Corporate tax avoidance, firm size, and capital misallocation ⋆

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ABSTRACT

We develop a general equilibrium model to study how corporate tax avoidance affects firm policies and aggregate outcomes. Tax avoidance and investment are complementary inputs, leading the largest firms to engage in the most avoidance and face the lowest effective tax rates, consistent with the data. We find that tax avoidance significantly increases both the average firm size and concentration, disproportionately benefiting large firms. Tax avoidance also generates capital misallocation, lowering productive efficiency and welfare. We estimate the model to quantify the costs and benefits of tax avoidance and evaluate the equilibrium effects of changes to the statutory tax rate and costs of avoidance.

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1. Introduction

Firms expend significant resources in managing and reducing their corporate tax liabilities.[1] These actions, which we broadly refer to as corporate tax avoidance, do not just lower the average tax rate, but allow some firms to pay a lower rate than others. In particular, large firms have been scrutinized for achieving very low effective tax rates.[2] Coincidentally, this comes at a time that growing firm concentration is raising concerns that large firms are stifling competition and entry. If tax avoidance rewards large firms with a lower tax rate, this gives these firms a competitive advantage, with important implications for firm entry, allocation, productivity, and welfare.

We build and estimate a general equilibrium model of firm investment in order to evaluate the effect of tax avoidance on firm policies and equilibrium outcomes. In the model, firms jointly make investment and tax avoidance decisions, resulting in endogenous effective tax rates that vary across firms and over time. Tax avoidance and investment are complementary inputs, leading the largest firms to engage in the most avoidance and face the lowest effective tax rates, consistent with our empirical results. Endogenous tax avoidance affects the allocation of capital and labor across firms, distorting aggregate TFP, firm concentration, entry, exit, and the equilibrium wage. We estimate the model using data on public firms to quantify these distortions and to evaluate alternative tax policies.

We show that effective tax rates decline substantially with firm size in the data, and the model matches well this empirical relation. Because small firms face a higher tax rate than large firms, this puts smaller firms at a competitive disadvantage, suppressing competitive entry and the wage rate in equilibrium. Large firms respond to this by increasing their scale of production, which with decreasing returns, results in lower aggregate TFP. Thus, tax avoidance acts as an inefficient government subsidy to large firms—or, equivalently, an extra tax on small firms—leading to significant misallocation of capital and labor, and increased firm concentration. We estimate the aggregate direct costs of tax avoidance activities to be economically significant; however, they are small relative to the costs of

[1] See, for example, Shackelford and Shevlin (2001) and Hanlon and Heitzman (2010) for reviews of the evidence.

[2] See, for example, Kocieniewski (2011) and Fair Tax Mark (2019).

misallocation. We find that a tax revenue-neutral policy that eliminates avoidance would hurt large firms but increase both aggregate firm profits, consumption, and welfare. Furthermore, this tax-revenue-neutral removal of avoidance increases aggregate TFP by 6%. However, policy changes that make tax avoidance more costly, without fully eliminating it, can actually exacerbate the negative allocative consequences of tax avoidance by widening the gap between small and large firms.

We begin by exploring the empirical relation between effective tax rates and firm size in the cross-section. For decades, there has been a concern that large corporations are able to substantially reduce their tax liability using a variety of strategies. This concern has only grown in recent years as the increased importance of intangible assets and global operations has further enabled avoidance practices.[3] Despite this popular belief, the academic literature has found mixed evidence on the empirical relation between firm size and ETRs.[4] We reconsider this evidence using the long-term measure of tax avoidance proposed by Dyreng et al. (2008). Over a ten-year horizon, we find that large firms pay a significantly lower cash ETR than small firms. For example, firms in the largest decile pay 10.8 p.p. (26%) lower taxes than those in the smallest decile, and this spread increases to 14.4 p.p. (35%) for the largest 1 percent of firms. These empirical patterns support the conjecture that larger firms engage in greater tax avoidance and suggest that certain tax management practices—such as avoiding and managing net operating losses (NOLs)—may benefit from scale.

In the model, firms make capital and labor decisions frictionlessly as inputs to a decreasing returns to scale production technology. At the same time, firms choose the level of costly tax avoidance to engage in, which determines the effective tax rate paid on their profits. We remain agnostic as to the sources of the costs of tax avoidance; this could be the costs of attorneys and accountants, earnings smoothing and management, operational and investment choices, organizational structures including subsidiaries, etc. The tax avoidance technology is assumed to be complementary to the inputs of production but with decreasing returns to scale. We use the observed effective tax rates in the data to estimate the unobserved parameters of this avoidance technology that dictate the unit cost and returns

[3] See, for example, Clausing (2016), Albertus et al. (2021), and Albertus et al. (2019).

[4] See, for example, Zimmerman (1983) and Chen et al. (2010). Belz et al. (2019) performs a meta-analysis of the literature.

to scale. Optimally, more productive firms choose to produce more, generate more profits, and pursue more tax avoidance as they benefit more from a lower tax rate. We find this parsimonious tax avoidance technology does well to match the empirical ETR patterns we document.

We model a competitive economy with a continuum of firms where firms make shareholder value-maximizing production, tax avoidance, entry, and exit decisions in response to idiosyncratic productivity shocks. The framework admits a closed-form long-run stationary distribution of firms and a market clearing wage. This model structure quantifies how interaction between tax avoidance and production decisions influences the distribution of firms. We estimate the model by minimizing the difference between empirical and model moments related to earnings, the firm size distribution, and effective tax rates for US public firms. The model, which is over-identified, does well to approximate the empirical moments, suggesting our assumed tax function is consistent with the data.

In the estimated model, the presence of endogenous tax avoidance has two distinct channels through which firm and aggregate outcomes are affected. To see this, consider a counterfactual world in which all firms face the statutory rate; we call this the *no avoidance* case. The introduction of tax avoidance has two separate effects on the tax environment. First, tax avoidance results in an implicit tax cut in that it reduces the tax rate faced by the average firm. Second, tax avoidance results in tax rate heterogeneity in that larger firms face a lower effective tax rate. In certain dimensions, these channels have counteracting effects. Therefore, it is insightful to consider the effects of a tax cut separate from tax avoidance.

We isolate the effect of a tax cut by considering the effect of lowering the statutory tax rate in the no avoidance case. The new, lower, tax rate is chosen such that tax revenue is equivalent to that in the baseline model that features tax avoidance. In other words, the aggregate size of this tax cut is the same as the tax reduction achieved through avoidance, but all firms face the same tax rate. We find that aggregate firm value, output, and profits increase significantly as a result of the tax cut. At the same time, the average firm produces less, as they choose a smaller scale. With decreasing returns to scale, this improves aggregate TFP, and in turn allocative efficiency. Aggregate TFP increases by 6% and consumption by 7.4% from the tax cut as a result of improved allocation.

To understand the response to a tax cut, it is critical to understand the effect of tax rates on firm entry. A lower tax rate makes the expected value of entry more attractive, all else equal. However, in equilibrium the market clearing wage increases in response to the lower tax rate. While a lower tax rate alone would increase the firm's chosen scale of production, the effect of a higher wage offsets this and in equilibrium firms choose a lower scale after the tax cut, increasing TFP. Together, aggregate output increases, despite a decline in the average firm's output, by encouraging entry and increasing the number of firms producing in equilibrium. In addition, the tax cut has virtually no effect on concentration: it scales the mass of firms without significantly distorting the distribution because all firms face the same tax rate.

The effect of tax avoidance on firm and aggregate outcomes contrasts sharply with that of a tax cut. In contrast to a tax cut, the average firm size increases substantially as a result of tax avoidance; for example, average capital is 12.4% higher. It also results in an increase in aggregate firm value, capital, and output. Thus, while both a tax cut and tax avoidance lead to higher output, the increase from tax avoidance is the result of fewer firms producing at a larger scale, lowering TFP. In addition, tax avoidance gives larger firms a competitive advantage, increasing the share of profits coming from the top 1% of firms by 7.9%. Because smaller firms still face a high tax rate, as they choose to engage in less tax avoidance, competitive entry is suppressed.

In summary, tax avoidance results in both an implicit tax cut and effective tax rates that are declining in size. The former improves allocation, while the latter worsens it. Our decomposition reveals that both channels have significant effects on firm and aggregate outcomes. With respect to allocative efficiency, we find that these two competing effects roughly cancel out while also resulting in increased average firm size and concentration. Because of the allocative benefits of a tax cut, our policy experiments reveal that eliminating tax avoidance in a revenue-neutral manner significantly improves efficiency and surplus while also reducing the average firm size and concentration.

The model also allows us to consider policies that affect the difficulty with which firms avoid taxes, as well as the effects of statutory rate changes. For example, policymakers can make tax avoidance more difficult through legislative or enforcement changes. In the model, this is equivalent to an increase in the input cost of avoidance, a policy experiment we consider. While increasing the difficulty of tax avoidance would seem to be beneficial in that it reduces tax avoidance, we find that it actually exacerbates the problem because it further widens the gap between large and small firms. While tax revenue does increase, it further increases the average firm size and decreases productive efficiency. As a result, consumption and welfare decline. These results indicate that policies that attempt to eliminate heavily exploited tax savings strategies may actually have unintended negative consequences for real outcomes.

We also assess the effect of a statutory rate cut in the presence of tax avoidance. Because few firms face the statutory rate, a decrease in that rate has a limited impact on the effective rates that firms pay. Generally, corporate taxes distort capital allocation and lead to inefficiencies. Therefore, tax cuts lead to an increase in total surplus. This remains the case when a statutory tax cut occurs in the presence of tax avoidance. However, we find that the gains are muted relative to a tax cut in a world without any avoidance. Thus, tax cuts may be a less potent policy tool to stimulate investment if tax avoidance is allowed to persist.

Related Literature

A large literature investigates the role of corporate taxes on real investment and financing decisions within a neoclassical, or q-theory, framework (Hall and Jorgenson, 1967; Summers, 1981; Hayashi, 1982; Hassett and Hubbard, 2002; Hennessy and Whited, 2005; Barro and Furman, 2018) as well as a focus on the effectiveness of tax incentives in stimulating investment (House and Shapiro, 2008; Yagan, 2015; Zwick and Mahon, 2017). A related literature explores the incidence of corporate taxes on shareholders, workers, and consumers (Harberger, 1962; Fuest et al., 2018; Baker et al., 2020). We contribute to these literatures by demonstrating that tax avoidance is distinct from simple tax rate changes and results in distortions to investment and allocations.

Our paper also contributes to a burgeoning literature on increasing firm concentration and the declining labor share (Gutiérrez and Philippon, 2017; Grullon et al., 2019; Hartman-Glaser et al., 2019; Autor et al., 2020; De Loecker et al., 2020). We find that tax avoidance, and the advantage larger firms face in lowering their tax liabilities, may be contributing to increased firm concentration.

From a modeling perspective, our paper relates to a strand of literature in finance and economics that study equilibrium models of firm dynamics.[5] Miao (2005) studies entry, exit, and firm dynamics in a tradeoff model of leverage with default. Gourio and Roys (2014) study how a French tax on firms with more than 50 workers influences the firm size distribution and efficiency. Hartman-Glaser et al. (2019) study how an increase in firm level risk affects aggregate and average capital shares in an equilibrium model with entry and exit where firms insure workers. See Dixit and Pindyck (1994) for an overview of this class of continuous time models of firm dynamics.

A strand of the tax literature explores the firm characteristics that determine corporate tax outcomes, typically measured as the cash or GAAP effective tax rate (Gupta and Newberry, 1997; Dyreng et al., 2008). Several of these studies investigate the role of firm size (Zimmerman, 1983; Omer et al., 1993; Rego, 2003). The existing empirical literature, reviewed in Belz et al. (2019), has not found firm size to be a consistent determinant of tax rates. We show there is a robust relation between firm size and long-term effective tax rates, and that this pattern is not apparent over short horizons. In contemporaneous work, Gaertner, Glover, and Levine (2021) explore the specific tax preferences that allow larger firms to avoid taxes. They find that this pattern cannot be explained by the determinants commonly considered in the tax avoidance literature, for example incidence of foreign income or R&D expenditures. However, they find evidence that the ability of large firms to manage and avoid losses may significantly reduce their taxes paid.

