution is to incorporate a monopsonistic labor market. In doing so, we also introduce endogenous labor market participation. Our framework can be used to study questions related to monopsonistic labor markets and growth, while retaining some tractability of the original model. One important feature brought by our enhanced model is equilibrium wage inequality workers following by a firm wide wage premium, which has been found in studies such as the ones by Abowd et al., 1999, Bonhomme et al., 2019, Bonhomme et al., 2023 or Wong, 2023.

Altogether, we obtain a rich framework that allows us to understand how labor supply elasticities shape aggregate output through their effect on entry, the firm size distribution, misallocation, and employment. Furthermore, we speak to how these elasticities can be affected by tax policy.

Our paper's contribution to the issue of the relation between economic output and taxes relates to some degree to research on taxation in general, for example by Gechert and Heimberger, 2022 or Lee and Gordon, 2005. However, we more specifically speak to income taxation such as Nguyen et al., 2021. We specifically highlight a novel channel, in contrast to more holistic work such as Altig et al., 2001. Recent work by Macnamara et al., 2024 examines ways in which overall lower income taxation may increase productivity growth. Our model allows us to decompose these effects, and we present evidence that lower taxation can have significantly different effects depending on whether taxation is lowered through level- or progressivity cuts.

The paper proceeds by showcasing the model. We then discuss analytical results before turning to a quantification of the model which we use to simulate policy counterfactuals and to compare the strength of various channels that are affected by the tax progressiveness.

2 Model

Like standard models of creative destruction, our model features monopolistic firms with production of intermediate goods along a good-specific quality ladder. Intermediate goods are bundled by a competitive final goods producer. Households not only value consumption of the final good, but also have idiosyncratic preferences over different employers and make a discrete choice regarding their workplace and employment status. The economy grows as a result of firms' innovation efforts that lead to an increasing quality of the final good. Finally, the government raises revenue from a wage bill tax, and spends all revenue on government consumption, which benefits each household equally.

2.1 Final good producers

There is a competitive final goods producer that aggregates differentiated intermediate goods from a unit interval according to a Cobb-Douglas aggregator:

$$Y_t = \exp \int_0^1 \ln(q_{it} y_{it}) di, \quad i \in [0,1], \tag{1}$$

where Y_t is final output, q_{it} is the quality level of good i, and y_{it} is the quantity of that good. This set-up implies that demand for each differentiated good follows:

$$p_{it} y_{it} = P_t Y_t, \quad P_t \equiv \exp \int_0^1 \ln(p_{it}/q_{it}) di, \tag{2}$$

where we normalize $P_t \equiv 1$. For a detailed derivation of intermediate good demand, refer to section A.3. We further introduce a quality index $Q_t \equiv \exp \int_0^1 \ln(q_{it}) di$. Aggregate output can be interpreted as a combination of quality level and physical output: $Y_t = Q_t \exp \int_0^1 \ln(y_{it}) di$.

This demand specification makes intermediate goods in the same product line i produced by different firms perfect substitutes and the final goods producer purchases from the firm j with the lowest quality-adjusted price, i.e. $p_{it}/q_{it} = \min_{j \in \mathcal{J}} \frac{p_{ijt}}{q_{ijt}}$. To break ties between intermediate goods producers posting equal quality-adjusted prices, we assume that the good with the higher quality is preferred.

For technical details on the good demand, refer to Appendix A.5. Essentially, intermediate goods producers compete in a Bertrand manner within each product market, and product demand for good i facing firm j is formally expressed as:

$$y_i(p_{ijt}, q_{ijt}, Y_t) = \begin{cases} \frac{Y_t}{p_{ijt}} & \text{if } \frac{p_{ijt}}{q_{ijt}} < \frac{p_{ij't}}{q_{ij't}}, \quad \forall j' \in \mathcal{J} \setminus j \\ \frac{Y_t}{p_{ijt}} & \text{if } \frac{p_{ijt}}{q_{ijt}} \leq \frac{p_{ij't}}{q_{ij't}}, \quad \forall j' \in \mathcal{J} \setminus j \\ & q_{ijt} > q_{ikt}, \quad \forall k : \frac{p_{ijt}}{q_{ijt}} = \frac{p_{ikt}}{q_{ikt}} \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

2.2 Households

A mass $\mathcal{L}$ of households derive utility from private and government consumption and make a discrete choice over workplaces and home production in each period. They can choose to seek employment ($g = e$) in a company $j \in \{1, ..., J\}$, or engage in home production ($g = u$). Households, indexed by o, have preferences for consumption as well as working at different firms and home production,

$$u_{ojt} = \kappa \ln C_{ojt} + \xi_{ogt} + (1 - \sigma)\varepsilon_{ojt} \tag{4}$$

where C_{ojt} is Cobb-Douglas aggregated private (C^p_{oj}) and government consumption (G). Households do not save, but fully consume the wage earned at firm j, which implies $C_{ojt} = W^{\eta}_{ojt} G^{1-\eta}_t$. In our model, wages will differ only by across firms j, not across households workin within a single firm. We thus drop the o subcript for the wage, and can state household utility as:

$$u_{ojt} = \underbrace{\kappa\eta}_{\beta} \ln(W_{jt}) + \kappa(1 - \eta) \ln(G) + \xi_{ogt} + (1 - \sigma)\varepsilon_{ojt} \tag{5}$$

where ε_{ojt} is independently and identically extreme value type 1 distributed. Similarly ξ_{ogt} is also i.i.d. extreme value type 1 distributed. G_t is government consumption. If the household chooses to work at a firm, they earn the firm j specific wage W_j. If they choose to engage in home production, they instead receive ωY. Utility from consumption takes a Cobb-Douglas form with elasticity η. Overall utility combines the Cobb-Douglas utility of consumption, with individual preferences over workplace, and weighs the two components using the parameter κ. The product $\kappa\eta = \beta$ thus capture how sensitive a household's utility is to a higher wage. In the limiting case where $\kappa \to \infty$, households stop caring about workplace utility relative to consumption utility.

Households compare all options available to them and choose to work at a firm, or in home production, depending on what choice gives them the highest utility. The formulation thus captures, in addition to wages, individual preferences over working at any given firm (ε_{ojt}) and being employed at all (ξ_{ogt}), which does not depend on the workplace. This setup follows the nested logit outlined in McFadden (1977), which implies that the labor supply facing firm j is given by:

$$L_j(W_{jt}) = \mathcal{L} \frac{W_{jt}^{\frac{\beta}{1-\sigma}}}{(\sum_{k=1}^{\mathcal{J}} W_{kt}^{\frac{\beta}{1-\sigma}})^{\sigma}(\omega Y)^{\beta} + \sum_{k=1}^{\mathcal{J}} W_{kt}^{\frac{\beta}{1-\sigma}}},$$

For details on solving the nested discrete choice problem, refer to section A.2. We define $D_{e,t} \equiv \sum_{k=1}^{J} W_{kt}^{\frac{\beta}{1-\sigma}}$ and $z_t \equiv \frac{\mathcal{L}}{D_{e,t}}^{\sigma}(\omega Y)^{\beta} + D_{e,t}$. We further assume that the number of firms, J is large enough, such that no intermediate goods producer takes it's own effect on z into account. The labor supply facing firm j is then given by

$$L_j(W_{jt}) = z_t W_{jt}^{\frac{\beta}{1-\sigma}}, \tag{6}$$

where z_t is an equilibrium object taken as given by firms, assuming that each individual firm considers it self small enough to not have an influence on z_t. Firms hence do not take the effect of their wage on the labor market into account, making the model a model of monopsony as opposed to oligopsony.

2.3 Intermediate goods producers

Intermediate goods producers, $j \in \{1, ..., J\} = \mathcal{J}$, set prices for intermediate goods, and decide how much to invest into research. The firm problem can conceptually be divided into two optimization problems: a static and a dynamic one. Statically, setting prices for intermediate goods determines production quantities and profits within a period. Dynamically, the firm decides how much to invest in research today, which leads to quality innovations in the next period. When a firm can produce the highest quality of an intermediate good, it can sell that product at a marked-up price. In the following, the two parts of the firm problem are described in more detail.

Within a period, firms maximize their static profit by setting their quality-adjusted price for each intermediate profit, p_{ijt}/q_{ijt}, taking as given the current state of product quality in each line, q_{ijt}, as well as the quality adjusted prices of rival firms. As described above, intermediate product demand is given by Equation 3. Setting intermediate prices hence determines how much the firm produces, which in turn implies the required labor input. The wage is then set via the labor supply facing the firm, such that the labor input is matched. Firms also pay a tax at rate $T(W_{jt}/\bar{w}_t)$ on their wage bill. Formally, the static problem is given as:

$$\Pi_j(Y_t, \{q_{ijt}\}_{i\in[0,1]}) = \max_{\{p_{ijt}\}_{i\in[0,1]}} \int_0^1 p_{ijt} y_{it} di - (1 + T(W_{jt}/\bar{w}_t))W_{jt}L_{jt}, \tag{7}$$

$$\text{s.t.} \quad L_{jt} = \int_0^1 f^{-1}(y_{ijt})di, \quad W_{jt} = \left(\frac{L_{jt}}{z_t}\right)^{\frac{1-\sigma}{\beta}} \tag{8}$$

$$\text{Intermediate product demand as in (3)}, \tag{9}$$

where $f^{-1}(y_{ijt})$ is the inverse of the intermediate production function in labor.

To impact its future ability to make static profits via $\{q_{ijt}\}_{i\in[0,1]}$, the firm can choose to engage in research. Denote the last firm to innovate upon product line i as $j(i)$ and the firm with the next highest product-specific quality as $j'(i)$. We refer to these firms as "(quality) leader" and "(quality) follower". Innovation is modeled as a $\gamma > 1$ step over the highest existing quality level of a good, i.e. $\gamma = \frac{q_{j(i)}}{q_{j'(i)}}$. Innovation is undirected in the sense that firms do not decide which product lines to innovate in. However, we assume that firms do not innovate on product lines where they are already the leading quality producer, and that they do not draw the same product line as someone else in the same period. Research costs are a function of the mass of product lines x_{jt} the firm wishes to be a quality leader in: $C^R\left(Y_t, x_{jt}\right)$.

The full firm problem is:

$$
\begin{aligned}
V_{jt}(Y_t, \{q_{jit}\}_{i\in[0,1]}) = & \max_{x_{jt}} \Pi_j\left(Y_t, \{q_{ijt}\}_{i\in[0,1]}\right) - C^R\left(Y_t, x_{jt}\right) & (10)\\
& + R_t V_{t+1}(Y_{t+1}, \{q_{jit+1}\}_{i\in[0,1]}) & (11)
\end{aligned}
$$

Assuming there is no uncertainty over the future state of the economy, i.e. the path of Y_t and R_t is known, firms will only engage in costly research if there is something to gain from being a quality leader in additional lines. In other words, firms do not invest into gaining a quality advantage if they do not plan to use that advantage to generate (static) profits. This implies that firms want to produce in all lines in which they are quality leaders, given that they behaved optimally in their dynamic optimization. In all lines i, the quality leader $j(i)$ sets the quality-adjusted price equal to his follower's quality-adjusted marginal costs, that is $p_{j(i)it} = \gamma mc_{j'(i)it}$, and fulfils the implied product demand y_{it}. The firm size in terms of the number of varieties produced n_{jt} is hence given as:

$$
n_{jt} = \int_0^1 \mathbf{1}(q_{ijt} > q_{ikt}, \forall k \in \mathcal{J} \setminus j)di \tag{12}
$$

The dynamic firm problem therefore boils down to choosing n_{jt+1}.

Finally, note that other firms will become quality leaders in some of the product lines included in n_{jt} in the next period. To take into account innovation activities by other firms, we introduce the aggregate variable $\chi_t = \sum_{j\in\mathcal{J}} x_{jt}$, and n_{jt} decreases at that rate. To summarize, the intermediate producers maximize the following:

$$
V_{jt}(Y_t, n_{jt}) = \max_{x_{jt}} \Pi_j\left(Y_t, n_{jt}\right) - C^R\left(Y_t, x_{jt}\right) + R_t V_{t+1}(Y_{t+1}, n_{jt+1}) \tag{13}
$$

$$
\text{s.t. } n_{jt+1} = (1-\chi_t)n_{jt} + x_{jt}. \tag{14}
$$

2.3.1 Firm Entry

When a firm enters, it pays a cost ζY_t and draws its type s: We use α for the probability of being an h-type firm, and $1-\alpha$ of being an l-type one. Households also draw their idiosyncratic preference shocks for working at that firm. Then, the firm starts producing output and can invest in R&D to grow. Firms will hence enter as long as the expected firm value is greater than the entry cost:

$$\zeta Y_t \leq E_t \left[V_{st}(Y_t, n_{st}) \right] \tag{15}$$

Because we restrict ourselves to a balanced-growth analysis, entering firms are assumed to enter at there optimal size. We consider the balanced growth path to be one where the number of firms is constant, with the value of a potential entrant exactly matching the entry cost.