2. Empirical Facts

In this section we present evidence on the empirical relationship between firm size and effective tax rates. There are countless strategies firms use to reduce their tax payments, most of which are not easily observable. However, the details of how tax avoidance occurs is not the focus of this study; see Gaertner, Glover, and Levine, 2021 for an investigation of the underlying tax preferences linking size and tax rates. Therefore, we adopt from Dyreng,

[5] See, e.g., Jovanovic (1982), Hopenhayn (1992a,b), Ericson and Pakes (1995), Cooley and Quadrini (2001), Clementi and Hopenhayn (2006), Luttmer (2007), Clementi and Palazzo (2016).

Hanlon, and Maydew (2008) the broad definition of tax avoidance as "anything that reduces the firm's cash tax rate over a long time period, i.e. ten years."[6]

Our firm-level data are from Compustat Fundamentals Annual covering public US firms for the period 1988–2017. This time period is chosen because of the stability in the statutory corporate tax rate during the interval between the significant corporate tax changes enacted in the Tax Reform Act in 1986 and the Tax Cuts and Jobs Act in 2017.[7] We exclude firms in the utility, financial, and quasi-governmental industries (SIC codes 4900–4999, 6000–6999, and 9000–9999). We require firms to have book asset values of at least $50 million in 2017 dollars and non-missing values for cash taxes paid, pretax income, and market value of equity.

We measure a firm's effective tax rate as the ratio of cash taxes paid to GAAP pretax income.[8] While this measure is common in the literature, it is typical to estimate the effective tax rate at a one-year horizon. In contrast, in this study we focus on the longer term effective tax rate measured using multiple years of data using an approach introduced in Dyreng et al. (2008). Measuring the tax rate over multiple years is advantageous for at least two reasons. First, a long-run measure more accurately reflects the true economic cost of taxes to the firm. The average annual tax rate may misrepresent this cost.[9] Second, as emphasized by Henry and Sansing (2018), a long-run approach mitigates a sample selection problem caused by high-frequency tax rate measures: observations with negative income must be excluded which occurs more frequently at the annual horizon. We believe the benefits of using the long-run measure exceeds the cost of a smaller sample size.

[6] Similarly, Hanlon and Heitzman (2010) defines tax avoidance broadly "as all transactions that have any effect on the firm's explicit tax liability." Their definition, and ours, "does not distinguish between real activities that are tax-favored, avoidance activities specifically undertaken to reduce taxes, and targeted tax benefits from lobbying activities," nor between legal and illegal avoidance (see page 137 of Hanlon and Heitzman, 2010, for a discussion of the definition and types of tax avoidance).

[7] The top federal corporate income tax rate was 34% from 1988–1992 and 35% from 1993–2017.

[8] The ability to reduce the cash effective tax rate is commonly called non-conforming tax avoidance in that it relies on differences between book and tax accounting, lowering taxes paid (the numerator). In contrast, book-tax conforming tax avoidance is the result of firms reducing their reported pretax income (the denominator), for example through interest deductions. Hanlon and Heitzman (2010) provide a discussion of conforming versus non-conforming tax avoidance and measurement approaches. Like most studies, we focus only on non-conforming tax avoidance.

[9] An extreme example illustrates this point: suppose a firm pays $1 in taxes every year, but its income alternates between $1 and $1 billion. The long-run tax rate is effectively zero, but the average annual tax rate is 50%.

The N-year cash effective tax rate (ETR) in year t for firm i is measured as

$$\mathrm{ETR}_{i,t}^{N} = \frac{\sum_{s=0}^{N-1} \mathrm{TXPD}_{i,t-s}}{\sum_{s=0}^{N-1} \mathrm{PI}_{i,t-s}} \tag{1}$$

where $\mathrm{TXPD}_{i,t}$ is total cash taxes paid (federal, state, and foreign) and $\mathrm{PI}_{i,t}$ is pretax income.[10] The ETR is measured every year and we require data in all N years for inclusion. We focus on the 10-year rate as our benchmark ($\mathrm{ETR}_{i,t}^{10}$), shown in specification (1) of Table I. The mean (median) ten-year cash ETR is 35.1% (31.9%) in our sample.

To explore the relationship between firm size and ETR, we sort firms into deciles based on the firm's average (quasi-)market value or book value of assets over the same period.[11] The table reports the average ETR within each decile in specifications (1) and (2) sorted on market and book value of assets, respectively. These values, along with the average ETR for the top 1% of firms, are also shown in Figure 1.

We see from specification (1) of Table I that ETRs decline significantly in firm size, with the largest firm decile facing a 10.8 percentage point (or 26%) lower tax rate than the smallest firm decile. In addition, this gap grows even larger when we focus on the top 1% of firms, who face a 14.4 percentage point (or 35%) lower ETR than the smallest firm decile. The negative relation between size and ETR is nearly monotonic and is statistically significant as shown by the bootstrapped standard errors or t-statistics reported to the right of each sample statistic. The pattern is similar, although not as pronounced among the very largest and smallest firms, when size is measured as the book value of assets, shown in specification (2).

Specifications (3) and (4) show that this pattern is robust to alternative approaches to measuring the effective tax rate. Specification (3) excludes special items from pretax income in the ETR measure, the benchmark used in Dyreng et al. (2008). This results in a lower mean ETR (29.5%) because special items are on average negative; however, the pattern is very similar. The relationship is also similar when measuring the ETR at the five-year horizon ($\mathrm{ETR}_{i,t}^{5}$), shown in specification (4).

[10] Consistent with the literature, observations with negative taxes paid or non-positive pretax income are dropped, and tax rates are winsorized above at 1. This results in a possible range of $[0, 1]$ for the ETR measure.

[11] The market value of assets is defined as the book value of debt plus the market value of equity minus the book value of shareholder equity. The size quartile cutoffs are constructed annually using data from the full sample.

Finally, specification (5) reports the average one-year cash ETR, the most common measure used in the literature. The one-year rates are lower on average (29.5%) and slightly more volatile. Strikingly, there is no meaningful variation in tax rates with respect to size. This lack of relationship at the one-year horizon may explain the indeterminate role of size in determining tax rates in the extant tax literature (see Belz et al., 2019 for a review).

We have shown that larger firms face a significantly lower effective tax rate than smaller firms in the medium and long term. This superior tax avoidance by large firms is economically meaningful resulting in an effective tax rate 10.8 percentage point (or 26%) difference between the tenth and first deciles over our sample, corresponding roughly to \$1.9 trillion in tax savings for the top 10% of firms.

3. Model

In order to understand the effect of tax avoidance on firm policies and equilibrium outcomes, we develop a general equilibrium investment model with endogenous tax avoidance. Time is continuous and the horizon is infinite.

3.1. Firm production

Firms produce a homogeneous good in a competitive market using inputs of capital ($k_{i,t}$) and labor ($\ell_{i,t}$) to generate output, $y_{i,t}$, according to

$$y_{i,t} = z_{i,t} k_{i,t}^{\alpha} \ell_{i,t}^{\beta}, \tag{2}$$

where $0 < \alpha + \beta < 1$. Firm-specific productivity shocks $z_{i,t}$ evolve according to

$$\frac{dz_{i,t}}{z_{i,t}} = \mu dt + \sigma dB_{i,t}, \tag{3}$$

where $B_{i,t}$ is a standard Brownian motion. Firms are also subject to idiosyncratic exit shocks that arrive with constant intensity λ.

3.2. Profits, cash flows, and tax avoidance

Firms face a statutory tax rate τ_0. However, firms can reduce their effective tax rate, $\tau_{i,t}$, by engaging in a costly tax avoidance technology, $h_{i,t}$, that has a unit cost b: the dollar cost of tax avoidance activity is $bh_{i,t}$. The after-tax profit function for the firm is

$$\pi_{i,t} \equiv \pi(z_{i,t}, w_t) = \max_{k_{i,t},\ell_{i,t},h_{i,t}} \left\{(1-\tau_{i,t})y_{i,t} - (1-\tau_0)(\delta k_{i,t} + w_t \ell_{i,t}) - rk_{i,t} - bh_{i,t} - c_f\right\}. \quad (4)$$

We assume that depreciation and labor expense are deductible at the statutory rate τ_0. The opportunity cost of capital, r, and the cost of tax avoidance, $bh_{i,t}$, are not tax deductible. The latter choice is made because we want to capture not just the cost of attorney and accountant fees, which may be a tax deductible expense, but also indirect costs such as inefficient use of resources and foregone or poorly allocated investment.[12] Finally, firms are subject to a fixed operating cost, c_f.

We depart from standard models in that the the firm's tax rate, $\tau_{i,t}$, is an endogenous choice variable for the firm that depends on the firm's investment in a tax reduction technology.[13] To define the endogenous tax rate, we assume that the tax rate is

$$\tau_{i,t} = \begin{cases} \tau_0 & \text{if } h_{i,t} = 0 \\ 1 - (h_{i,t} + h_0)^{\gamma} & \text{if } 0 < h_{i,t} < \bar{h} \\ \tau_L & \text{if } h_{i,t} \geq \bar{h}. \end{cases} \quad (5)$$

where $\gamma \in (0,1)$ is the returns to scale on the tax reduction technology. There are three regions to the tax rate. In the first region, the firm faces the statutory tax rate τ_0 when they do not spend on tax reduction ($h_{i,t} = 0$). With some spending on tax reduction, the firm faces a decreasing tax rate up until the point $\bar{h}$ where the minimum attainable tax rate, τ_L, is achieved. In the second region, the firm faces decreasing returns to scale on tax reduction technology (i.e., $\gamma < 1$). We impose continuity in the tax rate across the three regions, which gives $h_0 = (1-\tau_0)^{\frac{1}{\gamma}}$ and $\bar{h} \equiv (1-\tau_L)^{\frac{1}{\gamma}} - h_0$.

We will show that, when tax avoidance $h_{i,t}$ is chosen optimally, the three regions of the tax rate are determined by the firm's productivity $z_{i,t}$. We define z_l and z_h as the thresholds at which the firm moves from region one to two (when the firm first begins to spend on tax

[12]These costs are akin to those of adjustment costs in a standard model, which are not typically considered tax deductible for these reasons. Making some or all of these costs tax deductible would not have a significant effect on our results.

[13]As discussed in Footnote 8, this study focuses on non-conforming tax avoidance. This is consistent with our cash flow specification in Eq. (4) in that tax avoidance reduces the firm's effective tax rate. In contrast, conforming tax avoidance would reduce the firm's pretax income (e.g., by using debt with tax deductible interest payments). Our focus on non-conforming tax avoidance also allows us to model the firm as all-equity financed because debt choice does not directly affect our measure of tax avoidance.

reduction) and from region two to three (when the firm has attained the minimum tax rate), respectively. Later, we will derive these thresholds.

In equilibrium, which we define and discuss Section 3.9, the wage rate is time invariant because the distribution of firms is stationary over time. For this reason, we henceforth suppress the time subscript on the wage rate w.