2.4 Government

The government raises taxes on firms' wage bills[1], and spends all tax revenue in the same period on government consumption G_t. Government consumption benefits all households equally, that is, each household consumes some g_t, such that $g_t = G_t/\mathcal{L}$. We assume that the government commits to a tax schedule $T(W_j/\bar{w})$, where $\bar{w}_t \equiv \sum_{j=1}^{\mathcal{J}} W_{jt} L_{jt} / \sum_{j=1}^{\mathcal{J}} L_{jt}$ is a reference wage. The government does not have an objective function, but makes handouts such that the budget constraint binds in each period:

$$G_t = \sum_{j=1}^{\mathcal{J}} T(W_{jt}/\bar{w}_t) W_{jt} L_{jt} \tag{16}$$

Government consumption benefits households without distorting labor supply and workplace choices, and is additive in the indirect utility function specified in equation 5. We derive the indirect utility function from a function where the good consumed is a Cobb-Douglas aggregate of public and private consumption. For details, refer to appendix A.1.

2.5 Market clearing

Final output Y_t is used for consumption and research expenditure X_t. Consumption occurs in the form of wage-financed private consumption C_t^p, tax-financed government consumption $\mathcal{L}G_t$, and rents R_t. The following identity must hold:

$$Y_t = X_t + C_t^p + \mathcal{L}G_t + R_t \tag{17}$$

[1]Note that this is equivalent to raising taxes on worker's wages, for details refer to appendix A.4

In our model, there are rents due to non-zero entry costs ζY_t. Further, we can express research costs as:

$$X_t = \sum_j C_t^R(\chi n_{jt}) \tag{18}$$

Private consumption is the sum of all net wages paid, and government expenditure is the sum of all taxes paid:

$$C_t^p = \sum_{jt} W_{jt} L_{jt}, \quad \mathcal{L}G_t = \sum_j T(W_{jt}/\bar{w}_t) W_{jt} L_{jt} \tag{19}$$

Finally, rents are the sum over profits in production minus research costs:

$$R_t = \sum_j (n_{jt} Y_t - W_{jt} L_{jt} - C^R(\chi n_{jt})) \tag{20}$$

Plugging in these expressions for aggregate variables yields:

$$\begin{aligned}
&Y_t \\
&= \sum_j C^R(\chi n_{jt}) + \sum_j W_{jt} L_{jt} \\
&\quad + \sum_j T(W_{jt}/\bar{w}_t) W_{jt} L_{jt} + \sum_j (n_{jt} Y_t - (1 + T(W_{jt}/\bar{w}_t)) W_{jt} L_{jt} - C_t^R(\chi n_{jt})) \\
&= \sum_j n_{jt} Y_t = Y_t
\end{aligned}$$

3 Model results

In this section, we present analytical equilibrium results for a simple version of the model as well as a way to interpret TFP and misallocation. The aim is to build intuition for the main dynamics and predictions of the model. We begin by making assumptions on the functional form of production, the tax scheme, and and that there are two firm types. In the following subsections, we start by discussing the solution to the static firm problem, and then discuss the dynamic firm problem under two assumptions of research costs, starting with linear research costs, and proceeding to convex research costs.

Production technology: good i is produced using a linear technology, $y_j(l_{ijt}) = s_j l_{ijt}$. We therefore have the following expression for the total labor input: $L_{jt} = \int_0^1 y_{ijt}/s_j$. Using this production function, we can express the wage of a firm in terms of aggregate variables. Note that each firm produces $Y_{jt} = \frac{n_{jtt} Y_t}{\gamma m_t}$, and that the labor input needed to produce this is given by $L_{jt} = Y_{jt}/s_j$. Using the labor supply function and rearranging yields:

$$W_{jt} = \left(\frac{n_{jtt} Y_t}{s_j \gamma z_t m_t} \right)^{\frac{1-\sigma}{\beta}} \tag{21}$$

Firm types: As in the previous section there are two firm types, $s \in \{h, l\}$, but solutions generalize for more firm types.

3.1 Static allocation

Starting with the static firm problem, with aggregate variables and product quality in each line being taken as given by the intermediate goods producers. A Bertrand Nash Equilibrium exists when firms engage in limit pricing by setting prices in all product lines where they are not quality leaders equal to their marginal cost, and set prices where they are quality leaders equal to the quality improvement, γ, times the marginal cost of the quality follower: $p_{ijt} = \gamma mc_{j'(i)t}$. For details, refer to Appendix A.5.

From the Cobb-douglas aggregation specified in section 2.1 follows that a total revenue of Y goes into each product line i. Using the pricing result from above, this implies we can pin down the labor input needed by quality leaders to fulfill demand in a product line:

$$\int_0^1 l_{it} di = \int_0^1 l_{j(i)t} di = \int_0^1 \frac{Y_t}{\gamma mc_{j'(i)t} s_{j(i)t}} di$$

Product line-level markups will equal the product line price relative to the intermediate good producer's marginal costs, $\mu_{ijt} \equiv p_{ijt}/mc_{jt}$. Markups thus depend on relative marginal costs, as the price is a γ-step over the follower's marginal cost: $p_{it} = \gamma mc_{j'(i)t}$. Hence, product line-level markups with two firm types can take on three values:

$$\mu_{hh} = \mu_{ll} = \gamma \tag{22}$$

$$\mu_{hl} = \gamma \frac{mc_{lt}}{mc_{ht}} \tag{23}$$

$$\mu_{lh} = \gamma \frac{mc_{ht}}{mc_{lt}}. \tag{24}$$

Since markups are variable, aggregate TFP will be subject to misallocation which we will discuss further in section 3.3. Crucially, what will now matter for firms is the followers which they face in the lines they lead. As our model features a continuum of lines, the distribution of followers for all firms is equal to the distribution across all lines. For this purpose, we define h as the share of lines controlled by high productivity firms. Focusing on equilibria in which h is constant over time, this share of controlled lines is also exactly the share of lines in which high productivity firms are quality followers. Using this result, we can define markups at the firm level μ_j, as the quantity weighted average firm-level price over the firm's marginal cost:

$$\mu_{jt} \equiv \frac{\int_0^{n_{jt}} y_{it} p_{it} di}{mc_{jt} \cdot \int_0^{n_{jt}} y_{it} di} = \frac{\gamma m_t}{mc_{jt}}. \tag{25}$$

Here, m is defined as a harmonic mean of marginal costs $m^{-1} := \frac{h}{mc_h} + \frac{1-h}{mc_l}$, and γm is the expected price when firms mark up prices with the quality upgrade γ over the follower's marginal costs.[2] The distribution of firm level markups will be critical for determining the firm size distribution in the dynamic firm problem in section 3.2.2.

To meet demand that arise given the prices in all product lines they lead, intermediate goods producers solve a firm-level static optimization problem using cost minimization.

$$\min_{W_{jt}} W_{jt} \cdot (1 + T(W_{jt})) \cdot L_{jt}(W_{jt}) \quad \text{s.t.} \quad s_j L_{jt} \geq Y_{jt} \tag{26}$$

Which can be solved for the firm-level gross wage:

$$W_{jt} \cdot (1 + T(W_{jt})) = s_j \cdot mc_{jt} \cdot \frac{\frac{\beta}{1-\sigma}}{1 + \frac{\beta}{1-\sigma} + \frac{\partial \log(1+T(W_{jt}))}{\partial \log W_{jt}}} \tag{27}$$

Where $\frac{\beta}{1-\sigma}$ is the labor supply elasticity with respect to the net wage W_j, facing the firm. The marginal cost, mc_j is an equilibrium object that enters as the Lagrange multiplier following from the cost minimization's output constraint. Finally, $\frac{\partial \log(1+T(W_{jt}))}{\log W_{jt}}$ denotes the tax elasticity with respect to the net wage. This elasticity depends on the tax scheme and may vary with the firm level wage.

From now, let the tax rate of the net wage relative to the mean wage be defined similarly as in Borella et al., 2022, reformulated such that the tax transaction is paid by the firm rather than the worker. $\bar{w}_t$ can be interpreted as a reference wage, or the average wage an employed worker receives. λ in the specification of Borella et al., 2022 governs the tax rate on the median gross wage, whereas we levy it on the average. τ pins down income tax progressiveness, with $1-\tau$ being the elasticity of post tax income w.r.t. pretax income.

$$T\left(\frac{W_{jt}}{\bar{w}_t}\right) = \left(\frac{W_{jt}^{\tau}}{1-\lambda} \frac{1}{\bar{W}_t^{\tau}}\right)^{\frac{1}{1-\tau}} - 1, \quad \bar{w} = \frac{J_h L_{ht} W_{ht} + J_l L_{lt} W_{lt}}{J_h L_{ht} + J_l L_{lt}}, \tag{28}$$

We make the simplifying modeling choice of having the firm pay the tax in full, instead of having an income tax on the worker side. Households only care about net wages, which gives them consumption utility, in their labor supply choices. Whether we model the tax as a wage bill tax of the firm or an income tax of the worker therefore does not impact outcomes. This step simplifies several model

[2]The final good producer demands in expectation $\mathbb{E}(y_{ijt}) = \mathbb{E}\left(\frac{Y_t}{p_{ijt}}\right) = \frac{Y_t}{\gamma}\mathbb{E}\left(\frac{1}{mc_{j'(i)t}}\right)$ when firms markup prices by γ over the quality follower's marginal cost. m is thus defined as a harmonic mean of marginal costs.

expressions, as the tax rate directly enters only the firm- rather than also the household decision problem.

We obtain a tax elasticity with respect to the net wage given by $\frac{\partial \log(1+T\left(\frac{W_j}{\bar{w}}\right))}{\partial \log W_j} = \frac{\tau}{1-\tau}$. The labor supply elasticity facing the firm with respect to the gross wage is then given by:

$$\frac{d\log(L_{jt})}{d\log(W_{jt}(1+T\left(\frac{W_{jt}}{\bar{w}_t}\right)))} = \frac{\beta}{1-\sigma} \cdot \frac{1-\tau}{\tau}. \tag{29}$$

This equation shows that the progressiveness of taxes measured by τ influences labor market power when workers derive utility from both wages and workplace such that $0 < \frac{\beta}{1-\sigma} < \infty$.

The pretax markdown defined as the gross firm-level wage over the expected marginal revenue of the last unit produced, $\gamma m s_j$ is given by Equation 30.[3]

$$\frac{W_{jt} \cdot (1+T\left(\frac{W_{jt}}{\bar{w}_t}\right))}{\gamma m s_j} = \frac{1}{\mu_{jt}} \cdot \frac{\frac{\beta}{1-\sigma}}{1+\frac{\beta}{1-\sigma}+\frac{\tau}{1-\tau}} \tag{30}$$

Notice how the gross wage approaches $\frac{\gamma \cdot m_t \cdot s_j}{\mu_{jt}} = mc_{jt} \cdot s_j$ when labor markets are well characterised by perfect competition, i.e. $\frac{\beta}{1-\sigma} \to \infty$. This occurs in labor markets where workers' utility are highly sensitive to consumption of the final good. Furthermore, we see that high markup firms exhibit greater labor market power in the sense that they mark down wages more than low markup firms. Finally, tax progressiveness decrease markdowns and thereby increase labor market power, holding markups fixed.

Tax progressiveness will in general influence markups. In particular, relative markups are affected which will matter for the firm size distribution which plays a key role in determining aggregate TFP.

3.2 Dynamic problem

3.2.1 Special Case: Linear research costs

Research costs: As layed out in the previous section, firms marginal cost, and especially their relative level, relate to many economic outcomes. In this subsection, we discuss will discuss a special case of the model in which this marginal cost dispersion is not given, namely linear research costs. This is an

[3] In equilibrium, firms only produce in product lines where they are quality leaders which leads to a discontinuity in the price of the next intermediate good produced We therefore consider the price of the last unit produced when defining markdowns.

useful exercise as it allows for closed form solutions for many key equilibrium objects. For now, we let research costs take the form, with $\Phi = 1$:

$$C^R(x_{jt}) = C^R(Y_t, n_{jt+1} - (1-\chi_t)n_{jt}) = \psi Y_t (n_{jt+1} - (1-\chi_t)n_{jt})^{\Phi}, \quad (31)$$

Tax scheme: To simplify the analytics in this section, we assume a constant tax rate, $T(W_j) = \bar{\tau}$, but we will discuss implications of progressive and regressive tax schedules at the end of this section. In our quantitative set-up, the calibrated tax schedule will match the observed tax schedule on income taxes.