The firm's optimal level of tax avoidance is given by

$$h_{i,t} = \begin{cases} 0 & \text{if } z_{i,t} \leq z_l \\ \left(\dfrac{\gamma y_{i,t}}{b}\right)^{\frac{1}{1-\gamma}} - h_0 & \text{if } z_l < z_{i,t} < z_h \\ \bar{h} & \text{if } z_{i,t} \geq z_h \end{cases} \tag{6}$$

where the expression in the middle region comes from the first order condition on the profit function with respect to $h_{i,t}$. Combining Equations (5) and (6) gives the tax rate in terms of the regions of $z_{i,t}$:

$$\tau_{i,t} = \begin{cases} \tau_0 & \text{if } z_{i,t} \leq z_l \\ 1 - \left(\dfrac{\gamma y_{i,t}}{b}\right)^{\frac{\gamma}{1-\gamma}} & \text{if } z_l < z_{i,t} < z_h \\ \tau_L & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{7}$$

Similarly, the optimal capital and labor are given by their first order conditions. Plugging in the optimal choice of tax reduction, capital, and labor into Eq. (4) gives the firm's optimal profit as a function of $z_{i,t}$ and w:

$$\pi(z_{i,t}; w) = \begin{cases} (1-\alpha-\beta) \left[\left(\dfrac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\dfrac{\beta}{w(1-\tau_0)}\right)^{\beta} (1-\tau_0) z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} - c_f & \text{if } z_{i,t} \leq z_l \\ (1-\alpha-\beta-\gamma) \left[\left(\dfrac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\dfrac{\beta}{w(1-\tau_0)}\right)^{\beta} \left(\dfrac{\gamma}{b}\right)^{\gamma} z_{i,t}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} + bh_0 - c_f & \text{if } z_l < z_{i,t} < z_h \\ (1-\alpha-\beta) \left[\left(\dfrac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\dfrac{\beta}{w(1-\tau_0)}\right)^{\beta} (1-\tau_L) z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} - b\bar{h} - c_f & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{8}$$

Details of this derivation are provided in Appendix A.1. We defer discussion on the effect of tax avoidance on firm policies to Section 3.10.

3.3. *Firm valuation*

Firms choose capital, labor, and tax avoidance, to maximize the flow of cash flows $\pi(z_{i,t}; w)$. Given the fixed operating costs, c_f, they also choose an optimal stopping time, denoted $\mathcal{T}_D$, to exit. Firm value is then given by

$$v(z_{i,t}; w) = \sup_{\mathcal{T}_D} \mathbb{E}\left[\int_t^{\mathcal{T}_D} e^{-(r+\lambda)s} \pi(z_{i,s}; w) ds \,\middle|\, z_{i,t} \right]. \tag{9}$$

The firm value is the discounted value of the stream of cash flows, $\pi(z; w)$, until the firm exits, either endogenously because its productivity falls to a sufficiently low level or exogenously via the arrival of an exit shock.

As we will see in Section 3.9, in stationary equilibrium the wage rate is constant over time. The value of a firm is given in the following proposition.

Proposition 1. *Define $\eta = 1 - \alpha - \beta$ and assume*

$$r + \lambda - \frac{\mu}{\eta} - \frac{\sigma^2}{2}\frac{1}{\eta}\left(\frac{1}{\eta} - 1\right) > 0. \tag{10}$$

The value of a firm facing wage rate w and current productivity z is given by

$$v(z; w) = \begin{cases} B_1 z^{\xi_1} + B_2 z^{\xi_2} + \dfrac{A_1 z^{1/\eta}}{\kappa_1} - \dfrac{c_f}{r+\lambda} & \text{if } z \le z_l \\ C_1 z^{\xi_1} + C_2 z^{\xi_2} + \dfrac{A_2 z^{\frac{1}{\eta-\gamma}}}{\kappa_2} + \dfrac{bh_0 - c_f}{r+\lambda} & \text{if } z_l < z < z_h \\ D_2 z^{\xi_2} + \dfrac{A_3 z^{1/\eta}}{\kappa_1} - \dfrac{b\bar{h} + c_f}{r+\lambda} & \text{if } z \ge z_h, \end{cases} \tag{11}$$

where

$$\begin{aligned}
A_1 &= \eta \left[\left(\frac{\alpha}{r + \delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} (1-\tau_0) \right]^{1/\eta} \\
A_2 &= \frac{1}{\eta - \gamma} \left[\left(\frac{\alpha}{r + \delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} \left(\frac{\gamma}{b} \right)^{\gamma} \right]^{\frac{1}{\eta-\gamma}} \\
A_3 &= \eta \left[\left(\frac{\alpha}{r + \delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} (1-\tau_L) \right]^{1/\eta} \\
\kappa_1 &= r + \lambda - \frac{\mu}{\eta} - \frac{\sigma^2}{2}\frac{1}{\eta}\left(\frac{1}{\eta} - 1\right) \\
\kappa_2 &= r + \lambda - \frac{\mu}{\eta - \gamma} - \frac{\sigma^2}{2}\left(\frac{1}{\eta-\gamma}\right)\left(\frac{1}{\eta-\gamma} - 1\right)
\end{aligned}$$

and ξ_1, ξ_2 are the roots of the fundamental quadratic, given by

$$\xi_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}}, \quad \xi_2 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}}, \tag{12}$$

with $\xi_1 > 1$ and $\xi_2 < 0$. The coefficients B_1, B_2, C_1, C_2, D_2 are determined by the boundary conditions.

A derivation is provided in Appendix A.2.

3.4. Special case: no tax avoidance

To evaluate the effects of tax avoidance, we also consider a special case of the model where firms are not able to engage in any tax avoidance. This can be thought of the case where the costs of avoidance become infinitely large: $b \to \infty$. In this "no avoidance" case, firms face a single, constant tax rate, τ_{NA}, on their operating income and there is no longer a choice of $h_{i,t}$. In the no avoidance case, the firm's profits are given by

$$\pi^{NA}(z_{i,t}; w^{NA}) = \max_{k_{i,t}, \ell_{i,t}} \left\{ (1 - \tau^{NA}) y_{i,t} - \delta k_{i,t} - w^{NA} \ell_{i,t}) - r k_{i,t} - c_f \right\}. \tag{13}$$

As before, the firm chooses capital, labor, and an optimal stopping time to exit to maximize its expected discounted cash flows:

$$v(z_{i,t}; w^{NA}) = \sup_{\mathcal{T}_D} \ \mathbb{E} \left[\int_t^{\mathcal{T}_D} e^{-(r+\lambda)s} \pi^{NA}(z_{i,s}; w^{NA}) ds \, \middle| \, z_{i,t} \right]. \tag{14}$$

In general, the equilibrium wage rate and firm policies will differ in the no avoidance case relative to the baseline model in which firms are able to avoid taxes. In the analyses that follow, we compare the firm's policies as well as equilibrium outcomes between these two cases to illustrate the effects of tax avoidance.

3.5. Entry and exit

Firms can pay a one-time cost to enter the market and we assume that this cost is increasing in the flow of entrants, N_t. Specifically, we assume an entrant faces a cost of entry, $c_{E,t}$ given by

$$c_{E,t} = c_{E,0} N_t^{\theta - 1}, \tag{15}$$

where N_t is the flow of new entrants, $c_{E,0}$ is a scale parameter, and θ parameterizes the elasticity of the supply of entrants.

At entry, all firms begin with initial productivity z_0 after which their productivity evolves following the dynamics in Equation (3). Thus, the firm's entry condition is

$$v(z_0; w_t) \geq c_{E,0} N_t^{1-\theta}, \tag{16}$$

where this holds with equality in an equilibrium with positive entry. For the case of $\theta = 1$, there is a perfectly elastic supply of entrants and this collapses to a free entry condition. The flow of entrants, N_t is determined endogenously in equilibrium. Firms exit for two reasons: they are hit with an exogenous exit shock with intensity λ or their productivity falls to z_D, at which point they find it optimal to shut down.

3.6. Firm distribution

The equilibrium, defined in Section 3.9, admits a stationary firm distribution, which we now derive. Given the presence of fixed operating costs and an endogenous exit decision, the productivity of incumbent firms is over the domain (z_D, ∞). Let $\phi(z)$ denote the probability density function of firm productivity.

Proposition 2. *The stationary distribution of firm productivity is*

$$\phi(z) = \begin{cases} H_1 z^{\zeta_1 - 1} + H_2 z^{\zeta_2 - 1} & \text{if } z_D < z < z_0 \\ J_2 z^{\zeta_2 - 1} & \text{if } z > z_0, \end{cases} \tag{17}$$

where

$$\zeta_1 = \frac{\mu}{\sigma^2} - \frac{1}{2} + \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \qquad \zeta_2 = \frac{\mu}{\sigma^2} - \frac{1}{2} - \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \tag{18}$$

and the coefficients H_1, H_2, J_2 are solved by imposing the boundary conditions.

Details of the derivation are provided in Appendix A.3.

The firm distribution for productivity has a right tail that follows a Pareto distribution with parameter $\zeta_2 < 0$. The probability a firm's productivity z is above some value $\hat{z} > z_0$ is given by

$$Pr[z > \hat{z}] = \left(\frac{-J_2}{\zeta_2}\right) \hat{z}^{\zeta_2}. \tag{19}$$

Let Q_t denote the mass of operating firms, which is determined in equilibrium. In a steady state equilibrium, the mass of active firms Q_t is constant; however, individual firms are entering, exiting, and moving through the distribution according to the realization of their productivity shocks. For the mass of firms to be constant, we need the flow of new entrants, N_t, to equal the flow of exiting firms. Thus the flow of entrants, $N_t = N$, in a stationary equilibrium is given by

$$N = \lambda Q + \frac{1}{2}\sigma^2 Q \left(\zeta_1 H_1 z_D^{\zeta_1} + \zeta_2 H_2 z_D^{\zeta_2}\right). \tag{20}$$

3.7. Household

There is a representative household that consumes and supplies labor with flow utility $u(C_t, L_t)$. The household's problem is to maximize lifetime utility subject to the aggregate budget constraint:

$$\max_{C_t, L_t} \int_0^\infty e^{-\rho t} u(C_t, L_t) dt$$
$$s.t. \tag{21}$$
$$C_t + c_{E,t} N_t = w_t L_t + \Pi_t + T_t,$$

where C_t is aggregate consumption, $c_{E,t}N_t$ is the flow cost of new entrants, $w_t L_t$ is the wage bill, Π_t is the after-tax profits, and T_t is the aggregate taxes paid. The after-tax aggregate cash flows, Π_t, are net of the aggregate avoidance costs bH_t. Note that we assume that the taxes paid are rebated lump sum to the household and that the aggregate cost of tax avoidance, bH_t, is a deadweight loss.

We assume the household's utility takes the form

$$u(C_t, L_t) = \frac{C_t^{1-\nu}}{1-\nu} - \psi \frac{L_t^{1+\chi}}{1+\chi}, \tag{22}$$

where ν is the degree of risk aversion, ψ is the preference for leisure, and χ is the inverse Frisch elasticity of labor supply. The household's first order condition determine the aggregate labor supply in equilibrium:

$$\frac{-u_L(C_t, L_t)}{u_C(C_t, L_t)} = w_t. \tag{23}$$

3.8. Aggregates

Given the optimal firm policies, the stationary distribution of firm productivity, and the mass of operating firms, we can now construct aggregates in the model. We use capital letters to denote aggregate values. We define aggregate output (Y), capital (K), labor (L), tax avoidance (H), cash flow (Π), firm value (V), and consumption as

$$Y = Q\int_{z_D}^{\infty} y(z;w)\phi(z)dz \tag{24}$$

$$K = Q\int_{z_D}^{\infty} k(z;w)\phi(z)dz \tag{25}$$

$$L = Q\int_{z_D}^{\infty} \ell(z;w)\phi(z)dz \tag{26}$$

$$H = Q\int_{z_D}^{\infty} h(z;w)\phi(z)dz \tag{27}$$

$$\Pi = Q\int_{z_D}^{\infty} \pi(z;w)\phi(z)dz \tag{28}$$

$$V = Q\int_{z_D}^{\infty} v(z;w)\phi(z)dz \tag{29}$$

$$C = \Pi + wL + T - c_E N \tag{30}$$

Given that the stationary distribution function, $\phi(z)$, is a probability density function that integrates to one (i.e., $\int_{z_D}^{\infty}\phi(z)dz = 1$), the total mass of incumbent firms, Q, scales each of the aggregate quantities in the model. While individual firms are continuously entering, exiting, and moving through the productivity distribution due to different realizations of their individual productivity shocks, the aggregate quantities in the model are constant over time. The aggregate quantities for the case of no tax avoidance, $Y_{NA}, K_{NA}, L_{NA}, \Pi_{NA}, V_{NA}, C_{NA}$, are defined analogously.