We consider a balanced growth path (BGP) equilibrium, where output grows at a constant rate, the interest rate is constant, and the share h of product lines where intermediates are produced by the firms of type h. Moreover, the number of total firms is constant and entry costs are equal to expected firm value. Such an equilibrium consists of an allocation of workers over firms and into home production, wages and product prices, such that firms and workers behave optimally, markets clear, and the resource constraints of the economy hold.

The growth rate of output, $g \equiv \frac{Y_{t+1}}{Y_t}$, is equal to the growth rate of aggregate quality Q, which we can easily read from $Y_t = Q_t \exp \int_0^1 \ln(y_{it}) di$, noting that $y_{it} = s_{j(i)} l_{it}$ and the distribution of workers over firm-and line types stays constant on the BGP by definition. Details are provided in Appendix A.7. Further, aggregate quality grows at γ^{χ}, so χ_t must be constant on the BGP. Marginal costs and wages grow at the same rate, and the labor market index z_t grows at $g_z = g^{-\frac{\beta}{1-\sigma}}$.

These allow us to detrend the firm problem and drop time subscripts. We also divide the value function by Y_t and note that $R = \frac{\rho}{g}$ on the BGP. We can then define detrended Y on the BGP as $Y = \frac{Y_t}{g^t}$, with detrended m, z, W_j similarly defined relative to their respective growth rates. Using this, we can state the dynamic firm problem as:

$$\begin{aligned} v_j(n_j) = \max_{n'_j} \, & n_j - (1+\bar{\tau}) \left(\frac{n_j Y}{s_j \gamma m z} \right)^{\frac{1-\sigma}{\beta}} \frac{n_j}{s_j \gamma m} \\ & - \psi(n'_j - (1-\chi)n_j) \\ & + \rho v_j(n'_j). \end{aligned}$$

Taking first order conditions and adding market clearing and resource constraints yields closed-form solutions for firm size in terms of n, as well as wages, marginal costs, the average wage, the labor share, intermediate good prices, and the aggregate rate of creative destruction. We summarize the BGP solution in table 1, and a more detailed derivation is found in Appendix A.8. Note that the growth rate does not depend on the degree of monopsony in this basic model. Instead,

Variable	Solution	Description
n_j	$s_j^{\frac{1-\sigma+\beta}{1-\sigma}} / (J_h s_h^{\frac{1-\sigma+\beta}{1-\sigma}} + J_l s_l^{\frac{1-\sigma+\beta}{1-\sigma}})$	Firm size for firm type j
h	$J_h s_h^{\frac{1-\sigma+\beta}{1-\sigma}} / (J_h s_h^{\frac{1-\sigma+\beta}{1-\sigma}} + J_l s_l^{\frac{1-\sigma+\beta}{1-\sigma}})$	Market share for firm type h
W_j	$Q \frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)} s_j$	Wage for firm type j
$\bar{w}$	$Q \frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)} \left(\frac{h}{s_h} + \frac{1-h}{s_l} \right)^{-1}$	Average wage
$mc_j = m$	Q/γ	Marginal costs in production
p	Q	Intermediate good prices
χ	$\frac{\gamma-1}{\gamma\psi} + \frac{\rho-1}{\rho}$	Aggregate innovation rate
g	γ^{χ}	Growth rate
$\frac{1}{Y}\sum_j W_j L_j$	$\frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)}$	Labor share
Y, $\mathcal{J}$, z, L_j:	$\zeta Y = E[v_j]$	No entry in eq.
	$z = \frac{\mathcal{L}}{\left(\sum_k W_k^{\frac{\beta}{1-\sigma}}\right)^{\sigma} (\omega Y)^{\beta} + \sum_k W_k^{\frac{\beta}{1-\sigma}}}$	Labor market clearing
	$L_j = \frac{n_j Y}{s_j Q} = z W_j^{\frac{1-\sigma}{\beta}}$	Firm size and labor supply

Table 1: Analytical BGP variables and solutions

growth depends only on the size of the quality innovation steps, the research costs, and the discount rate. Introducing monopsony in our model essentially means increasing marginal costs in output. With everything else moving linearly in firm size, each firm type essentially 'chooses' the same level of marginal cost. When marginal costs equalize, the markup in each line is equal to γ, the quality step size. So while the degree of monopsony, β, affects the relative size of big vs. small firms, it does not impact profit margins and the amount of research a firm is optimally conducting. Therefore, the degree of monopsony does not affect the innovation rate χ or growth γ^{χ}.

The degree of monopsony power does however affect equilibrium wages and the labor share, where less monopsony means higher wages and a higher labor share, and relative firm sizes, where productive firms become relatively larger as they are less affected by the upward sloping labor supply curve. Monopsony power also affects the total number of firms entering the market, and the output level.

3.2.2 Non-linear research costs

Research costs: In this section, we let research costs be convex. This assumption is standard in Schumpetarian growth models as it is a sufficient feature that provide a firm size break without imposing decreasing returns to scale in production or input market power. Let research costs take the form, with $\Phi > 1$:

$$C^R(x_{jt}) = C^R(Y_t, n_{jt+1} - (1-\chi_t)n_{jt}) = \psi Y_t (n_{jt+1} - (1-\chi_t)n_{jt})^{\Phi}, \quad (32)$$

Tax scheme: From now, we apply the progressive taxation function described in section 3.1 for the full version of the model as well as the quantitative results.

When the research costs are non-linear, the two firm types marginal costs no longer equalize. In this case, there are two non-linear costs that increase in firm size: (i) monopsony leads to increasing costs of production in the within-period optimization problem; (ii) increasing costs of research and firm expansion in the across-period, dynamic optimization. At the same level of marginal costs in production, mc, the more productive firm type will produce more output, and have more product lines. However, with decreasing returns to research effort, these firms will choose to stay smaller compared to the case where research costs are linear.

Allowing research costs to take a more general shape, the intermediate goods producers' first order condition of the dynamic problem in Equation 13 give a relation between relative marginal research costs and relative expected marginal profits of the two firm types:

$$\frac{\frac{dC_h^R}{dx_h}}{\frac{dC_l^R}{dx_l}} = \frac{\gamma m - mc_h}{\gamma m - mc_l}. \quad (33)$$

With research costs given by the form specified by Equation 32, the above Equation 33 can be rewritten in terms of relative firm size according to:

$$\frac{n_h}{n_l} = \left(\frac{\gamma m - mc_l}{\gamma m - mc_l}\right)^{\frac{1}{\Phi-1}} \quad (34)$$

Unlike the special case with $\phi = 1$, marginal costs are no longer equal, but due to the price normalization still fulfill $Q/\gamma = mc_h^h \cdot mc_l^{1-h}$. We can again state the detrended firm problem on the balanced growth path as a function of only n_j and aggregate objects.

$$v_j(n_j) = \max_{n'_j} n_j - \left(1 + T\left(\frac{n_j Y}{\gamma m z s_j \bar{w}}\right)\right)\left(\frac{n_j Y}{s_j \gamma m z}\right)^{\frac{1-\sigma}{\beta}} \frac{n_j}{s_j \gamma m}$$
$$- \psi(n'_j - (1-\chi)n_j)^{\phi}$$
$$+ \rho v_j(n'_j).$$

Taking the first order condition, we now have a relation between firms' marginal costs, size and creative destruction. In aggregate terms, this first order condition shows that there is a relation between Output Y (which enters marginal costs), the firm size distribution h and productivity growth from creative destruction.

$$\frac{mc_j - \gamma m}{\gamma m} \frac{1}{n_j^{\phi-1}} = \psi\phi\chi^{\phi-1}\frac{\rho-1}{\rho} - \chi^{\phi} \tag{35}$$

It is not possible to solve the model analytically. However, we can say clearly that that the firm size distribution h will interact with both production and research. Any factor increasing h shifts production from low-productivity firms to more productive ones. An increase in h thus increases static productivity. On the other hand, an increase in h will increase the research costs $\psi(n'_j - (1-\chi)n_j)^{\phi}$ necessary to obtain a given level of creative destruction.

Changes in concentration h thus have the potential to increase static productivity while at the same time lowering growth. As can be seen in equation 35, any factor influencing marginal costs will affect firm sizes and thus h. A key factor for these marginal costs in our model is the labor supply elasticity. There is thus potential for both household preferences (β, σ) as well as policy (through progressivity τ) to affect the labor supply elasticity and through it market concentration, output and growth. From section 4 onward, we numerically solve the model and show that this channel is quantitatively significant.

In the following section, we will describe a way to decompose output and TFP, which will allow us to specify an objective function to evaluate a tax schedule with.

3.3 Aggregate output and TFP

In this section, we decompose output to account for various factors that determine it in a static and a dynamic sense. From the production function of total output, we can factor out the aggregate quality level Q, the aggregate productivity level $S \equiv \exp \int_0^1 \ln(s_j(i))di$, and $L = \sum_j L_j$, as well as a factor $M = 1 - CV^2/2$, where CV is the coefficient of variation in labor supply employed in different product lines. For details, refer to Appendix B. A short version follows here:

$$Y = \exp \int_0^1 \ln(q_i y_i) di = Q \exp \int_0^1 \ln(s_j(i)) di \exp \int_0^1 \ln(l_j(i)) di \tag{36}$$

$$= Q \cdot S \cdot M \cdot L \tag{37}$$

With this, we can easily decompose TFP:

$$TFP = Q \cdot S \cdot M$$

This expression makes it clear that TFP does not just stem from the quality level and the average productivity of a product line, but the variation of product leader-follower combinations matters via M. The whole distribution of firms works through the markup channel to determine TFP.

Next, we will consider a dynamic version of this decomposition. In addition to static output within each period, growth via research matters here. One reason we are interested in the present value (PV) of aggregate output per capita, is that it can be interpreted as a proxy for welfare. The PV is the sum over all future static output discounted at rate $1-\rho$ along the balanced growth path. We decompose it as suggested in Boppart and Li, 2021 into microfounded sources of TFP:

$$PV \left\{ \frac{Y}{\mathcal{L}} \right\}_{t=0}^{\infty} \approx \underbrace{\frac{Q_0}{1-\rho(1+g)} \cdot S \cdot M}_{TFP} \cdot \frac{\sum_{j \in \mathcal{J}} L_j}{\mathcal{L}} \tag{38}$$

Where we define Q_0 as the initial level of the quality index which we set to 1. Since quality grows in perpetuity at a constant rate, we express the contribution of growth to welfare as a geometric series that depends on the growth rate g and discounting R. Furthermore, we define $S = \exp \int_0^1 \ln s_{j(i)} di$ as the geometric average process efficiency which crucially depends on the share of the economy held by firms with a high process efficiency. Next, we identify M as a factor which arises due to variation in prices and process efficiency. This factor is a second order Taylor approximation around the mean line level employment and is given by the expression

$$M = \frac{3}{2} - \frac{\mathbb{E}\left(\frac{1}{\left(s_{j(i)} p_{j(i)}\right)^2}\right)}{2 \cdot \mathbb{E}\left(\frac{1}{s_{j(i)} p_{j(i)}}\right)^2}. \tag{39}$$

Because it arises due to variation in prices and process efficiency, the factor can be interpreted as misallocation as discussed in Hsieh and Klenow, 2009. The last factor in equation 41 measures the share of households employed to produce intermediate goods and is the only production factor in our economy. We show how we derive the full expression in Appendix B.

As tax progressiveness may have ambiguous effects on the various components of aggregate TFP and growth, we turn to a quantitative version of our model to evaluate the strength of the various effects that a progressive tax.

4 Quantitative results

In the quantitative part of this paper, we allow for convexity in research costs ($\phi >= 1$) and use the progressive taxation formulation specified in Equation 28. For the solution algorithm used for this section, please refer to Appendix C.

4.1 Calibration

The full model has fourteen parameters, of which we assign seven. The remaining parameters are numerically calibrated using the Simulated Method of Moments (SMM). Table 2 summarizes the calibration strategy.

We directly assign a discount factor ρ of .95, which is a standard value. Tax parameters are averages of the values in Borella et al., 2022 for the US between 1969 and 1981. We define the share of h-types as the top 10% of firms, and set $\alpha = .1$. We normalize the labor productivity s_l of l-type firms to 1, and back out s_h using Compustat data on manufacturing firms, where we take the average over the years 1954–2007. Details on this can be found in Appendix D. The parameter η, which is used in the Cobb-Douglas aggregation of private and government consumption, is set to the average of US government spending as a percentage of GDP between for the same period using BEA, 2024c data.

Among the parameters calibrated using SMM are preference parameters β, σ, and ω, as well as the R&D cost function shifter ψ and curvature Φ. Finally, the quality innovation step size γ and entry cost shifter ζ are also calibrated.

We target seven moments in the numerical calibration, a summary of which is given in Table 3. For the average markup, we target a value of 1.24, which we take from Aghion et al., 2023 and Autor et al., 2020. The rate of TFP growth is calibrated to 1.078 following BLS, 2024b data for the years 1954–2007 . For R&D spending as a percentage of GDP, we use World Bank, 2024 data for the year 1996. Similarly to the relative productivity assigned in the previous step, we also get the output share of the top 10% of firms from compustat data, where we take the average between 1954 and 2007. For the labor market participation rate and the profit share, we use data by the U.S. BLS, 2024a and BEA, 2024a. Finally, we set the wage premium of the top 10% to 21% following Wong, 2023 (p. 20, Table 1).

Definition	Parameter	Value
Numerically calibrated		
Weight on fixed utility	β	16.21
Weight on group shock	σ	0.02
Outside option value	ω	0.69
Linear R&D cost	ψ	2.43
Exponential R&D cost	ϕ	1.47
Quality step	γ	1.23
Entry cost	ζ	0.01
Assigned		
Discount factor	ρ	0.95
Linear tax component	λ	0.103
Exponential tax component	τ	0.078
Share of high-type firms	α	0.10
Low type productivity	s_l	1.0
High type productivity	s_h	1.49
Government-private aggregation elasticity	η	0.32

Table 2: Calibrated parameter values

4.2 Model fit

Overall, the model does a good job matching the targeted moments. It matches average markups, growth, output concentration, and labor market participation almost exactly. It is only for firm profits that the model truly struggles to match the data. Related, R&D spending is higher in the model than in the data. The 'missing' profits are R&D spending in the model. Using this calibration, the tax parameters are below revenue-maximizing levels. Ergo, increasing λ, τ would increase current tax income. However, changing these tax rates has dynamic implications, influencing future output, and therefore future tax revenue. We discuss the dynamic dimension of taxes in section 5.

Note first that on BGP, the growth in output from quality increases does not have an effect on aggregate labor supply. This is consistent with the evidence of Boppart and Krusell, 2020, who found that hours worked per capita have not exhibited a clear upward or downward trend in the US since the 1950s.

4.3 The Effect of Monopsony Power

In this section, we examine the effects of decreases in monopsony power through preference changes in β, which governs the relative importance of the wage compared to idiosyncratic preferences over employers in labor supply decisions. This increases the elasticity of the labor supply facing a firm with respect to the

Definition	Data	Model
Average Markup	1.24	1.24
Growth rate	1.078%	1.078%
R&D spending (% of GDP)	2.45%	6.06%
Share of Output, top 10% firms	75.59%	75.65%
Labor Market Participation	83.4%	83.4%
Profit Share	5.45%	0.07%
Top 10% wage premium	21%	21.2%

Table 3: Moments

net wage, which is given as:

$$\frac{\partial \log(L_j)}{\partial \log(W_j)} = \frac{\beta}{1-\sigma} \tag{40}$$

This means that increasing β by a factor of two increases the labor supply elasticity by the same factor. On a balanced growth path, the effect of β on static equilibrium outcomes are summarized in Figure 1. A higher labor supply elasticity allows large productive firms to expand, increasing the concentration of output at the top. This has a positive effect on the level of output, as more efficient firms control a larger share of the economy. In addition, wages and labor market participation rise.

However, at the same time, changes to the degree of monopsony impact the dynamic side of the model. These results are summarized in Figure 2. With an increase in the labor supply elasticity, less productive firms are increasingly competing against highly productive firms, as these expand. Essentially, lowering monopsony power removes a barrier that protects low-productivity firms from competition in the form of more productive firms. This significantly decreases the returns to R&D for small, low s_j firms. While large firms increase their R&D spending, they do not do so sufficiently to offset the decrease for smaller firms. Thus, R&D intensity of the whole economy decreases, while at the same time concentrating at fewer firms. This leads to a lower rate of productivity growth. The response is nonlinear, but a 1% increase in β is roughly associated with a 0.5% decrease in productivity growth.

5 Policy evaluation

As shown in the previous section, monopsony power affects both static (production) and dynamic (growth) outcomes in the model. However, as market power follows from household preferences, it is not clear how to influence these channels using policy tools. However, as our model shows, an income tax schedule with a level and a progressivity shifter, can be used by policymakers to achieve the same results. Macnamara et al., 2024 argue that such tax cuts may boost growth in

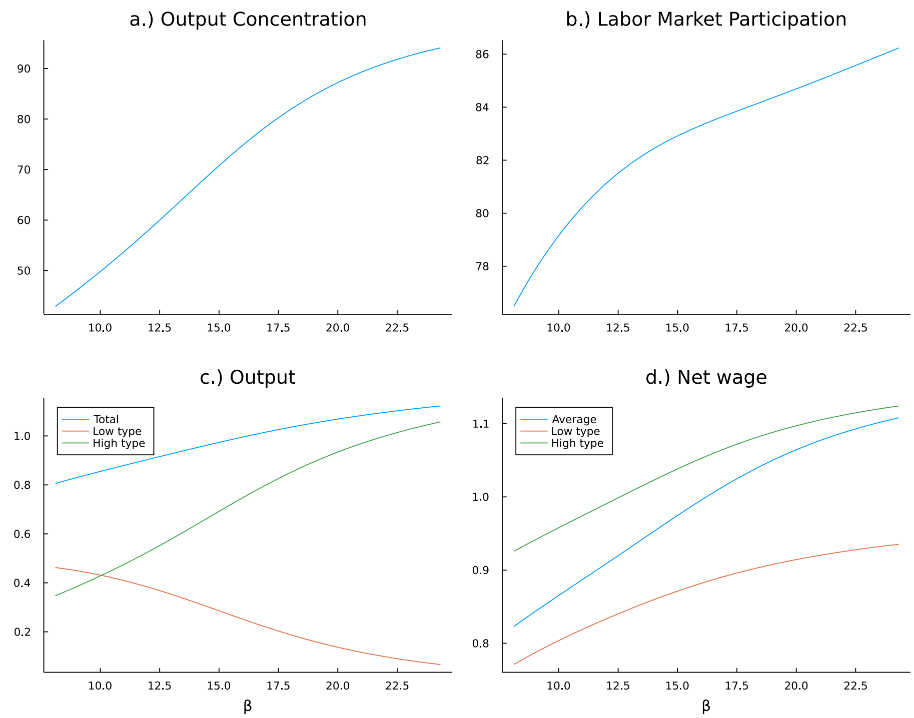

Figure 1: Static outcomes at different levels of β

Note: Figures a.) and b.) are expressed in percent, where "concentration" refers to the share of output produced by the top 10% most productive firms. Figures c.) and d.) are relative to the steady state levels of output and average wage from the calibration in section 4.1.

the long run. In our model, the way in which taxes are raised matters: changing the average tax level (governed by λ in our model) has no strong effect on the firm-size distribution. This is because all firms are affected in the same way. Decreases (increases) in the average tax level can thus increase (decrease) output, productivity growth, and labor market participation. Changing tax progressivity on the other hand affects (gross wage) labor supply elasticities, and thus market concentration. This can also be understood as progressive taxation placing a tax on firm expansion that is more pronounced for large firms, which are more productive and pay higher wages. Decreasing the tax progressivity allows productive firms to expand. This has a positive effect on current TFPQ and output, but also shifts R&D activity from smaller to larger firms - in essence working through a similar channel as a decrease in monopsony power as covered in the previous section.

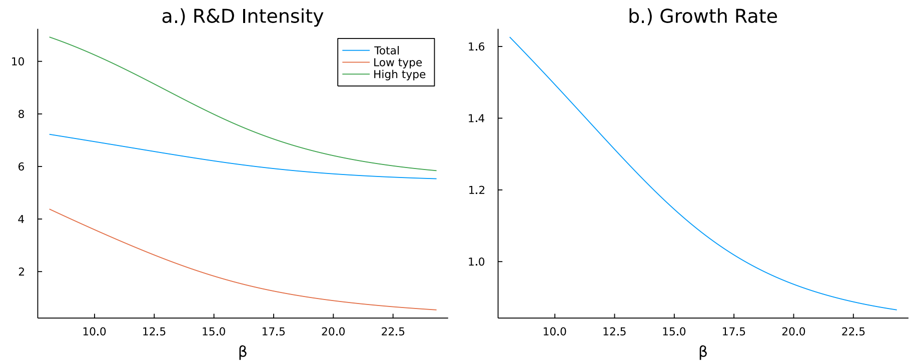

Figure 2: Dynamic outcomes at different levels of β

Note: Both graphs are in percentage points. R&D intensity is spending relative to firm-level Output for the type-specific lines, and economy-wide Output for the total.

5.1 1980s tax reform

Building on the estimation results by Borella et al., 2022, we test the model against a historical tax reform in this section. As shown in Borella et al., 2022, the Reagan tax cuts reduced both the average level and the progressivity of income taxes. An issue of this approach is, that the underlying tax rates on real incomes fluctuate significantly due to inflation and irregular tax reforms. This poses a challenge: A long-run growth model would perform better in situations where there is one policy change and long periods before and after without changes. In reality, the variation of tax policy only allows for the analysis of specific tax reforms during shorter time periods. In this case study, we consider the tax cuts to be a single reform which brought the economy from one BGP (pre 1981) to another (post 1988). The change in the tax schedule is summarized in Table 4. Notably, we find that the long-term growth rate of TFP is not increased by this reform, neither in the data nor in our model. The model predicts a nearly unchanged rate, whereas in the data it actually lowers slightly.

Parameter	Value before 1981	Value 1988 – 2007
Tax average λ	0.103	0.088
Tax curvature τ	0.078	0.070

Table 4: Parameter changes

Table 5 summarizes the outcomes, i.e. the changes in productivity growth in the data and the model. “Old BGP” here refers to the balanced growth path calibrated in the previous section. “New BGP” refers to model outcomes when implementing the tax schedule change according to Table 4, and the average rate of TFP growth between 1988 and 2007 in the data. The exact choice of this time period does not seem to make a big difference, as varying the time horizon of the period starting in 1988 yields the same result of lower TFP growth post the tax cuts.

Average TFP growth	Old BGP	New BGP
Data	1.078%	0.984%
Model	1.078%	1.077%

Table 5: TFP growth response

In addition to considering growth implications, we compare the state of the economy right before and right after this reform, to test whether the model model predictions hold. For this purpose, Table 6 contains the predictions of the model regarding the level of output and the labor share. Note that the increase in output from the model is due to both increases in static efficiency, and the (largely unaffected) rate of productivity growth. The "counterfactual" column here refers to the model prediction of the changes between 1981 and 1987 without the tax reform, i.e. remaining on the previous balanced growth path.

Definition	Output/Capita	Labor Force Participation
Data	19.1%	4.1%
Model	8.3%	1.6%
% explained	43.6%	38.8%
Counterfactual	6.6%	N/A

Table 6: Tax reform: Changes 81 − 87

Note: Data, model and counterfactual values are all changes in percentages.

Our comparison between model and data is based on output per capita from annual BEA, 2024b data. Unexplained shares of the change in output per capita are to some extent to be expected due to confounding factors. For example, U.S. public debt relative to GDP increased significantly over this time period. As there were also a number of underlying trends in the labor participation rate in the 80s, the fact that the model undershoots this change is not too surpriging. When adding an exogenous increase to labor force participation to match the 4.1% from the data in this time from, the model explains around 60% of the increase in output per capita. Overall, model predicts that output in 1987 was 1.6% higher with the reform than it would have been without it. Using the results from appendix B, we can decompose the changes in output into the various channels of the model. Performing this decomposition shows that output increased by 1.4% due to the increase in labor market participation alone, with another 0.2% increase following from higher average productivity due to h-type firms growing. Neither the change in quality growth nor that in misallocation have significant influence. Through the lens of our model, the main channel of this reform was thus an increase in labor market participation.

5.2 Alternative tax schemes

Largely, this reform makes it seem like income taxation has little effect on productivity growth. In this section, we aim to show that this is mainly due to the specific tax reform in question, which affects both the average level and progressivity. For this purpose, we consider once more the base scenario as calibrated in Section 4. In this exercise, we fix the detrended government spending G at the BGP level. We then consider those combinations of average tax rate λ and progressivity τ that generate the same revenue for the government, and look at outcomes along that path.