3.9. Equilibrium

We now characterize the equilibrium in this economy. The model admits a stationary equilibrium such that the wage rate and the distribution of firms does not change over time. In a stationary equilibrium, individual firms are continuously entering, exiting, and adjusting their capital, labor, and tax avoidance in response to idiosyncratic shocks; however, the mass and distribution of firms remain constant as there are no aggregate shocks in the model. Consequently, in the stationary equilibrium all aggregate values are constant.

Definition 1. *A stationary equilibrium consists of a wage rate w, firm policy functions for capital k, labor ℓ, tax reduction h, an exit threshold z_D, a stationary distribution $\phi(z)$, a flow of entrants N, and a mass of incumbent firms Q, such that* *i. Firm policies, k, ℓ, h, and z_D solve the firm's problem given in Equation* (9)

ii. The entry condition in Equation (16) *holds*

iii. The labor market clears

iv. The distribution $\phi(z)$ is stationary with support $[z_D, \infty)$.

The firm's entry condition in Equation (16) and the household's first order condition for labor supply jointly determine the equilibrium wage, w, and aggregate labor L. Equivalently, because aggregate labor scales with the mass of firms, Q, this amounts to jointly solving for the equilibrium wage and mass of firms in a steady state equilibrium given by the following two equations:

$$w = \psi L^{\chi} C^{\nu} \tag{31}$$

$$v(z_0; w) = c_{E,0} N^{\theta-1}. \tag{32}$$

In the no avoidance case, the equilibrium is defined similarly. The difference is that firms do not choose a tax avoidance policy (h). As a result, firms' effective tax rates and their optimal policies for capital, labor, entry, and exit are different as well. This results in a different equilibrium mass of firms and wage compared to the baseline model with tax avoidance.

3.10. Firm policies

We now illustrate firm policies from the model with a focus on how tax avoidance affects these policies. We use the parameter values from the estimation, which is discussed in Section 4. The firm and time subscripts are henceforth suppressed for brevity.

In Panel A of Figure 2, we plot a firm's optimal choice of capital, k, as a function of its productivity, z. Similarly, Panels B and C show the cash flow and firm value plotted against the current level of productivity. In all three panels, the solid blue line shows the optimal policy in the baseline model with tax avoidance and the dashed red line shows the optimal policy in the no avoidance version of the model. In all cases we fix the wage to be a constant value when comparing the baseline and no avoidance model policies. Our goal is to show how firm policies vary with firm productivity and how these differ in the presence of tax avoidance. A firm's choice of capital, labor, and output are all increasing in the firm's productivity and are higher in the case with tax avoidance. That is, holding fixed the wage and a firm's level of productivity, tax avoidance leads firms to optimally choose higher levels of capital and labor, which corresponds to higher levels of output, cash flow, and valuation.

In Figure 3 we show how a firm's taxes and its optimal choice of tax avoidance vary with productivity. Again, we compare the baseline case with tax avoidance (solid blue line) to the case of no tax avoidance (dashed red line). Panel A of Figure 3 plots a firm's optimal tax avoidance expense, $b \times h$, as a function of its productivity. As productivity increases, a firm optimally spends more on avoiding taxes. Eventually, the avoidance expenditure becomes flat in productivity when $z > z_H$ and the firm has reached the minimum effective tax rate it can attain.

In Panels B and C of Figure 3, we plot a firm's taxes paid and effective tax rate as a function of its productivity. Panel B of Figure 3 shows that the amount of taxes paid is increasing in a firm's productivity, but at a lower rate for the case in which a firm can avoid taxes. For any level of productivity, a firm pays lower taxes in the baseline case than what it would pay in the case with no avoidance.

In Panel D of Figure 3, we plot the firm's effective tax rate as a function of its productivity. With no tax avoidance, the effective tax rate is constant and does not change with firm productivity. In the model with avoidance, the effective tax rate is an endogenous outcome of the firm's policies, both for avoidance as well as capital and labor. For a firm with productivity z facing wage rate w, its effective tax rate is computed as

$$ETR(z; w) = \frac{\tau^* y - \tau_0(\delta k + w\ell)}{y - \delta k - w\ell}. \tag{33}$$

As shown by Equation (33), a firm's effective tax rate is endogenously determined in the model and varies with the level of productivity, the wage rate, as well as other model parameters. With tax avoidance, we see that the effective tax rate is declining in firm productivity. For a sufficiently high level of productivity, $z > z_H$, the firm's effective tax rate is constant as it has attained the minimum possible tax rate.

In Figure 4, we plot measures of firm productivity on the level of shock z. As before, we compare the firm policies in the baseline model with avoidance (solid blue line) to the policies in the no avoidance case (dashed red line). In Panels A and B we plot the marginal product of capital and labor on the level of the shock z. In the no avoidance case, the level of marginal products are constant in the shock z. When firms can avoid taxes in the baseline model, the marginal products are declining in z up to z_H. For values of $z > z_H$, the marginal products become flat again. In the right column of Figure 3, Panels C and D show that firms produce less output per unit of capital and have higher average costs as a function of productivity in the baseline model compared to the case with no avoidance.

4. Model estimation

In this section we present the estimation of the model. We first discuss the predefined parameters that are set outside of our estimation. We then explain the identification of the parameters estimated in the model. Finally, we present the results of the model estimation.

4.1. Predefined parameters

We partition the vector of model parameters into a subset that is predefined (α, β, r, δ, z_0, $c_{E,0}$, ν, ψ, χ) and a subset that is estimated in the model (μ, σ, λ, c_f, b, γ, τ_0, τ_L^{ETR}). The predefined parameters and their values are displayed in Panel A of Table 2.

We set the capital and labor returns to scale parameters, α and β, to 0.44 and 0.22, respectively. This gives $\alpha + \beta = 0.66$, a value consistent with the investment literature (Cooper and Ejarque, 2001; Cooper and Haltiwanger, 2006). We set $r = 0.05$ and $\delta = 0.10$. We normalize the initial level of firm productivity, $z_0 = 1$, and entry cost parameter, $c_{E,0} = 1$. Gutiérrez et al. (2019) estimate entry elasticities by industry. We set $\theta = 1.55$, which is their median estimate. We set the household preference parameters to be consistent with macro models in the literature. We choose risk aversion of $\nu = 2$. We set $\psi = 1$ and choose $\chi = 1.33$, which implies a Frisch elasticity of labor supply of 0.75, consistent with the range of estimates in Chetty et al. (2011).

4.2. Identification and choice of moments

We use the generalized method of moments (GMM) to estimate the remaining parameters in the model. In total, we use 17 moments to estimate eight model parameters. In general, there is not a one-to-one mapping between a model parameter and moment. For example, the tax avoidance parameters b and γ, affect not only ETRs but also "non-tax" moments such as the mean and volatility of earnings growth (see Appendix B.2). We discuss below which moments are most informative for each parameter. In Appendix B.2 we provide details on how the moments are computed in the model.

The first two moments, the mean and volatility of earnings growth, are primarily informative for identifying the mean and volatility of productivity growth (μ and σ), respectively. Intuitively, a higher mean or volatility of productivity growth corresponds to a higher growth and volatility of cash flows. The third moment is the Pareto tail coefficient from the right tail of the firm size distribution. As discussed in Section 3.6, the right tail of the firm productivity distribution has a Pareto tail. Given values for α and β, the Pareto tail coefficient for firm size is a function of μ, σ, λ.

We use the exit rate primarily to identify the fixed cost parameter, c_f. In the model, firms exit for two reasons: they are hit with an exit shock with intensity λ or their productivity falls to z_D such that they find it optimal to cease operations and exit. Thus, the total exit rate depends on the λ parameter as well as the flow of firms hitting the endogenous exit threshold z_D. The rate of firms hitting z_D in turn depends on the size of the fixed costs of operation, c_f. For a higher fixed cost c_f, a firm optimally chooses a higher exit threshold z_D. Thus, the exit rate is increasing in c_f.

The remaining moments are effective tax rates, used to identify the tax avoidance parameters in the model. We use the aggregate ETR, the mean ETR across all firms, and the mean ETR conditional on size for the ten size deciles and the largest size percentile. These moments help to identify the four tax parameters in the model: $\tau_0, \tau_L^{ETR}, b, \gamma$. Given the empirical pattern of ETRs declining in size, the ETRs in the smallest size deciles are most informative for τ_0, the tax rate faced when a firm engages in no avoidance (i.e., $h = 0$). Similarly, the ETR of the 99th size percentile is especially informative for identifying τ_L^{ETR}, which is the minimum attainable ETR. Finally, the cost of avoidance, b, and the returns to scale of the avoidance technology, γ, determine the relationship between firm size and ETR in the model. Thus, the average ETR for each of the ten size deciles are used to identify the tax avoidance parameters b and γ.

4.3. Estimation results

In Table 2, Panel B, we present the estimates and standard errors for the eight parameters from the GMM estimation of the model. The standard errors are computed using a two-way clustered covariance matrix where we cluster by firm and year. To estimate the covariance matrix, we use the influence function approach of Erickson and Whited (2002). See Appendix B for details on the estimation.

We estimate the drift and volatility of the productivity process, as -0.005 and 0.106, respectively. The estimated value for λ of 0.048 implies a 4.8% annual probability of an exit shock. The estimate for the fixed operating cost, c_f, is 0.03. We estimate τ_0 of 0.415, implying a firm faces a maximum tax rate of 41.5%. This value is consistent with the average combined federal and state tax rate in the US during our sample period (1988–2017).[14] We estimate τ_L^{ETR}, the minimum attainable ETR, to be 0.269. Thus, firms in our model can choose ETRs that range between 26.9% and 41.5%. The statutory and minimum tax rates are directly informed by observed tax rates, but the returns to scale (γ) and unit cost (b) of tax avoidance parameters must be chosen to match the shape of the ETR function as a function of size. While the magnitudes of γ and b are difficult to interpret, the empirical identification strategy is straightforward. We estimate γ, the returns to scale on tax avoidance, to be 0.03. The curvature parameter is chosen to match the observed decline in ETRs across nearly the entire distribution of firms. A high γ would imply nearly all firms would engage in either zero or maximum avoidance. In contrast, a low γ would result in a zero mass of firms at either the statutory or minimum tax rate. The marginal cost parameter, b, is estimated as 7×10^4. This parameter allows the model to match the observed mass of firms paying taxes

[14]For most of our sample, the top federal corporate tax rate was 35%. In addition, the top statutory corporate income tax rate averaged 6.8% at the state level (this average excludes Nevada, Ohio, Texas, and Washington which impose a gross receipts tax in lieu of a corporate income tax) in 2017 (Scarboro, 2017). Combined, this implies roughly a 41.8% statutory rate.

at or near the statutory rate. A lower (higher) value for b would imply counterfactually low (high) ETRs for smaller (larger) firms.

In Table III, we report the empirical moments alongside the corresponding model moments from the estimation. The last column of the table reports a t-statistic for the difference between the model and data moment. In general, the model does a good job of matching the moments targeted in the estimation. The model closely matches the empirical values for the volatility of earnings growth, the Pareto tail coefficient for firm size, and the exit rate. The model estimate for the earnings growth drift is smaller than the mean growth rate we estimate in the data (0.024 vs. 0.029).

In the data, we see a significant difference between the mean firm ETR (0.351) and the aggregate ETR (0.285). While the model matches the mean firm ETR (0.351), the estimated aggregate ETR of 0.302 is slightly higher than the empirical value. Thus, while the estimated model produces an economically significant gap between the firm average and aggregate ETRs, this gap is somewhat smaller than the gap in the data (4.9 *p.p.* vs. 6.6 *p.p.*). For some moments the t-statistic indicates a statistical difference between the model and data. However, in economic terms the estimated model produces a close fit to the targeted empirical moments.

An important goal of our estimation is to match the cross-sectional relationship between firm size and ETRs. In Figure 5, we plot the ETRs by size bin for both the estimated model (blue circles) and data (red crosses). The figure shows the average ETR for each of the 10 size deciles as well as the largest size percentile. The model hits the mean ETR for the largest size percentile, but misses somewhat on matching the 9th and 10th decile ETRs. Overall, we see that the estimated model generally does a good job of capturing the cross-sectional relationship between size and ETR that we document in the data.

4.4. The effects of tax avoidance

We evaluate the equilibrium effect of tax avoidance on firm and aggregate outcomes by comparing outcomes under the estimated baseline model to the model where tax avoidance has been shut down (the *no avoidance*, or *NA* case). The no avoidance equilibrium eliminates tax avoidance ($b = \infty$), meaning all firms face the statutory rate τ_0. All other model parameters are held at their values from the estimated baseline model. Section 3.4 describes the firm's problem in the case of no tax avoidance. We re-solve for the equilibrium in the no avoidance case. In what follows, we present the effects of tax avoidance on various model outcomes.

In Table IV we show the effect of tax avoidance, relative to the no avoidance case, on aggregate and firm average quantities. We report the percentage increase for a model quantity in the baseline (with avoidance) model relative to the no avoidance model. The left panel reports aggregates and the right panel reports firm averages.

Table IV shows that the model with tax avoidance results in much lower taxes paid and effective tax rates compared to the no avoidance model. Avoidance results in a 31.1% decline in the total taxes paid, with the average firm paying 31.2% less in taxes. The average firm's ETR declines 6.4 percentage points with avoidance, while the aggregate ETR declines 11.3 percentage points. This larger increase for the aggregate comes from the fact that larger firms optimally engage in more avoidance and consequently face lower ETRs. While tax avoidance results in a reduction in the effective tax rate firms face, it is fundamentally different from a simple cut in the tax rate. We compare tax avoidance and a tax rate cut in Section 4.5.

Tax avoidance also affects the equilibrium outcomes and firm policies in the model. With avoidance, the equilibrium wage is 8.8% higher. As shown in Panel C of Figure 2, for a given wage and level of productivity, a firm has a higher value in the case with avoidance. Consequently, the equilibrium market-clearing wage is higher in the case where firms are able to engage in tax avoidance.

Turning to firm policies, tax avoidance has two effects in equilibrium. First, it allows firms to reduce their tax rate (for a cost), which leads to higher output and valuations. This effect is heterogeneous across firms as larger firms find it optimal to spend more on avoidance and thus face lower tax rates. The second effect is an increase in the equilibrium wage, which leads to lower output and valuations. This change in the equilibrium wage is common across firms and the magnitude is determined by the market clearing conditions. Taken together, the effects of tax avoidance are heterogeneous across firms.

In Panel B of Table IV, we see that tax avoidance results in higher average firm value, output, capital, labor, and profit. In equilibrium, the average firm value and output increase by 12.9% and 4.6%, respectively, with avoidance. The increase in these aggregate quantities is slightly larger than the average because the equilibrium mass of active firms (Q) increases slightly by 0.2% with tax avoidance. For all of the aggregate quantity changes, these can be expressed as the product of the change in the firm average and the change in the mass of firms.

Next, we turn to the effects of tax avoidance on profitability and productivity. In Panel A of Table IV, we report the effects on the aggregate gross (pre-tax) profit margin, defined as

$$\frac{Y - wL - (\delta + r)K}{Y}, \tag{34}$$

as well the aggregate net (after-tax) profit margin, defined as

$$\frac{\Pi}{Y}, \tag{35}$$

where the capital letters refer to aggregate variables. We see that tax avoidance has opposite effects on the aggregate gross and net profit margins. The aggregate gross (pre-tax) profit margin decreases by 4.8 percentage points with tax avoidance, while the aggregate net (after-tax) profit margin increases by 0.7 percentage points. In the case with tax avoidance, firms scale up, which reduces their gross profit margin due to decreasing returns to scale. However, tax avoidance also increases after-tax profits such that the aggregate after-tax profit margin is higher in the presence of tax avoidance.

To further investigate the effects of avoidance on allocation and productivity, we compute total factor productivity (TFP). At the firm level, we define TFP

$$TFP = \frac{y}{(k^{\alpha}\ell^{\beta})^{\frac{1}{\alpha+\beta}}}, \tag{36}$$

We also compute an aggregate measures of TFP, which is defined analogously with the aggregate values for output, capital, and labor. In Panel A of Table IV, we see that aggregate TFP decreases by 1.8% with tax avoidance. Panel B shows that with tax avoidance the firm average TFP actually increases by 1.3%.

In order to understand why tax avoidance leads to lower aggregate productivity, Figure 6 plots the cumulative distribution of firm-level TFP. For a firm facing a tax rate τ^* and wage w, and choosing optimal capital, labor, and output, Eq. (36) becomes

$$TFP(w) = \frac{A(w)}{(1-\tau^*)}, \tag{37}$$

where $A(w)$ is a constant that depends only on the model parameters and equilibrium wage.[15] In the case with no avoidance, τ^* is simply the statutory rate (τ_0) and all firms have the same TFP independent of the firm's productivity z. This degenerate distribution in the no avoidance case is shown by the vertical dashed line in Figure 6. In contrast, in the baseline model with tax avoidance, the firm's tax rate τ^* depends on its choice of tax avoidance (i.e. τ^* is a function of z and w). As higher z firms choose a lower τ^*, a firm's TFP is monotonically decreasing in z. At the optimally chosen tax rate, the above quantity becomes

$$TFP(z;w) = \frac{\tilde{A}(w)}{z^{\frac{\gamma}{\eta-\gamma}}} \tag{38}$$

in the interior region of tax avoidance (i.e., $z_\ell \leq z \leq z_h$), where $\tilde{A}(w)$ is a constant that depends only on the model parameters and equilibrium wage w and recall $\eta \equiv 1-\alpha-\beta$.[16] Equation (38) shows that with tax avoidance firm-level TFP is decreasing in z.The distribution of TFP in the baseline model is shown by the solid line. With avoidance, the distribution is not degenerate because firms choose heterogeneous tax rates. In particular, higher z firms engage in more tax avoidance, face a lower tax rate, and in turn choose a higher scale of production. Because the firm faces decreasing returns to scale, this higher scale results in lower TFP.

The distribution of TFP in the baseline model in Figure 6 reveals that firms may have higher or lower TFP relative to the no avoidance case. This is because tax avoidance increases the equilibrium wage relative to the no avoidance case. To understand the effect of a higher wage on TFP, consider a firm from the no avoidance distribution (dashed line) and a firm from the right-most mass of the baseline. These firms face the same effective tax rate (equal to the statutory rate), but the firm from the baseline faces a higher wage. This means it will choose a lower scale, which corresponds to a higher TFP.

Table IV shows that the firm average TFP is 1.3% higher with tax avoidance, while aggregate TFP is 1.8% lower. This is because TFP is monotonically decreasing in z, as firms

[15] See Appendix A.1 for the optimal levels of k, ℓ, and y.

[16] This follows from Eq. (37) where the optimal tax rate τ^* is given in Eq. (A-6).

with higher z choose higher tax avoidance which in turn leads to lower TFP (see Eq. 38). Thus, a disproportionate amount of output is being produced by firms in the left end of the firm distribution in Figure 6.

In summary, we find that tax avoidance leads to lower aggregate total factor productivity. Tax avoidance lowers effective tax rates for higher z firms, which encourages investment and production. With decreasing returns to scale, this results in lower TFP. That said, we have not addressed whether tax avoidance leads to capital and labor "misallocation" in the sense that it has negative effects on welfare: while TFP and tax revenue are lower with tax avoidance, firms benefit from higher profits and the household benefits from higher wages and output. We discuss allocative efficiency and the aggregate effects on welfare in Section 4.4.2.

4.4.1. Size distribution and concentration

While the average firm size is significantly larger due to tax avoidance, most of this increase in the average is due to growth in the largest firms. Panel A of Table V reports the percent increase in the percentiles of four measures of size due to tax avoidance. We see that firms from the left half of the distribution are similar in size; however, in the right tail the firm size is significantly larger. For example, at the 95th percentile firms have a 13.7% higher valuation and 19.0% more capital because of tax avoidance. This is because the incentives to invest and produce coming from tax avoidance are increasing in size.

Panel B of Table V shows that the effect on the size distribution coming from tax avoidance also has implications for concentration. We see that tax avoidance leads to increased concentration. For example, the share of revenue from the top 10% of firms increases by 3.5% due to tax avoidance. The effect on capital is even greater, with the top 10% increasing their share of capital by 5.4%. As expected, tax avoidance has the opposite effect on the concentration of taxes paid, with the top 10% reducing their share of taxes by 10.0%. In addition, the top 10% account for 38.4% of the direct costs of tax avoidance (TAC).

Our results indicate that tax avoidance has the potential to contribute to an increase in firm concentration. Indeed, a substantial increase in concentration over the last three decades (Grullon, Larkin, and Michaely, 2019) has coincided with a decline in effective tax rates (Dyreng, Hanlon, Maydew, and Thornock, 2017). While our model does not feature imperfect competition, our results indicate that tax avoidance may exacerbate concentration and should be considered when addressing concerns of increasing market power.

4.4.2. Welfare

To evaluate the welfare consequences of tax avoidance, we consider the three parties affected by tax policy in our model: firm owners, workers, and taxpayers (or more precisely, the beneficiaries of tax revenue). Table VI reports the equilibrium effects of tax avoidance on these three groups as a percent change relative to the equilibrium in an economy with no avoidance. Aggregate firm profits, before entry costs, are 9.9% higher because of tax avoidance. In addition, aggregate entry costs increase by 3.5%. Firm owners are better off with avoidance and the largest firms benefit disproportionately. As firms pay a lower tax rate, aggregate tax revenue declines by 31.1%.

As we saw in Table IV, tax avoidance leads to higher output and wages, both positive outcomes for the household. Aggregate consumption is 1.8% higher with avoidance. While consumption is higher, welfare is actually lower in the economy with tax avoidance. To compare the welfare between the two economies, we calculate a certainty equivalent change in consumption. In particular, we ask how much would consumption in the NA economy have to change in order to deliver the same level of utility as the baseline economy with avoidance? We find that the decline in welfare in the baseline economy with avoidance, relative to the no avoidance economy, is equivalent to a 0.55% reduction in aggregate consumption.

There are two channels through which tax avoidance leads to a decline in surplus: the deadweight cost of avoidance ($b \times H$), and inefficient allocation of capital and labor caused by distortionary tax policy. It is critical to note that the negative effect of tax avoidance on welfare is relative to a system where all firms face the statutory rate, a much higher rate than the aggregate effective rate in the baseline. We will see in Section 4.5 that tax avoidance results in significantly lower welfare than a tax revenue neutral tax system in which all firms face the same tax rate.

4.5. *Tax avoidance versus a tax cut*

We saw that tax avoidance results in an equilibrium with larger firms, higher output and concentration, and a higher wage. It also causes a misallocation of capital and labor. However, the degree of misallocation, on the surface, appears small. In this section, we will see that the negative allocative consequences of tax avoidance are obscured by the implicit tax cut resulting from tax avoidance. Lower tax rates improve allocation. Separately, tax avoidance generates effective tax rates declining in size that leads to reduced allocative efficiency. The net allocative effects caused by tax avoidance is a combination of these competing effects.