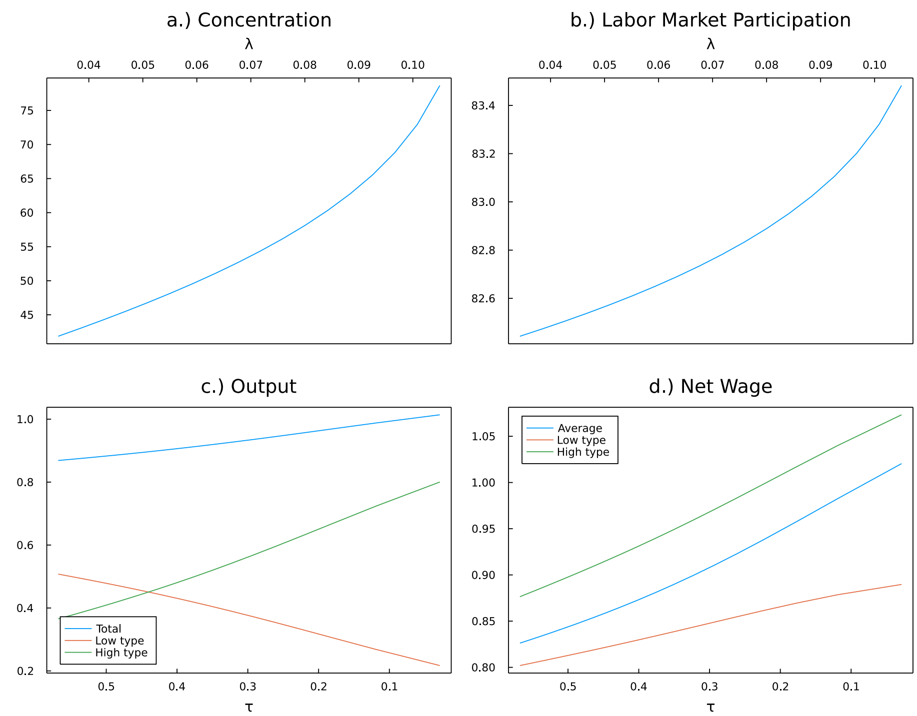

Figure 3: Static Outcomes at different (λ, τ), fixed G

Note: All values are at a pair (λ, τ), such that G is at the level from the base calibration. a.) and b.) are in percentages, c.) and d.) relative to base calibration values.

The results in Figures 3 and 4 clearly show that there is a trade-off between the static and dynamic dimension. Monotonically, increasing revenue through the average tax instead of progressivity (lower τ, higher λ) increases the elasticity of labor supply faced by firms. This effect is similar to the preference-based change considered in Section 4.3. Following Equation 29, around its calibrated value, a 1% decrease in τ increases the labor elasticity by approximately 1.06%. The increased labor supply elasticity in turn increases concentration and, to a lesser extent, labor market participation, and through these static output. The rise in concentration is crucial for this outcome, as low productivity firms produce less, but the increase in high-type output more than compensates for this. Wages increase in all firms, and more workers work at larger high-wage firms, such that both within- as well as between-firm effects increase the average wage.

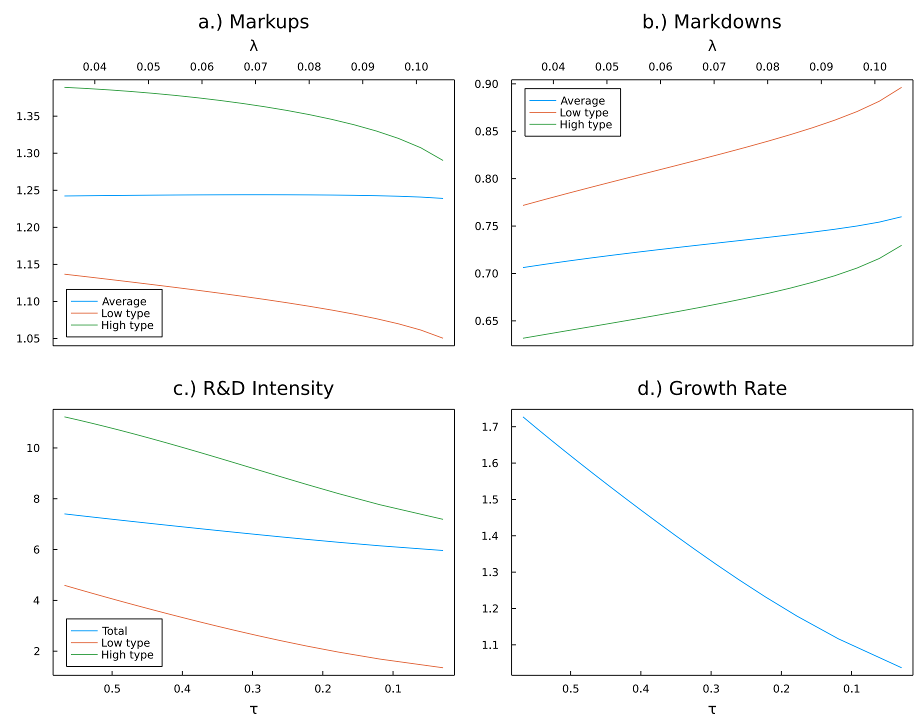

Figure 4: Growth and its determinants at different (λ, τ), fixed G

Note: Markdowns are computed using the pretax wage. R&D intensity is spending relative to firm-level Output for the type-specific lines, and economy-wide Output for the total.

At the same time, the dynamic outcomes of the model change. (sales-weighted) markups change only slightly. However, this follows from a between-firm effect partly cancelling out stronger within-firm effects. Markdowns (on the pretax wage) are significantly higher for high λ, low τ. This highlights an important channel, driving down the profits firms make, as more and more revenue is spent on wages. While both firm types charge lower markupsas λ increases, increased concentration keeps the index nearly constant. Markdowns also respond, with the portion of revenue going into wages and taxes increasing. Dynamically, lower progressivity especially makes R&D activity less attractive for smaller firms, and shifting activity toward large firms additionally makes it less efficient. The aforementioned 1% decrease in τ lowers productivity growth by 0.16%.

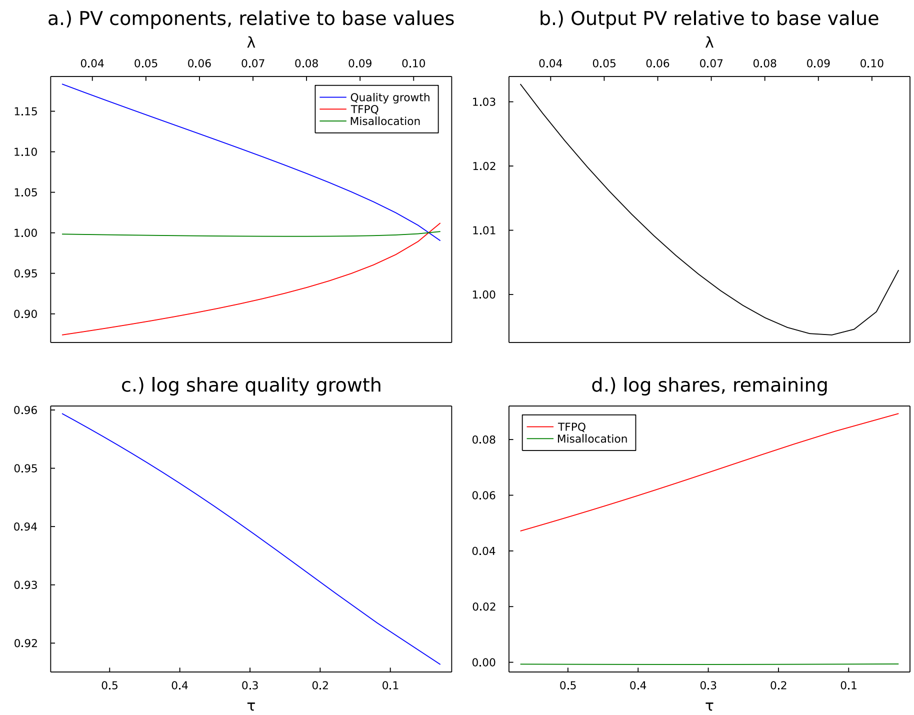

Figure 5: PV decomposition at different (λ, τ), fixed G

Note: Figures a.) and b.) show the components of the PV, as well as its total relative to their base calibration values. Figures c.) and d.) show the log shares of each component.

In addition to comparing static and dynamic outcomes, we can use the decomposition introduced in section 3.3 to understand the different channels at work. Recall the following decomposition of the present value of output per capita:

$$PV\left\{\frac{Y}{\mathcal{L}}\right\}_{t=0}^{\infty} \approx \underbrace{\frac{Q_0}{1-\rho(1+g)} \cdot S \cdot M}_{TFP} \cdot \frac{\sum_{j\in\mathcal{J}} L_j}{\mathcal{L}}. \tag{41}$$

Figure 5 shows this decomposition of the present value of output per capita. Crucially, by far the largest factor for this present value is the level of quality growth, which makes up around 95% of log output across the (λ, τ) region we examine. Figure 5 a.) generally illustrates the trade-off. Misallocation changes only slightly in response to taxes, with changes mainly driven by increases (decreases) in TFPQ and corresponding decreases (increases) in quality growth. According to these results, the present value of output is maximized in a highly progressive τ, low average λ tax regime. Note that the right hand side of figure 5 b.) shows there is a slight U-shape to these results. Under regressive taxation ($\tau < 0$), it is possible to reach a higher net present value of output. Intuitively, a regressive income tax schedule could counteract the positive slope of the labor supply curve coming from monopsony power in the labor market. Note that static productivity and participation increases operate through increasing concentration, which will cap as $h \to 1$.

6 Conclusion

This paper explores the role of monopsony power within a growth model with product market power and creative destruction. Our findings demonstrate that monopsony power introduces new dynamics, particularly in the trade-offs between output levels and economic growth. Specifically, monopsony power reallocates labor towards smaller, less productive firms, which reduces static output, but simultaneously increases research incentives through markdowns. Furthermore, when research exhibits decreasing returns to scale, this reallocation enhances research efficiency, as it directs resources towards more impactful smaller firms. These insights are crucial for policymakers, as we show that income tax schedules can mimic the effects of monopsony power, offering a tool for optimizing economic outcomes.

We aimed at quantifying the relationship between monopsony power, income taxation, and aggregate outcomes. Our model illustrates how monopsony power influences labor allocation, output, and research efficiency, and shows that adjusting the progressivity of income taxation can replicate these effects. This connection provides a clear answer to how monopsony power and tax policy interact to shape overall economic performance. Our results also speak to the firm wage premium incurred by the presence of monopsonistic labor markets. In the presence of sorting of more skilled workers to more process efficient firm, our results understate the magnitude to which a progressive tax harms large firms.

The broader implications of our findings suggest that monopsony power is relevant in the macroeconomic growth context, with trade-offs that imply the existence of an 'optimal level' of monopsony, dependent on specific economic objectives. The framework we develop could serve as a foundation for future investigations to determine this optimal level, offering valuable insights for both researchers and policymakers. Additionally, we emphasize that the labor supply elasticity, originating from monopsony power, can be shaped by income tax policies, a critical factor that should be considered in both academic research and policy design.

However, our analysis is not without limitations. The calibration of preference parameters that determine the degree of monopsony is complex. Furthermore, finding practical applications to benchmark and test the model is challenging due to the frequency of tax changes and the complexities involved in cross-country comparisons. Additionally, the model's transition paths pose significant challenges.

Looking ahead, we see potential for improvement by integrating researchers into the monopsonistic labor market, rather than relying on an ad-hoc formulation of research costs. Moreover, identifying a robust cross-country or policy intervention application would greatly enhance the ability to test and validate the model's predictions. These directions could offer deeper insights into the relationships between monopsony power, taxation, output, and growth.

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A Model Derivations

A.1 Indirect utility function

Workers in our model get utility from private and government consumption. We assume there is no saving such that workers spend all their (net) income W is spent on private consumption. Government consumption that the household consumes is denoted as G. Workers then enjoy utility from consuming a Cobb-Douglas aggregate of private and public goods:

$$U = (W^{\eta} G^{1-\eta})^{\kappa} e^{\xi_g + (1-\sigma)\varepsilon_j}, \tag{42}$$

where ξ_g, ε_j are idiosyncratic preference shocks of the household for working in home production vs a firm, and working at a particular firm j, respectively.

Applying a log to both sides yields the formulation of indirect log-utility we use to derive the choice probabilities in the labor supply, see also A.2. Finally, we define $\beta \equiv \kappa\eta$ for readability:

$$\begin{aligned} u \equiv \ln(U) &= \kappa\eta \ln(W) + \kappa(1-\eta)\ln(G) + \xi_g + (1-\sigma)\varepsilon_j \\ &= \beta \ln(W) + \kappa(1-\eta)\ln(G) + \xi_g + (1-\sigma)\varepsilon_j \end{aligned}$$

A.2 Labor Supply: Nested Discrete Choice

The labor supply choice is modeled as a nested discrete choice problem. For technical details of the derivation of choice probabilities, refer to Train, 2009 or McFadden, 1977.