We disentangle the effects of a tax cut and heterogeneous tax rates induced by tax avoidance in Table VII. The first column summarizes the effects of tax avoidance as presented in Tables IV–VI, that is, comparing the baseline outcome to that of the no avoidance case in which all firms face the baseline statutory rate ($\tau_0 = 0.415$). The second column reports the effect of a simple tax cut in a counterfactual world without tax avoidance (*no avoidance tax cut*): the tax rate is reduced to 25.3%, the level at which tax revenue is equivalent to the baseline model. In other words, tax avoidance reduces aggregate taxes paid by 31.1%, while inducing heterogeneous tax rates across firms (first column); lowering the statutory tax rate to 25.3%, in a world without tax avoidance, reduces aggregate taxes paid by the same amount and all firms face the same tax rate (second column).

We see that the no avoidance tax cut in the second column has large effects on firm and aggregate outcomes. First, it results in a much larger increase in the equilibrium wage (17.7%) than in the case of tax avoidance (8.8%), corresponding to much higher output. Aggregate firm value, output, capital, and profits increase in both columns. However, the no avoidance tax cut results in much larger increases. For example, aggregate firm output increases by 16.4% with the tax cut compared to only 4.8% with avoidance.

The first column of Table VII shows that tax avoidance results in a slight increase of 2.2% in the flow of new entrants, whereas the no avoidance tax cut results in a large increase in the entry flow of 32.6%. Avoidance results in approximately the same total mass of firms but larger average size. With decreasing returns to scale, aggregate TFP improves with a no avoidance tax cut.

We saw in Table V that tax avoidance results in an increase in average firm size as well as concentration. The share of firm value, output, and profits captured by the largest firms increases with avoidance. In contrast, the second column of Table VII shows that the top 1% share of profits decreases slightly with a no avoidance tax cut.

Finally, we see significant positive effects on welfare from the no avoidance tax cut, reported in Table VII. Both firm profits and consumption increase substantially more with a no avoidance tax cut than with tax avoidance, while the change in tax revenue has been equated by construction. The larger increase in consumption is a result of the larger increase in the wage and larger increase in output. In the second column, aggregate firm profits increase both because the number of firms increases and the average firm profits are higher. In contrast, the increase in aggregate firm profits with tax avoidance are driven essentially entirely by higher profits per firm as the total number of firms is nearly unchanged (0.2% increase).

Taken together, the no avoidance tax cut significantly increases welfare, amounting to a 10% increase in certainty equivalent consumption. These gains come from improved allocative efficiency, as shown by the higher aggregate TFP.[17] In contrast, with tax avoidance, the implicit tax cut is squandered because it mostly benefits larger firms rather than the smaller firms that determine the wage through competitive entry. Because small firms still face high tax rates, they are deterred from entering, keeping wages low and encouraging large firms to produce at an inefficiently high scale. Equivalently, a system of tax avoidance can be thought of as a policy that imposes a higher tax on small firms, which disincentivizes new firms from entering, in turn reducing competition and reducing wages.

In the third column of Table VII, we repeat the exercise of a no avoidance tax cut but choose the new statutory tax rate such that the firm average ETR matches the firm average ETR in the baseline model with avoidance (as opposed to matching aggregate tax revenue as in the second column). In other words, the firm average ETR in the first and third columns both decline by 6.4 percentage points. Qualitatively, columns two and three as similar, with

[17] Gourio and Miao (2010) show a similar increase in TFP in response to a dividend tax cut. Kaymak and Schott (2019) show that tax loss provisions distort allocation and lower TFP.

the effects larger in the second column corresponding to a larger aggregate tax cut.

In summary, tax avoidance results in both an implicit tax cut and effective tax rates that are declining in size. The former improves allocation, while the latter worsens it. We have seen that each of these competing effects has significant effects on firm and aggregate outcomes. In our baseline, we find that these two competing effects roughly cancel out with respect to allocative efficiency, while also increasing average firm size and concentration.

5. Policy Experiments

In this section we evaluate outcomes of three types of policy experiments. In the first set of experiments, we consider a policy change that eliminates tax avoidance such that all firms face the same tax rate. In the second, we consider the effect of varying the difficulty with which firms are able to lower their tax rate. We show the effects of both an increase and decrease in the cost of avoidance parameter, b, in the model. In the third, we evaluate the effect of a change in the statutory rate while still allowing firms to engage in avoidance.

5.1. Eliminating tax avoidance

The first policy experiment we consider is the elimination of tax avoidance, i.e. that all firms must pay the same effective tax rate on their pretax earnings. These counterfactuals are presented in Table VIII. The first column reports the percent change in various firm and aggregate variables when tax avoidance is eliminated but all other parameters, including the statutory tax rate, remain unchanged. This is simply the inverse of the effect of tax avoidance discussed in Section 4.4. In the second and third columns, we eliminate tax avoidance and cut the statutory tax rate such that aggregate tax revenue, or firm average ETR, is unchanged.

The economic mechanisms and qualitative outcomes in Table VIII are the same as discussed in Sections 4.4 and 4.5 and so we will not repeat them here. In summary, eliminating tax avoidance while simultaneously lowering tax rates to maintain revenue results in more entry, increasing aggregate output, profits, TFP, allocative efficiency, and consumption, while simultaneously reducing the average firm size and concentration.

5.2. *Varying the cost of tax avoidance*

The tax code provides countless opportunities for firms to reduce their effective tax rate, and these opportunities vary in their cost and difficulty. For example, claiming an investment tax credit may be relatively easy while restructuring operations to move into low tax jurisdictions may be quite costly. Policies which change the firm's cost of engaging in tax avoidance are captured in the model by the avoidance cost parameter b.

Table IX reports the change in the equilibrium outcomes if these costs are decreased (column 1) or increased (column 2). The changes in the avoidance cost parameter b are chosen such the aggregate effective tax rate decreases or increases by 1 percentage point. The table reports the percent increase in each quantity under the new policy relative to the estimated model. To help interpret these results, Figure 7 plots various average and aggregate outcomes as a function of b.

The first observation is that the aggregate effective tax rate is relatively inelastic with respect to b: a one percentage point increase (decrease) in the aggregate ETR requires an increase (decrease) of 44.7% (33.4%) in b. This is in part because the aggregate ETR depends heavily on the larger firms that continue to maximize tax avoidance in either scenario. Indeed, the changes in firm average ETR (-5.3% and 4.6%) are much larger in magnitude than the one percentage point change in aggregate ETR. As expected, Panels A and B of Figure 7 show that aggregate and average taxes paid, and aggregate and average ETRs, are strictly increasing in b: as tax avoidance becomes more costly, more taxes are collected.

Interestingly, aggregate spending on tax avoidance ($b \times H$) is non-monotonic, shown in Panel C of Figure 7. The increased use of tax avoidance for low b is a result of the floor on ETRs. When $b = 0$, all firms choose the maximum tax avoidance, $\bar{h}$, and the aggregate tax avoidance expense is zero. As b becomes positive, some firms begin to choose $h < \bar{h}$, lowering aggregate avoidance H, but the aggregate avoidance expense becomes positive and therefore increases. As the unit cost b becomes sufficiently high, enough firms choose $h < \bar{h}$ such that aggregate $b \times H$ begins to decline: this declining region is the typical response to rising unit costs, as firms choose less of the input. This non-monotonicity in aggregate tax avoidance costs is apparent in Table IX as it shows a decline in these costs for both a decrease and increase in b.

When the unit cost of tax avoidance is lowered (column 1 of Table IX), some of the negative effects of tax avoidance discussed in Section 4.4 are mitigated. In particular, the flow on entrants increases, increasing the wage. Aggregate output and firm value increase, but the average firm is smaller and produces less. This is because with a lower cost of tax avoidance, lower effective tax rates become more accessible to smaller firms, incentivizing competitive entry. In turn, allocative efficiency and aggregate TFP improve, and concentration goes down. Aggregate consumption increases by 0.7%. The effect of b on firm value, value share, and consumption can also be seen in Panels D, E, and F of Figure 7. Consumption increases as the gap between small and large firms diminishes, as well as lower average effective tax rates. This reveals that one way to remove the negative effects of tax avoidance is by making it more accessible to small firms; in essence, as b declines, tax avoidance becomes more like a simple tax cut.

In contrast, when the unit cost of tax avoidance is increased (column 2 of Table IX), the negative effects of tax avoidance are exacerbated. Higher b negatively affects small firms the most, and the ETR of these firms increases disproportionately. This, in turn, reduces competitive entry and pushes down the equilibrium wage. Concentration increases with an increase in b and consumption decreases. All together, consumption and aggregate TFP decline as the competitive advantage of large firms is increased. Panels F, G, H, and I show that aggregate consumption, the mass of firms, the wage, and aggregate TFP all decrease as the cost of avoidance increases. Increasing the cost of avoidance can provide an even greater relative advantage to the largest firms, resulting in less efficient allocations and lower consumption.

These results should signal caution for policymakers who attempt to remedy the negative consequences of tax avoidance by closing heavily exploited "loopholes" and by generally making tax avoidance more difficult to achieve. Paradoxically, these actions may have the unintended effect of exacerbating the inequality of tax avoidance, further benefiting large firms at the expense of productive efficiency, competitive entry, and welfare. Indeed, our results indicate that making tax avoidance less costly to achieve improves efficiency by encouraging entry and leveling the playing field between large and small firms. Any policy that has the potential to exacerbate tax inequality across firms should be viewed with caution.

5.3. *Tax cuts in the presence of avoidance*

Policy discussion around taxation often focus on changes in the statutory tax rate. However, firm behavior and outcomes depend on the effective tax rate, and changes in the statutory rate can have ambiguous effects on the ETR. In this section, we evaluate the effect of a tax cut with and without the presence of tax avoidance.

5.3.1. *A cut in the statutory tax rate*

In the model, performing a policy experiment on a cut in the statutory tax rate requires us to take a stance on how this rate change interacts with tax avoidance. In particular, how does cutting the top rate affect the ability of a firm to reduce their effective tax rate? We consider two possibilities. The first assumption is that a cut in the statutory tax rate *truncates* the ETR function from above (lowers the maximum ETR) but leaves the minimum achievable ETR unchanged. The second assumption is that a lower statutory rate *shifts* the entire ETR function downward, such that both the maximum and minimum rates are proportionately lower. These two assumptions are shown graphically in Figure 8.[18]

We evaluate the effect of a 5 p.p. statutory tax rate cut in the case of ETR truncation and shifting in columns 2 and 3 of Table X. The columns report the percent increase in each quantity under the new policy relative to the baseline. For quantitative comparison, we also report the effect of a 5 p.p. statutory tax cut in the counterfactual world without tax avoidance, shown in column 1. We complement this table with Figure 9 in which we show the effect of a tax cut by plotting various outcomes on the new statutory tax rate τ_0. The tax cut in the no avoidance world is shown with a dotted line. The tax cut assuming truncation or shifting ETR function are shown with dashed and solid lines, respectively. We normalize all non-ETR values by the benchmark model estimated value.

[18]The effect of tax avoidance activity ($h_{i,t}$ and in turn $\tau_{i,t}$) on a firm's ETR, given in Eq. (33), depends jointly on the unit cost of tax avoidance, b, the returns to scale of tax avoidance, γ, the statutory rate τ_0, and the minimum achievable rate τ_L. To implement the truncated and shifted ETR functions shown in Figure 8, these four parameters must be chosen jointly. It is straightforward to show that, for a given truncation or shift, the set of parameter values that replicate the new ETR function is unique.

In a world without tax avoidance, all firms face the same tax rate. Therefore, the no avoidance tax cut shown in column 1 translates into a 5 p.p. decline in both the aggregate and average ETR. Qualitatively, this experiment is equivalent to the tax cuts shown in Table VIII, columns 2 and 3; Section 4.5 provides a detailed discussion of the effect of a tax cut in the no avoidance world. To summarize, aggregate firm value, profits, and output increases. The lower tax rate leads to increased increased competitive entry and a smaller average firm scale, increasing the wage and consumption. The loss in tax revenue is smaller than the gains in output, leading to an increase in consumption. As there are no deadweight costs of tax avoidance, all of the increase in surplus comes from improved TFP and allocative efficiency as the distortionary corporate tax is lowered.

In column 2, the ETR function is truncated above, lowering the maximum rate, but leaving the minimum ETR unchanged. We see that the effect of a cut in the statutory rate has only a very small effect on the effective rate: the 5 p.p. statutory cut translates into only a 0.1 p.p. reduction in the aggregate ETR. This is because the new lower statutory rate disproportionately affects the smallest firms that produce only a small fraction of total output. Similarly, the tax cut results in only a 0.7 p.p. decline in the average ETR, as most of the mass of firms are unaffected by the lower tax rate. The low elasticity of aggregate and mean ETR with respect to the statutory rate can also be seen in Panels A and B of Figure 9 (dashed lines). In addition, the deadweight costs of tax avoidance decline substantially as a result of the tax cut, as smaller firms now automatically receive the lower rate without any cost.

Despite little effect on the aggregate and average ETR, this tax cut targets the smallest firms leading to competitive entry increasing by 7.1%. Put another way, this tax cut compresses the spread in rates between small and large firms, reducing the competitive advantage that tax avoidance affords to large firms. In effect, this modest cut in the effective tax rate has significant and positive effects on allocative efficiency and consumption, similar to those achieved by the much larger effective tax cut in the no avoidance case shown in column 1. This compression between large and small can also be seen by in the reduction in the concentration of profits and the value of the top 1% of firms. As the average firm scales down production, with capital 6% lower under the lower tax rate, TFP improves by

2.4% on average and 2.8% in aggregate. The effect of lowering the statutory rate on average firm value, concentration, and allocative efficiency can also be seen in Panels C, D, and E of Figure 9.

Interestingly, the statutory tax cut leads to a 5.8% *increase* in tax revenue. Aggregate ETR is virtually unchanged, but improved allocative efficiency spurred by increased competitive entry leads to a substantial increase in production and taxable income. Notably, in this case, a tax cut makes firms, households, and taxpayers all better off. While this result suggests that certain tax cuts may increase tax revenue—that we may be on the decreasing portion of a Laffer curve, as shown with the dashed line in Panel F of Figure 9—it is important to caveat that tax rates would need to be lowered only for the smallest firms, without lowering the rates on the largest. We consider the alternative case next.

Column 3 considers the same 5 p.p. statutory rate cut but under the assumption that the ETR function is shifted down proportionately, allowing firms to achieve new minimum rates. In this case, the reduction in the aggregate ETR is larger at 1.6 p.p. but it is still far less than the statutory cut. The effect on output, the equilibrium wage, and consumption is similar to the truncation case in Columns 2, but still much more modest than the tax cut without tax avoidance shown in Column 1. The policy change increases entry and reduces the average firm size, but to a somewhat lesser extent than in column 2. In general, the shifting of the ETR function makes taxes collected more sensitive to statutory tax rate changes but does somewhat less to reduce the allocative inefficiency generated by tax avoidance and the gap between small and large firms, as large firms also benefit from a lower tax rate. This can be seen by the fact that concentration declines in firm profit are less in Column 3 than Column 2, the the top 1% share of profit actually increasing in Column 3. In turn, surplus increases by 0.38% versus 0.46% in the case with ETR truncation. Notably, we are no longer on a declining portion of the Laffer curve (solid line in Panel F of Figure 9): taxes paid decline by 0.1%, versus a 5.8% *increase* with truncation.

5.3.2. The Tax Cuts and Jobs Act

At the end of 2017, the Tax Cuts and Jobs Act (TCJA) was enacted, representing the most significant corporate tax legislation in three decades. One of the key provisions was the lowering of the federal corporate income tax rate by 14 p.p., from 35% to 21%. In the final column of Table X, we use the model to evaluate the effect of this statutory rate cut. We assume that the change did not eliminate tax avoidance, instead that it proportionately shifted the achievable tax rates as shown in Panel B of Figure 8.[19]

We find that the model predicts that this 14 p.p. cut in the statutory rate leads to a decline in the aggregate and average ETR of 6.4 and 7.8%. This model-implied response in effective tax rates is closely in line with empirical estimates of the realized decline: Dyreng, Gaertner, Hoopes, and Vernon (2020) estimate that cash ETRs declined by 7.5% following the implementation of the TCJA. We also predict that aggregate tax revenue declines by 9.3%, and the deadweight cost of tax avoidance declines by 56.5%, as lower rates are achieved with less avoidance activity.

The model predicts an increase in output of 9.7% and an increase in the equilibrium wage of 7.5% leading to an increase in consumption of 6.1%. Aggregate firm value increases significantly, but the average firm value increases by only 1.8%. Importantly, this reduction in average size is seen similarly among the largest firms, and lowers concentration. In effect, the tax cut somewhat compresses the gap between small and large firms, while also lowering the distortion caused by corporate income taxes. In aggregate, tax distortions are reduced and allocative efficiency improves.

Overall, our model predicts that the tax cut provided by the TCJA are stimulative to investment, increasing the capital stock by 14.1% in the long-run. These results, however, should be viewed with caution for at least two reasons. First, while our model appears to match the average decline in ETRs observed in the data, the effect of the TCJA on avoidance as it relates to size is an open question. Second, we do not consider the effects of moving from a worldwide to a territorial tax system that occurred with the TCJA. Albertus, Glover, and Levine (2021) show that multinationals had incentive to over-invest abroad prior to the TCJA, and a reversal would lower the expected consolidated investment of these firms post-TCJA.

[19]The case of ETR truncation, discussed in the previous subsection, would imply that all firms face the same ETR after the reform.

6. Conclusion

We develop a general equilibrium model to study how corporate tax avoidance affects firm policies and aggregate outcomes. In both the model and data, effective rates decline in firm size, leading larger firms to receive the greatest benefit from tax avoidance. We find that the heterogeneity in tax rates induced by tax avoidance has important consequences for investment and competitive outcomes, and that these tax distortions differ from those in a neoclassical model where all firms face the same tax rate. In particular, tax avoidance increases the average firm size substantially, with much of this increase coming from the largest firms. Thus, tax avoidance increases concentration despite lowering the tax rate firms face; in contrast, a tax cut decreases concentration when all firms face the same tax rate. Tax avoidance reduces allocative efficiency and results in a deadweight loss. We find that policies to limit tax avoidance may actually exacerbate misallocation.

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Table I: **Effective Tax Rates.** Reports statistics on cash effective tax rates (ETRs) using five different measurement approaches. The N-year cash ETR is calculated for each firm and year as the sum of cash taxes paid (TXPD) over the previous N years divided by the sum of pre-tax income (PI) over that same period. See Section 2 for details of construction. The top four rows report summary statistics of the ETRs for the full sample. In the second panel, each year firms are sorted into deciles based on either the average market value of assets over the N-year period (specifications 1, 3, 4, and 5), or the average book value of assets (specification 2), and the means are reported within each decile. The average ETR for the top 1% of firms by asset value is also reported. The last two columns report the ETR difference between the tenth and first decile, and the top 1% and first decile, respectively. Specification 3 uses pretax profits minus special items as the denominator in the ETR estimate. Bootstrapped standard errors or t-statistics are reported to the right of each sample statistic.

	(1)		(2)		(3)		(4)		(5)	
Tax rate measure:	Ten-year ETR		Ten-year ETR		Ten-year ETR		Five-year ETR		One-year ETR	
Size measure:	Market assets		Book assets		Market assets		Market assets		Market assets	
Special items:	Include		Include		Exclude		Include		Include	
		S.E.		S.E.		S.E.		S.E.		S.E.
Mean	0.351	0.003	0.351	0.003	0.295	0.003	0.336	0.002	0.295	0.002
Median	0.319	0.002	0.319	0.002	0.281	0.003	0.310	0.002	0.275	0.002
Std dev.	0.201	0.003	0.201	0.003	0.169	0.003	0.211	0.002	0.225	0.001
Obs	23,927		23,927		21,601		39,108		58,436	
Size Decile										
(Small) 1	0.414	0.010	0.394	0.009	0.363	0.011	0.392	0.008	0.301	0.005
2	0.392	0.009	0.386	0.008	0.334	0.009	0.359	0.007	0.294	0.005
3	0.384	0.009	0.368	0.008	0.322	0.008	0.354	0.006	0.297	0.004
4	0.377	0.009	0.368	0.008	0.307	0.007	0.357	0.006	0.295	0.004
5	0.347	0.007	0.367	0.008	0.292	0.007	0.344	0.005	0.298	0.004
6	0.342	0.007	0.345	0.008	0.284	0.006	0.333	0.005	0.297	0.004
7	0.325	0.007	0.318	0.007	0.281	0.007	0.313	0.005	0.293	0.004
8	0.317	0.006	0.327	0.007	0.262	0.005	0.320	0.005	0.290	0.004
9	0.327	0.009	0.330	0.008	0.263	0.006	0.310	0.006	0.295	0.004
(Large) 10	0.306	0.008	0.318	0.009	0.255	0.007	0.306	0.006	0.295	0.004
Top 1%	0.269	0.018	0.304	0.023	0.221	0.015	0.284	0.016	0.290	0.013
Difference		t-stat		t-stat		t-stat		t-stat		t-stat
(10)−(1)	−0.108	−8.27	−0.077	−5.93	−0.108	−8.21	−0.086	−8.68	−0.005	−0.79
Top 1%−(1)	−0.144	−6.73	−0.090	−3.70	−0.142	−7.63	−0.108	−6.19	−0.010	−0.73

Table 2: **Model parameter estimates.** The table presents model parameter estimates. Panel A presents parameters that are estimated outside of the model. Panel B presents parameters estimates from the methods of moments estimation of the model, with standard errors in parentheses. Parameters are at an annualized frequency, where applicable. For details on the estimation, see Section 4 and Appendix B.

Panel A: Predefined parameters

Parameter	Description	Value
α	Capital returns to scale	0.22
β	Labor returns to scale	0.44
r	Discount rate	0.05
δ	Depreciation rate	0.10
z_0	Initial productivity	1
$c_{E,0}$	Entry cost scaling	1
θ	Elasticity of supply of new entrants	1.55
ψ	Preference for leisure	1
χ	Inverse Frisch elasticity of labor supply	1.33
ν	Risk aversion coefficient	2

Panel B: Estimated parameters

Parameter	Description	Estimate
μ	Productivity drift	-0.005
		(0.008)
σ	Productivity volatility	0.106
		(0.006)
λ	Exit shock intensity	0.048
		(0.025)
$b \times 10^{-4}$	Marginal cost of avoidance	6.99
		(0.95)
γ	Avoidance returns to scale	0.030
		(0.001)
c_f	Fixed operating costs	0.029
		(0.011)
τ_L^{ETR}	Minimum ETR with avoidance	0.269
		(0.013)
τ_0	Tax rate with no avoidance	0.415
		(0.016)

Table III: **Targeted moments in model estimation.** The table displays the moments that we target in our estimation. The first column of the table reports the moment in the estimated model and the second column is the value in the data. The third column reports a t-statistic for the difference between the model estimated moment and the moment in the data. For more details on the estimation, see Section 4 and Appendix B.

	Model	Data	t-stat
Mean of earnings growth	0.024	0.029	-0.58
Volatility of earnings growth	0.341	0.336	2.39
Pareto tail, firm size	-1.367	-1.345	-4.03
Exit rate	0.074	0.074	1.15
Mean firm ETR	0.351	0.351	-0.06
Aggregate ETR	0.302	0.285	0.69
Mean ETR, decile 1	0.405	0.415	-0.88
Mean ETR, decile 2	0.389	0.392	-0.32
Mean ETR, decile 3	0.378	0.386	-1.16
Mean ETR, decile 4	0.369	0.377	-1.19
Mean ETR, decile 5	0.360	0.347	2.14
Mean ETR, decile 6	0.353	0.343	1.84
Mean ETR, decile 7	0.343	0.324	3.86
Mean ETR, decile 8	0.330	0.318	2.20
Mean ETR, decile 9	0.308	0.327	-3.32
Mean ETR, decile 10	0.276	0.310	-6.48
Mean ETR, 99th percentile	0.269	0.269	0.00

Table IV: **The effect of tax avoidance.** The table reports the percent increase in aggregates and firm-level averages due to tax avoidance; negative numbers indicate a decrease due to tax avoidance. These are constructed by comparing the estimated baseline model steady state equilibrium to a counterfactual steady state equilibrium where tax avoidance has been shut down. With the exception of tax avoidance, all other model parameters are held fixed across the two cases (see Table 2 for parameter values) and we compute the equilibrium separately for each case. Aggregate values are shown in Panel A and firm average values are shown in Panel B.