The idea is that households o choose between employment ($g = e$) and home production ($g = u$), and conditional on choosing employment, they will pick a firm j to work for. If the household chooses to work at a firm, they earn wage W_j. If they choose to engage in home production, they instead receive ωY. They make choices to maximize indirect utility

$$u_{o,j} = \beta \ln(W_{g,j}) + \kappa(1-\eta)\ln(G) + \xi_{o,g} + (1-\sigma)\varepsilon_{o,j} \tag{43}$$

where $\varepsilon_{o,j}$ follows an i.i.d. EVT1 distribution. Similarly, $\xi_{o,g}$ is i.i.d. EVT1 distributed. This means within each nest, draws are independent, but not across nests. Specifically, for a given worker, the non-wage preferences of one workplace vs. another is independently drawn, but through ξ, all jobs have a common relative attractiveness compared to unemployment.

Households compare all options available to them and choose to work at the workplace that gives them the highest indirect utility, i.e. they make a discrete choice over workplaces. The formulation thus captures, in addition to wages, individual preferences over working at any given firm ($\varepsilon_{o,j}$) and being employed at a firm at all ($\xi_{o,g}$), which does not depend on the workplace.

It is possible to solve this as a two-step choice problem. First, conditional on choosing to work, the household chooses their preferred employer j^*. This can be written as:

$$j^* : \beta \ln(W_{j^*}) + \kappa(1-\eta)\ln(G) + \xi_{o,e} + (1-\sigma)\varepsilon_{o,j^*} \tag{44}$$

$$\geq \beta \ln(W_k) + \kappa(1-\eta)\ln(G) + \xi_{o,e} + (1-\sigma)\varepsilon_{o,k}, \quad \forall k \in \mathcal{J} \tag{45}$$

Since $\xi_{o,e}$ and $\kappa(1-\eta)\ln(G)$ are shared across jobs, these terms drop out. Further, we can divide by $(1-\sigma)$ and get:

$$j^* : \frac{\beta}{1-\sigma}\ln(W_{j^*}) + \varepsilon_{o,j^*} \geq \frac{\beta}{1-\sigma}\ln(W_k) + \varepsilon_{o,k} \tag{46}$$

$$\Leftrightarrow \varepsilon_{o,j^*} - \varepsilon_{o,k} \geq \frac{\beta}{1-\sigma}\ln(W_k/W_{j^*}) \tag{47}$$

The conditional choice probability for firm j^* is given as:

$$p_{j^*,e} = P\left(\varepsilon_{o,j^*} \geq \varepsilon_{o,k} + \frac{\beta}{1-\sigma}\ln(W_k/W_{j^*}), \forall k \in \mathcal{J}\right) \tag{48}$$

$$= \frac{W_{j*}^{\frac{\beta}{1-\sigma}}}{\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}} \tag{49}$$

There is a second choice the worker can make: engaging in home production. This will be chosen if the utility from it is higher than the utility level from the best possible employment the worker could choose. The probability of choosing any job over home production is hence given as:

$$p_{g=e} = \frac{\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right)^{1-\sigma}}{\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right)^{1-\sigma} + ((\omega Y)^{\frac{\beta}{1-\sigma}})^{1-\sigma}} \tag{50}$$

Hence, the unconditional choice probability of choosing a given employer is given as:

$$p_{j*} = p_{g=e} * p_{j^*,e} = \frac{\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right)^{1-\sigma}}{\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right)^{1-\sigma} + ((\omega Y)^{\frac{\beta}{1-\sigma}})^{1-\sigma}} \frac{W_{j*}^{\frac{\beta}{1-\sigma}}}{\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}} \tag{51}$$

$$= \frac{W_{j*}^{\frac{\beta}{1-\sigma}}}{\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right) + (\omega Y)^{\beta}\left(\sum_{k\in\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}\right)^{\sigma}} \tag{52}$$

To get to the labor supply $L_j(W_j)$ facing firm j, we simply multiply by the mass of households in the economy, $\mathcal{L}$:

$$L_j(W_j) = \mathcal{L}\frac{W_j^{\frac{\beta}{1-\sigma}}}{(\sum_{k=1}^{\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}})^{\sigma}(\omega Y)^{\beta} + \sum_{k=1}^{\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}}},$$

We further define:

$$\begin{aligned} D_e &\equiv \sum_{k=1}^{\mathcal{J}} W_k^{\frac{\beta}{1-\sigma}} \\ z &\equiv \frac{\mathcal{L}}{D_e^{\sigma}(\omega Y)^{\beta} + D_e} \\ \Rightarrow L_j(W_j) &= zW_j^{\frac{\beta}{1-\sigma}}, \end{aligned}$$

where each firm j takes the equilibrium 'labor market density' as given, i.e. we assume firms are small enough that they don't need to consider the effect of their wage setting on the aggregate labor market via D_e.

A.3 Intermediate Good Demand from CD Aggregator

The final goods producer maximizes profit by choosing the amount of each variety purchased and used in production. The production technology is a Cobb-Douglas aggregator of the quality-adjusted inputs:

$$Y = \exp \int_0^1 \ln(q_i y_i) di, \quad i \in [0,1] \tag{53}$$

The optimization problem of the final goods producer is:

$$\max_{\{y_i\}_{i\in[0,1]}} P \left(\exp \int_0^1 \ln(q_i y_i) di \right) - \int_0^1 p_i y_i di \tag{54}$$

The first order condition is given as:

$$\underbrace{P \exp \int_0^1 \ln(q_i y_i) di}_{=Y} \frac{1}{q_i y_i} q_i - p_i = 0 \tag{55}$$

$$\Leftrightarrow PY = p_i y_i \tag{56}$$

Finally, plugging the solution for intermediate goods demand into the production function gives an expression for the price index P:

$$Y = \exp \int_0^1 \ln\left(q_i PY/p_i\right) di \tag{57}$$

$$\Leftrightarrow P = \exp \int_0^1 \ln(p_i/q_i) di. \tag{58}$$

A.4 Equivalence of tax setups

This is a brief note on the equivalence of two tax set-ups: (i) the firm pays a wage bill tax T^f on the net wage the worker receives, W^w, or (ii) the worker pays a wage tax T^w on the gross wage the firm pays, W^f. The relationship between the gross and net wages under the two tax regimes are summarized as follows:

$$W^f = W^w(1 + T^f(W^w)) \tag{59}$$

$$W^w = W^f(1 - T^w(W^f)) \tag{60}$$

Rearranging then yields a mapping between the two tax schedules:

$$T^w(W^f) = 1 - \frac{1}{1 + T^f(W^w)} = 1 - \frac{1}{1 + T^f(W^f(1 - T^w(W^f)))}.$$

Note that this holds because a firm has exactly one wage rate, on the basis of which the tax schedule is built. If there were multiple wage rates within the same company, this mapping is not as straightforward. We chose to model the tax as a tax on the wage bill for algebraic clarity.

A.5 Nash equilibrium in the pricing game

The equilibrium concept we use to solve the model is Bertrand. Hence, within each product market firms compete taking all other firms' prices as given. Within a product line, goods are assumed to be perfect substitutes, which means the firm that posts the lowest quality-adjusted price attracts all demand for output in a given product line. Note that posted prices are binding and whoever attracts demand produces to fulfill that demand.

Within each intermediate good market i, demand by the final goods producer is

$$p_i y_i = PY. \tag{61}$$

Note that we assumed that the final goods producer only buys one (quality) type of each variety. This requires two assumptions: (i) the final goods producer has one preferred variety, and (ii) the producer is able to fulfill all market demand.

The first condition translates into a tie-breaking rule, i.e. we assume that if the quality-adjusted prices are equal, the final goods producer prefers the higher quality product. This assumption also allows us to rule out collusive equilibria wherein firms split product markets at a collusive price.

For the second condition to hold, we need to make sure that the prices posted by the quality leaders are always greater than their respective marginal cost. A sufficiently large quality step size ensures this is the case when calibrating our model, i.e. $\gamma > \frac{mc_k}{mc_l}, \forall k, l \in \{1, ..., \mathcal{J}\}$.

In one equilibrium of the model the quality leader sets the quality-adjusted price equal to his follower's quality-adjusted marginal costs. [4] Under this pricing, the quality adjusted prices of the firms are equal. Due to the tie-breaking rule, the quality leader produces the full demand for products in the given product line i and the follower produces nothing and earns zero surplus.

The price in a given product line is thus given by:

$$\frac{p_{j(i)}}{q_{j(i)}} = \frac{mc_{j'(i)}}{q_{j'(i)}} \Leftrightarrow p_{j(i)} = \gamma mc_{j'(i)}, \tag{62}$$

where $j'(i)$ indexes the 'follower' in a given market i, and $j(i)$ the quality leader.

The follower has no profitable deviation, since lower prices imply selling below marginal cost, and higher prices generate no sales. Meanwhile, there is no profitable unilateral deviation by the quality leader since a higher price loses all demand, and a lower price reduces the price without affecting output.

A.6 Capital Demand

Firms make profits that are paid out to firm owners via interest rates, and therefore discount future profits at rate $\frac{1}{1+r_t}$. Firms are owned by capitalists, who allocate consumption and investment to maximize lifetime utility.

$$\max_{\{c_t,k_{t+1}\}_{t=0}^{\infty}} \rho^t \ln(c_t) \tag{63}$$

$$s.t. \quad k_{t+1} = (1+r_t)k_t - c_t \tag{64}$$

Taking first order conditions yields the Euler equation

$$\frac{c_{t+1}}{c_t} = (1+r_t)\rho \tag{65}$$

Since consumption grows at a constant rate on a BGP, we have a constant interest rate $r^* = \frac{g_c}{\rho} - 1$, where g_c is the growth rate of consumption, and $R^* = \frac{\rho}{g}$.

A.7 Growth rates

Consider a balanced growth path for which all growth stems from quality improvements, i.e. $\frac{Q'}{Q} = \frac{Y'}{Y} = g$. Assume that n_j is constant on BGP. First, consider wage growth:

$$(W) : g_{\bar{w}} = g_w = \frac{(\frac{Y'}{m'z'})^{\frac{1-\sigma}{\beta}}}{(\frac{Y}{mz})^{\frac{1-\sigma}{\beta}}} = (\frac{g}{g_m g_z})^{\frac{1-\sigma}{\beta}}$$

[4] There is a continuum of Nash equilibria where the quality leader posts a lower price and followers posts prices below their marginal cost.

The growth rate of the marginal cost indexed is defined as

$$g_m = \frac{(\frac{h}{mc'_h} + \frac{1-h}{mc'_l})^{-1}}{(\frac{h}{mc_h} + \frac{1-h}{mc_l})^{-1}}$$

which implies that:

$$g_m = \frac{mc'_l}{mc_l} = \frac{mc'_h}{mc_h}$$

So we can look to either firm type j to figure out the growth rates:

$$g_m = \frac{mc'_j}{mc_j} = \frac{w'_j[1-\sigma+\beta+(1-\sigma+\beta)T(\frac{w'_j}{\bar{w}'}) + (1-\sigma)T'(\frac{w'_j}{\bar{w}'})\frac{w'_j}{\bar{w}'}]}{w_j[1-\sigma+\beta+(1-\sigma+\beta)T(\frac{w_j}{\bar{w}}) + (1-\sigma)T'(\frac{w_j}{\bar{w}})\frac{w_j}{\bar{w}}]}$$

Using the (W) result from above:

$$(M): g_m = g_w \frac{[1-\sigma+\beta+(1-\sigma+\beta)T(\frac{g_w w_j}{g_{\bar{w}}\bar{w}}) + (1-\sigma)T'(\frac{g_w w_j}{g_{\bar{w}}\bar{w}})\frac{g_w w_j}{g_{\bar{w}}\bar{w}}]}{[1-\sigma+\beta+(1-\sigma+\beta)T(\frac{w_j}{\bar{w}}) + (1-\sigma)T'(\frac{w_j}{\bar{w}})\frac{w_j}{\bar{w}}]} = g_w$$

Next, the growth rate of z is defined as follows:

$$\begin{aligned} g_z = \frac{z'}{z} &= \frac{[(\sum_k w_k^{'\frac{\beta}{1-\sigma}})^{\sigma}(\bar{w}Q')^{\beta} + \sum_k w_k^{'\frac{\beta}{1-\sigma}}]^{-1}}{[(\sum_k w_k^{\frac{\beta}{1-\sigma}})^{\sigma}(\bar{w}Q)^{\beta} + \sum_k w_k^{\frac{\beta}{1-\sigma}}]^{-1}} \\ &= \frac{[(g_w^{\frac{\beta}{1-\sigma}} \sum_k w_k^{\frac{\beta}{1-\sigma}})^{\sigma} g^{\beta}(\bar{w}Q)^{\beta} + \sum_k w_k^{\frac{\sigma\beta}{1-\sigma}}]^{-1}}{[(\sum_k w_k^{\frac{\beta}{1-\sigma}})^{\sigma}(\bar{w}Q)^{\beta} + \sum_k g_w^{\frac{\beta}{1-\sigma}} w_k^{\frac{\beta}{1-\sigma}}]^{-1}} \end{aligned}$$

From this we can see that, for g_z to be a constant, we need to have

$$(Z): g_w^{\frac{\sigma\beta}{1-\sigma}} g^{\beta} = g_w^{\frac{\beta}{1-\sigma}} \iff g_w = g$$

Putting together (Z) and (W), we get:

$$g_z = g^{-\frac{\beta}{1-\sigma}} \qquad\qquad g = g_Y = g_Q = g_m = g_w = \gamma^{\chi}$$

Note that costs also grow over time:

$$\frac{C'}{C} = \frac{1 + T(\frac{w'}{\bar{w}'})}{1 + T(\frac{w}{\bar{w}})} \frac{w'}{\bar{w}} = g_w = g$$

A.8 Analytical BGP Solution

We consider a BGP equilibrium with two types of firms: h, l. The number of h-type firms is J_h, and in equilibrium they hold a share h of all product lines. To derive the BGP solution, the firm problem is simplified to reflect BGP conditions. First, we consider equilibria where the number of firms is $1 < J < \infty$. Under this condition, we must have that firm size stays constant for each type of firm, i.e. $n_{jt} = n_{jt+1}$. Moreover, output Y_t grows at a constant rate g, i.e. $gY_t = Y_{t+1}$. Capitalists imply that the firm discounts future profits at ρ/g, for details refer to Section A.6. Finally, since research is costly, the firm will not choose to conduct more research than necessary for their desired firm size n_{jt}. Therefore, firm size n_{jt} will be equal to the number of lines where the firm is the quality leader.

This solution to the static firm problem (Equation 7) implies for prices where the firm is a quality leader:

$$p_{ijt} = \gamma mc_{ij'(i)t}, \tag{66}$$

where $j'(i)$ yields the index of the quality-follower (second highest quality producer) of product i.

Plugging in the law of motion of product lines n_{jt+1}, the dynamic firm problem with linear taxes and research costs is then given by:

$$V_{jt}(Y_t, n_{jt}) = \max_{n_{jt+1}} n_{jt}Y_t - (1 + \bar{\tau})W_{jt}L_{jt} \tag{67}$$

$$- \psi Q_t(n_{jt+1} - (1 - \chi_t)n_{jt})^{\Phi} \tag{68}$$

$$+ \frac{\rho}{g} V_{jt+1}(Y_{t+1}, n_{jt+1}), \tag{69}$$

$$s.t. \quad L_{jt} = \frac{n_{jt}Y_t}{s_j \gamma m_t} \qquad \& \qquad W_{jt} = \left(\frac{n_{jt}Y_t}{s_j \gamma m_t z_t}\right)^{\frac{1-\sigma}{\beta}}, \tag{70}$$

where we define

$$m_t \equiv \left[\int_0^1 \frac{1}{mc_{jt}} dj\right]^{-1}. \tag{71}$$

Next, we simplify the firm problem by taking into account growth rates that have to hold on a BGP: Growth rates are:

$$g_z = g^{-\frac{\beta}{1-\sigma}} \qquad\qquad g = g_Y = g_Q = g_m = g_w = \gamma^{\chi}$$

Refer to Section A.7 for a note on how to derive them. We also assume linear research costs, that is, $\Phi = 1$. As a first step, we divide the firm problem by Y_t to redefine it as $v_{jt} = V_{jt}/Y_t$:

$$v_{jt}(Y_t, n_{jt}) = \max_{n_{jt+1}} n_{jt} - (1+\bar{\tau}) \left(\frac{n_{jt} Y_t}{s_j \gamma m_t z_t} \right)^{\frac{1-\sigma}{\beta}} \frac{n_{jt}}{s_j \gamma m_t} \tag{72}$$

$$- \psi(n_{jt+1} - (1-\chi_t) n_{jt}) \tag{73}$$

$$+ \rho v_{jt+1}(Y_{t+1}, n_{jt+1}) \tag{74}$$

We can now drop time subscripts, and thus interpret aggregates as detrended variables, and get a recursive problem:

$$v_j(n_j) = \max_{n_j'} n_j - (1+\bar{\tau}) \left(\frac{n_j Y}{s_j \gamma m z} \right)^{\frac{1-\sigma}{\beta}} \frac{n_j}{s_j \gamma m} \tag{75}$$

$$- \psi(n_j' - (1-\chi) n_j) \tag{76}$$

$$+ \rho v_j(n_j') \tag{77}$$

Taking the first order condition, imposing $n_j = n_j'$ on BGP, and rearranging:

$$\frac{\psi}{\rho} = 1 - (1+\bar{\tau}) \frac{1-\sigma+\beta}{\beta} \left(\frac{n_j Y}{s_j \gamma m z} \right)^{\frac{1-\sigma}{\beta}} \frac{1}{s_j \gamma m} + \psi(1-\chi) \tag{78}$$

$$\Leftrightarrow \frac{n_j}{s_j^{\frac{1-\sigma+\beta}{1-\sigma}}} = \left(\left[1 + \psi(1 - \chi - \frac{1}{\rho}) \right] \frac{\beta \gamma m}{(1+\bar{\tau})(1-\sigma+\beta)} \right)^{\frac{\beta}{1-\sigma}} \frac{\gamma m z}{Y} \tag{79}$$

Since the r.h.s. of this expression does not depend on the firm type, we must have

$$\frac{n_j}{n_i} = \left(\frac{s_j}{s_i} \right)^{\frac{1-\sigma+\beta}{1-\sigma}} \tag{80}$$

A.8.1 Solution Firm Problem

From here, we can directly determine the firm sizes. The sum of all product lines held by all firms must equal 1. Using this, we get:

$$\sum_{k \text{ types}} J_k n_k = 1 \Leftrightarrow n_j = \frac{s_j^{\frac{1-\sigma+\beta}{1-\sigma}}}{\sum_{k \text{ types}} J_k s_k^{\frac{1-\sigma+\beta}{1-\sigma}}} \tag{81}$$

Similarly, the market share held by a specific type of firm j is given as $h_j = J_j n_j$:

$$h_j = \frac{J_j s_j^{\frac{1-\sigma+\beta}{1-\sigma}}}{\sum_{k \text{ types}} J_k s_k^{\frac{1-\sigma+\beta}{1-\sigma}}} \tag{82}$$

With two firm types, h and l, this boils down to:

$$1 = J_h n_h + J_l \left(\frac{s_l}{s_h}\right)^{\frac{1-\sigma+\beta}{1-\sigma}} n_h \tag{83}$$

$$\Leftrightarrow n_h = \left[J_h + J_l \left(\frac{s_l}{s_h}\right)^{\frac{1-\sigma+\beta}{1-\sigma}}\right]^{-1}, \quad n_l = \left[J_h \left(\frac{s_h}{s_l}\right)^{\frac{1-\sigma+\beta}{1-\sigma}} + J_l\right]^{-1} \tag{84}$$

Moreover, we get that the share of product lines where the h-type produces is

$$h = J_h \left[J_h + J_l \left(\frac{s_l}{s_h}\right)^{\frac{1-\sigma+\beta}{1-\sigma}}\right]^{-1} \tag{85}$$

The marginal cost mc_j is given as the derivative of production cost w.r.t. total firm output Y_j:

$$C(Y_j) = (1+\bar{\tau}) \left(\frac{Y_j}{s_j z}\right)^{\frac{1-\sigma}{\beta}} \frac{Y_j}{s_j} \tag{86}$$

$$\Rightarrow mc_j = C'(Y_j) = (1+\bar{\tau}) \frac{1-\sigma+\beta}{\beta} \left(\frac{Y_j}{s_j z}\right)^{\frac{1-\sigma}{\beta}} \frac{1}{s_j} \tag{87}$$

$$= (1+\bar{\tau}) \frac{1-\sigma+\beta}{\beta} \left(\frac{n_j Y}{s_j \gamma m z}\right)^{\frac{1-\sigma}{\beta}} \frac{1}{s_j} \tag{88}$$

Plugging this into the first order condition of the recursive (BGP) firm problem yields:

$$\frac{mc_j}{\gamma m} = 1 + \left(1 - \chi - \frac{1}{\rho}\right)\psi \tag{89}$$

Note that marginal cost according to this must be equal across firm types. With this, we can solve for wages and the level of marginal costs, starting with the following observation:

$$Y = Q \exp \int_0^1 \ln(y_i) d_i = Q \exp \int_0^1 \ln(Y) - \ln(\gamma) - \ln(mc_{j'(i)}) d_i, \tag{90}$$

and since $mc_j = m$, we have:

$$mc_h = mc_l = m = \frac{Q}{\gamma}. \tag{91}$$

Using the definition of marginal costs and rearranging in terms of the wage then gives rise to:

$$W_j = s_j \frac{\beta Q}{\gamma(1+\bar{\tau})(1-\sigma+\beta)} \tag{92}$$

A.8.2 Solution BGP Aggregates

From the firm problem FOC we have:

$$\frac{mc_j}{\gamma m} = 1 + \left(1 - \chi - \frac{1}{\rho}\right)\psi \tag{93}$$

Plugging this into the definition of m:

$$m = \left(\int_0^1 mc_{j(i)}^{-1} di\right)^{-1} = \gamma m \left[1 + \left(1 - \chi - \frac{1}{\rho}\right)\psi\right] \tag{94}$$

$$\Leftrightarrow \frac{1}{\gamma} = 1 + \left(1 - \chi - \frac{1}{\rho}\right)\psi \tag{95}$$

$$\Leftrightarrow \chi = \frac{\gamma - 1}{\psi\gamma} + \frac{\rho - 1}{\rho} \tag{96}$$

This yields the aggregate rate of innovation, that is $\chi = \sum_{j\in\mathcal{J}} x_j$, which also determines the growth of the economy, as $g_Y = \gamma^{\chi}$. Moreover, we can calculate average wages and the labor share. Starting from adding up the total wage bill $\tilde{W}$, and noting that $L_j = Yn_j/(\gamma m s_j)$:

$$\tilde{W} = \sum_{j=1}^{\mathcal{J}} L_j W_j = Y\frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)} \tag{97}$$

Then, the labor share (of output) is the given as:

$$\alpha_w = \frac{\tilde{W}}{Y} = \frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)}, \tag{98}$$

and the average wage is simply total wages divided by the number of workers. Simplifying yields:

$$\bar{w} = Q\frac{\beta}{\gamma(1+\bar{\tau})(1-\sigma+\beta)}\left(\frac{h}{s_h} + \frac{1-h}{s_l}\right)^{-1} \tag{99}$$

A.9 Marginal cost

Marginal costs of production, as relevant for the intermediate product market competition, is dervied from the following cost function:

$$C(Y_{jt}) = (1 + T(W(L(Y_{jt}))))W(L(Y_{jt}))L(Y_{jt}) \tag{100}$$

$$mc_{jt} = C'(Y_{jt}) \tag{101}$$

Moreover, we have $Y_{jt} = \frac{n_{jt}Y_t}{\gamma m_t}$, and therefore:

$$\frac{\partial C_{jt}}{\partial n_{jt}} = mc_{jt}\frac{Y_t}{\gamma m_t} \tag{102}$$

B Decomposition of output and TFP

Here, we show how to microfound aggregate TFP in an accounting exercise:

$$Y := \exp \int_0^1 \ln q_i y_i di \tag{103}$$

$$= Q \cdot \exp \int_0^1 \ln y_i di \tag{104}$$

$$= Q \cdot \exp \int_0^1 \ln s_{j(i)} di \cdot \exp \int_0^1 \ln l_i di \tag{105}$$

From here, we can define $S := \exp \int_0^1 \ln s_{j(i)} di$.

Furthermore, we can derive a relation between the geometric and arithmetic means by starting from the log of the geometric mean and then use a second order Taylor approximation of $\log l_i$ around the arithmetic mean of l_i:

$$\begin{aligned}
\int_0^1 \ln l_i di &\approx \ln \bar{l} + \int_0^1 \frac{1}{l_i}(l_i - \bar{l}) - \frac{1}{2\bar{l}^2}(l_i - \bar{l})^2 di \\
&= \ln \bar{l} - \left(\frac{\int_0^1 (l_i - \bar{l})^2 di}{2\bar{l}^2} \right) \\
&= \ln \int_0^1 l_i di - \frac{CV^2}{2}
\end{aligned}$$

Where CV denotes the Coefficient of Variation as it relates the standard deviation to the mean of the distribution of the line level employment l_i.

As a last step, take exponents of both sides and use the relation that $e^{-x} \approx 1 - x$ for small x. Then $\exp \int_0^1 \ln l_i di \approx \int_0^1 l_i di(1 - \frac{CV^2}{2})$. Use this relationship to isolate the labor input in each product line and plug in the labor supply facing the intermediate producers:

$$
\begin{aligned}
Y &\approx Q \cdot S \cdot \int_0^1 l_i di (1 - \frac{CV^2}{2}) && (106)\\
&= Q \cdot S \cdot (1 - \frac{CV^2}{2}) \cdot \sum_{j \in \mathcal{J}} \int_0^1 l_{ij} di && (107)\\
\text{Plug in labor supply: } &= Q \cdot S \cdot (1 - \frac{CV^2}{2}) \cdot \left(\sum_{j \in \mathcal{J}} \mathcal{L} \left(\frac{z}{\mathcal{L}} \right) W_j^{\frac{\beta}{1-\sigma}} \right) && (108)\\
&= Q \cdot S \cdot (1 - \frac{CV^2}{2}) \cdot \left(\sum_{j \in \mathcal{J}} \frac{z}{\mathcal{L}} \cdot W_j^{\frac{\beta}{1-\sigma}} \right) \cdot \mathcal{L} && (109)\\
&= \underbrace{Q \cdot S \cdot (1 - \frac{CV^2}{2})}_{TFP} \cdot \frac{\sum_{j \in \mathcal{J}} L_j}{\mathcal{L}} \cdot \mathcal{L} && (110)
\end{aligned}
$$

This gives us a microfoundation for aggregate output as in Boppart and Li, 2021. Aggregate TFP depends on the quality index, Q, which grows over time, and allocative efficiency which can be summarised as the geometric average of producer productivity, S, multiplied by the dispersion in line level employment, CV, and the employment rate.

The dispersion of line level employment is akin to a dispersion in revenue productivity, as it depends on the producer, which defines s_j, and the follower, which defines the price in equilibrium. To understand it better, we next rewrite it in terms of parameters and equilibrium objects known after solving the dynamic problem:

$$
\begin{aligned}
&\int_0^1 (l_i - \bar{l})^2 di \\
&= \sum_{j \in \{L,H\}} \sum_{j' \in \{L,H\}} \int_0^1 l_{i,j,j'}^2 di - \bar{l}^2 \\
&= h^2 \int_0^1 l_{i,H,H}^2 di + (1-h)^2 \int_0^1 l_{i,L,L}^2 di \\
&+ h(1-h) \int_0^1 l_{i,L,H}^2 + l_{i,H,L}^2 di - \bar{l}^2 \\
&= h^2 \int_0^1 \left(\frac{Y}{s_H \gamma mc_H} \right)^2 di + (1-h)^2 \int_0^1 \left(\frac{Y}{s_L \gamma mc_L} \right)^2 di \\
&+ h(1-h) \int_0^1 \left(\frac{Y}{s_L \gamma mc_H} \right)^2 + \left(\frac{Y}{s_H \gamma mc_L} \right)^2 di - \bar{l}^2 \\
&= \left(\frac{Y}{\gamma} \right)^2 \left(\left(\frac{h}{s_H mc_H} \right)^2 + \left(\frac{1-h}{s_L mc_L} \right)^2 \right.
\end{aligned}
$$

$$+ h(1-h)\left(\left(\frac{1}{s_L mc_H}\right)^2 + \left(\frac{1}{s_H mc_L}\right)^2\right)\Bigg) - \bar{l}^2$$

$$\iff$$

$$\frac{\int_0^1 (l_i - \bar{l})^2 di}{\bar{l}^2}$$

$$= \frac{\left(\frac{h}{s_H mc_H}\right)^2 + \left(\frac{1-h}{s_L mc_L}\right)^2 + h(1-h)\left(\left(\frac{1}{s_L mc_H}\right)^2 + \left(\frac{1}{s_H mc_L}\right)^2\right)}{\left(\frac{h^2}{s_H mc_H} + \frac{(1-h)^2}{s_L mc_L} + h(1-h)\left(\frac{1}{s_L mc_H} + \frac{1}{s_H mc_L}\right)\right)^2} - 1$$

Taken together with the aggregate output expression above, this means TFP equals:

$$TFP = Q \cdot S \cdot \underbrace{\left(\frac{3}{2} - \frac{\frac{h^2}{(s_H mc_H)^2} + \frac{(1-h)^2}{(s_L mc_L)^2} + h(1-h)\left(\left(\frac{1}{s_L mc_H}\right)^2 + \left(\frac{1}{s_H mc_L}\right)^2\right)}{2\left(\frac{h^2}{s_H mc_H} + \frac{(1-h)^2}{s_L mc_L} + h(1-h)\left(\frac{1}{s_L mc_H} + \frac{1}{s_H mc_L}\right)\right)^2}\right)}_{M}$$

$$= Q \cdot S \cdot \left(\frac{3}{2} - \frac{\mathbb{E}\left(\frac{1}{\left(s_j mc_{j'}\right)^2}\right)}{2 \cdot \mathbb{E}\left(\frac{1}{s_j mc_{j'}}\right)^2}\right)$$

This shows that, apart from initial assumptions of s_H, s_L, it is the equilibrium dispersion of marginal costs, and the equilibrium firm size distribution h that explain the misallocation factor.

C Quantitative Solution Algorithm

Setup, wage

$$\bar{w} = \int_0^1 w_{o,j(o)}\, do = \int_0^1 \left(\frac{J_h L_h}{L} w_{o,j(o)=h} + \frac{J_l L_l}{L} w_{o,j(o)=l}\right) do \tag{111}$$

Here, $L = J_h L_h + J_l L_l$. Using that $Y_j = \frac{n_j Y}{\gamma m}$, we can rewrite

$$\bar{w} = \frac{J_h L_h w_h + J_l L_l w_l}{L} = \frac{\frac{Y}{\gamma m}\left(J_h \frac{n_h}{s_h} w_h + J_l \frac{n_l}{s_l} w_l\right)}{\frac{Y}{\gamma m}\left(J_h \frac{n_h}{s_h} + J_l \frac{n_l}{s_l}\right)} = \frac{\frac{h}{s_h} w_h + \frac{1-h}{s_l} w_l}{\frac{h}{s_h} + \frac{1-h}{s_l}}$$

$$= f_w(h, w_h, w_l)$$

Setup, marginal cost

$$C(n_j) = \left(1 + \tau\left(\frac{1}{\bar{w}}\left[\frac{Y_j}{s_j z}\right]^{\frac{1-\sigma}{\beta}}\right)\right)\left[\frac{Y_j}{s_j z}\right]^{\frac{1-\sigma}{\beta}}\frac{Y_j}{s_j}$$

which results in the marginal cost as a function of n_j:

$$\begin{aligned} mc_j =& \frac{1}{\beta}\left(\frac{n_j Y}{\gamma m z}\right)^{\frac{1-\sigma}{\beta}}\left[\frac{1}{s_j}\right]^{\frac{1-\sigma+\beta}{\beta}}\Bigg[(1-\sigma+\beta)\left(1+\tau\left(\frac{1}{\bar{w}}\left[\frac{n_j Y}{\gamma m s_j z}\right]^{\frac{1-\sigma}{\beta}}\right)\right) \\ &+ (1-\sigma)\tau'\left(\frac{1}{\bar{w}}\left[\frac{n_j Y}{\gamma m s_j z}\right]^{\frac{1-\sigma}{\beta}}\right)\frac{1}{\bar{w}}\left[\frac{n_j Y}{\gamma m s_j z}\right]^{\frac{1-\sigma}{\beta}}\Bigg] \end{aligned}$$

Or:

$$mc_j = f_{mc}\left(n_j, s_j, \frac{Y}{mz}, \bar{w}\right) \tag{112}$$

Algorithm

Outer loop: Guess J_{guess}

Inner loop: Guess $h_{\text{guess}}, \left(\frac{Y}{mz}\right)_{\text{guess}}$

(a) Compute $n_h = \frac{h_{\text{guess}}}{J_h}, n_l = \frac{1-h_{\text{guess}}}{J_l}$

(b) Get $w_j = \left(n_h \left(\frac{Y}{mz}\right)_{\text{guess}} \frac{1}{\gamma s_j}\right)^{\frac{1-\sigma}{\beta}}$

(c) Get $\bar{w} = f_w(h, w_h, w_l)$

(d) $mc_j = f_{mc}\left(n_j, s_j, \frac{Y}{mz}, \bar{w}\right)$

(e) $m = \left[\frac{h}{mc_h} + \frac{1-h}{mc_l}\right]^{-1}$

(f) $D_e = J_h w_h^{\frac{\beta}{1-\sigma}} + J_l w_l^{\frac{\beta}{1-\sigma}}$

(g) Find Y such that $\left(\frac{Y}{mz}\right)_{\text{guess}} = \frac{Y^{1+\beta}\omega D_e^{\sigma} + Y D_e}{mLs}$

(h) $D_0 = (\omega Y)^{\beta}$

(i) $z = \frac{Ls}{D_0 D_e^{\sigma} + D_e}$

(j) $L_j = w_j^{\frac{\beta}{1-\sigma}} z$

Inner loop Check:
loss2 $= \left| n_h^{\phi-1}(mc_l - \gamma m) - n_l^{\phi-1}(mc_h - \gamma m) \right| + \left| mc_h^h mc_l^{1-h} - \frac{Q}{\gamma} \right|$

- Solve for $\chi \in (0,1)$ using $\frac{mc_j - \gamma m}{\gamma m} \frac{Y}{\psi \phi Q} \frac{1}{n_j^{\phi-1}} = \chi^{\phi-1} \frac{\rho-1}{\rho} - \chi^{\phi}$
- χ from above will be the same for either j.
- If there is no $\chi \in (0,1)$ solving the first order condition(s), the model has no solution at the current parameters and J , so loss1 = big number
- If χ is properly solved for, compute $V_{\text{entry}} = \frac{\alpha \tilde{v}_h(n_h) + (1-\alpha)\tilde{v}_l(n_l)}{1-\rho}$

Outer loop Check: loss1 $= |V_{\text{entry}} - \text{entry cost}|$

D Productivity and top 10% revenue share from Compustat

We use compustat data (Standard & Poor's, 2020) from 1954 to 2016, and take averages of various time periods for different applications. We focus on firms in the U.S. manufacturing sector by filtering the dataset to include only firms under NAICS codes starting with '31', '32', or '33', and reporting in U.S. dollars. Missing values were addressed by excluding firms without key variables like sales and employment, and only firms with positive sales and employment values were kept. Firms were categorized annually into the top 10% by sales and the remaining 90%. We calculate two key metrics: the revenue share of the top 10%, and the relative average revenue per employee, which compares the production

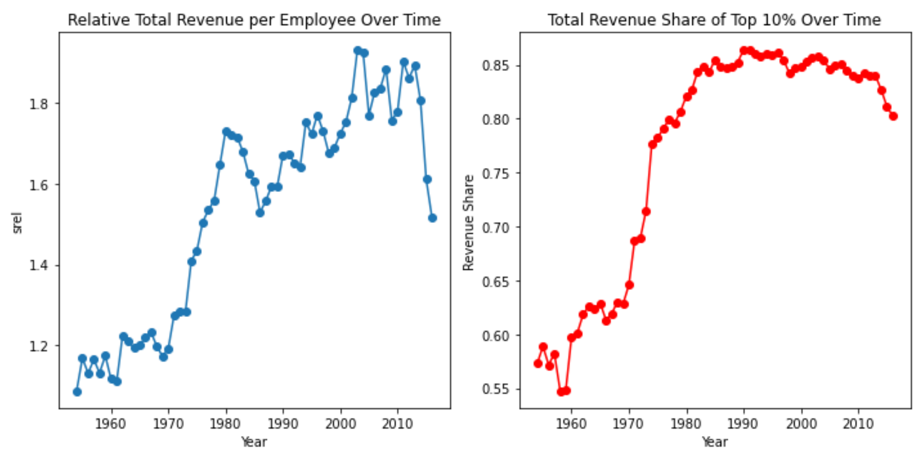

Figure 6: Time trends in top 10% revenue share and relative labor productivity.

efficiency of the top 10% with the bottom 90%. How these measures vary over time is depicted in Figure 6.