Panel A: Aggregates		Panel B: Firm averages	
Percent increase due to tax avoidance			
Firm value	13.1	Firm value	12.9
Output	4.8	Output	4.6
Capital	12.9	Capital	12.7
Labor	3.7	Labor	3.5
Profit	9.9	Profit	9.7
Taxes		*Taxes*	
Taxes paid	−31.1	Taxes paid	−31.2
ETR		ETR	
p.p.	−11.3	p.p.	−6.4
percent	−27.2	percent	−15.5
Productivity		*Productivity*	
TFP	−1.8	TFP	1.3
Gross (pre-tax) profit margin			
p.p.	−4.8		
percent	−12.4		
Net (after-tax) profit margin			
p.p.	0.7		
percent	4.9		
Wage (w)	8.8		
Mass of firms (Q)	0.2		
Entry flow (N)	2.2		
Exit threshold (z_D)	2.0		

Table V: **Effect of tax avoidance on size and concentration.** The table reports the percent increase in each variable due to tax avoidance; negative values represent a decrease due to tax avoidance. These are constructed by comparing the baseline model steady state equilibrium with the counterfactual steady state equilibrium where tax avoidance has been shut down. Panel A reports the percent increase in the percentiles of the size distribution where size is measured as firm value, capital, or output. Panel B reports the percent increase in concentration. Panel B also reports the level of concentration for each variable in the baseline model. Concentration is defined as the fraction or share of a given variable coming from the top X% of firms. For example, 58.4% of all capital is employed by the top 10% of firms, a 5.4% increase relative to the case without tax avoidance.

Panel A: Effect of tax avoidance on the size distribution

Percent increase in firm quantities at given percentile							
	Percentile						
	10	30	50	70	90	95	99
Value	0.0	1.7	3.1	5.8	11.0	13.7	17.2
Capital	−3.4	−0.1	2.3	6.1	14.7	19.0	19.0
Output	−4.8	−3.1	−1.8	0.5	5.9	8.4	8.4

Panel B: Effect of tax avoidance on concentration

		Share of firms in the...			
		Top 20%	Top 10%	Top 5%	Top 1%
Value	Level	0.778	0.667	0.566	0.376
	% increase	2.4	3.4	4.1	5.0
Capital	Level	0.696	0.584	0.486	0.315
	% increase	4.3	5.4	5.6	5.6
Revenue	Level	0.686	0.573	0.477	0.310
	% increase	2.8	3.5	3.7	3.7
Profit	Level	0.841	0.730	0.624	0.417
	% increase	3.9	5.5	6.7	7.9
Taxes Paid	Level	0.613	0.499	0.412	0.267
	% increase	−8.0	−10.0	−10.4	−10.4
Tax Avoidance Costs	Level	0.579	0.384	0.209	0.042

Table VI: **Welfare effects of tax avoidance.** The table reports the aggregate welfare effects due to tax avoidance. We report the percentage change in each value in the baseline economy with avoidance relative to the corresponding value in the economy with no avoidance. Certainty equivalent consumption is computed as the percentage change in consumption in the NA economy such that the household's welfare were equal to the welfare in the baseline economy with avoidance.

Effects of tax avoidance

Change in percent relative to NA economy	
Wage	8.83
Firm profits	9.93
Labor income	12.89
Tax revenue	−31.10
Entry costs	3.50
Consumption	1.80
Certainty equivalent consumption	−0.55

Table VII: **Comparing the effect of tax avoidance to a tax cut.** The table presents the percent change in a variable relative to the model with no tax avoidance. The first column shows the change for the baseline model with tax avoidance. The second column shows the change for the no avoidance model with a tax cut such that aggregate tax revenue is equivalent to the baseline model case. The third column shows the change for the no avoidance model with a tax cut such that the mean ETR is equal to the mean ETR in the baseline model. In all columns, the values reported are the percent change relative to the no avoidance model under the parameters given in Table 2. The ETR measures are reported as the percentage point changes.

	Baseline	Aggregate Tax revenue Equivalent	Average ETR Equivalent
Percent change relative to no avoidance model			
Aggregates			
Firm value	13.1	50.9	19.2
Output	4.8	16.4	6.7
Revenue	4.8	16.4	6.7
Capital	12.9	29.4	11.8
Labor	3.7	−1.1	−0.6
Profit	9.9	52.2	19.7
Taxes paid	−31.1	−31.1	−11.0
ETR (p.p.)	−11.3	−16.2	−6.4
TFP	−1.8	7.6	3.2
Consumption	1.8	9.3	4.0
Tax avoidance costs (TAC)			
Consumption excl TAC	3.2	9.3	4.0
Wage	8.8	17.7	7.3
Mass of firms	0.2	37.4	14.6
Entry flow	2.2	32.6	12.8
Firm Averages			
Firm value	12.9	9.8	4.0
Output	4.6	−15.2	−6.9
Revenue	4.6	−15.2	−6.9
Capital	12.7	−5.8	−2.4
Labor	3.5	−28.0	−13.2
Profit	9.7	10.8	4.4
Taxes paid	−31.2	−49.8	−22.3
TFP	1.3	7.6	3.2
ETR (p.p.)	−6.4	−16.2	−6.4
Distribution			
Top 1% share of profit	7.9	−1.9	−0.8
50th percentile of value	3.1	13.4	5.6
99th percentile of value	17.2	8.8	3.6

Table VIII: **The effects of eliminating tax avoidance.** The table presents the percent change in a variable relative to the baseline model with tax avoidance. The first column shows the change when tax avoidance is eliminated and the statutory tax rate is held fixed. The second column shows the change when avoidance is eliminated and the statutory tax rate is reduced such that the aggregate tax revenue is equal to the baseline case. The third column shows the change when avoidance is eliminated and the tax rate is reduced such that the firm average ETR is equal to the baseline case. In all columns, the values reported are the percent change relative to the baseline model under the parameters given in Table 2, except for the ETR measures, which are reported as the percentage point changes.

	No Avoidance	No Avoidance, Aggregate Tax Revenue Equivalent	No Avoidance Firm Average ETR Equivalent
	$\tau_0 = 0.415$	$\tau_0 = .253$	$\tau_0 = 0.351$
	Percent change relative to baseline model		
Aggregates			
Firm value	−11.6	33.3	5.4
Output	−4.6	11.1	1.8
Revenue	−4.6	11.1	1.8
Capital	−11.4	14.6	−0.9
Labor	−3.6	−4.6	−4.1
Profit	−9.0	38.4	8.9
Taxes paid	45.1	0.0	29.2
ETR (p.p.)	11.3	−4.9	4.8
TFP	1.8	9.5	5.1
Consumption	−1.8	7.3	2.2
Tax avoidance costs (TAC)	−100.0	−100.0	−100.0
Consumption excl TAC	−3.1	5.8	0.7
Wage	−8.1	8.1	−1.4
Mass of firms	−0.2	37.1	14.4
Entry flow	−2.2	29.6	10.4
Averages			
Firm value	−11.4	−2.7	−7.8
Output	−4.4	−19.0	−11.0
Revenue	−4.4	−19.0	−11.0
Capital	−11.2	−16.4	−13.4
Labor	−3.4	−30.4	−16.2
Profit	−8.8	1.0	−4.8
Taxes paid	45.4	−27.0	13.0
TFP	−1.3	6.2	1.9
Distribution			
Top 1% share of profit	−7.3	−9.1	−8.1
50th percentile of value	−3.0	10.0	2.4
99th percentile of value	−14.7	−7.2	−11.6

Table IX: **Varying the cost of tax avoidance.** The table presents the percent change in each variable that results from changing the cost of tax avoidance parameter, b. The first (second) column is for a lower (higher) input cost of tax avoidance, b, such that the aggregate ETR decreases (increases) by 1 percentage point. In both columns, the values reported are the percent change relative to the baseline model under the parameters given in Table 2, except for the ETR measures, which are reported as the percentage point changes.

	Decrease b	Increase b
Percent change relative to baseline		
Avoidance cost parameter, b	−33.4	44.7
Aggregates		
Firm value	1.2	−1.0
Output	1.0	−0.9
Capital	1.6	−1.4
Labor	0.1	−0.1
Profit	1.7	−1.4
Taxes paid	−3.2	3.3
ETR (p.p.)	−1.0	1.0
TFP	0.4	−0.3
Consumption	0.7	−0.6
Tax avoidance costs (TAC)	−1.2	−2.6
Firm averages		
Firm value	−0.6	0.3
Output	−0.8	0.4
Capital	−0.2	−0.1
Profit	−0.1	−0.1
Taxes paid	−4.9	4.7
ETR (p.p.)	−5.3	4.6
TFP	−0.2	0.2
Wage	1.5	−1.3
Mass of firms	1.8	−1.3
Entry flow	1.8	−1.5
Exit threshold	0.0	−0.1
Top 1% share of		
Revenue	−1.2	1.2
Profit	−1.6	1.5
50th percentile of value	1.0	−0.9
99th percentile of value	−1.4	0.9

Table X: **Tax policy experiments.** The table presents the percent change in each variable under an alternative policy with a lower statutory tax rate. The first column reports the results from a 5 percentage point tax cut in the no avoidance model. The second and third columns report the effects of a 5 percentage point cut in the baseline model with avoidance for a "truncated" and "shifted" tax rate function, respectively. The fourth column reports results from a 14 percentage point tax cut with shifting in the baseline model with avoidance, corresponding to the change under the TCJA. For details of the truncation and shifting to the tax function, see Section 5.3. All other parameters are set to the values reported in Table 2.

	(1)	(2)	(3)	(4)
Tax cut:	5 p.p.	5 p.p.	5 p.p.	TCJA, 14 p.p.
Initial policy:	No avoidance	Baseline	Baseline	Baseline
New policy:	No avoidance	Truncation	Shifting	Shifting
	Percent increase under new policy			
Aggregates				
Firm value	14.8	8.6	10.2	31.8
Output	5.2	2.4	2.7	9.7
Capital	9.2	2.8	3.9	14.1
Labor	−0.5	−1.8	−1.3	−3.3
Profit	15.1	9.4	10.3	34.0
Average cost	1.1	−2.2	−1.4	−2.5
Taxes paid	−8.4	5.8	−0.1	−9.3
ETR (p.p.)	−5.0	−0.1	−1.6	−6.4
TFP	2.5	2.8	2.3	7.3
Consumption	3.2	1.7	1.7	6.1
Tax avoidance costs (TAC)		−30.1	−16.4	−56.5
Consumption excl TAC	3.2	1.3	1.4	5.2
Wage	5.7	1.0	1.5	7.5
Mass of firms	11.3	9.4	8.7	29.5
Entry flow	9.9	7.1	6.6	23.5
Averages				
Firm value	3.2	−0.8	1.4	1.8
Output	−5.4	−6.4	−5.6	−15.3
Capital	−1.9	−6.0	−4.4	−11.8
Labor	−10.6	−10.3	−9.3	−25.3
Profit	3.5	0.0	1.4	3.5
Taxes paid	−17.7	−3.3	−8.1	−29.9
ETR (p.p.)	−5.0	−0.7	−0.9	−7.8
TFP	2.5	2.4	2.7	6.1
Distribution				
Top 10% share of				
Revenue	0.1	0.1	1.2	−9.5
Profit	−0.6	−1.4	−0.4	−12.0
Top 1% share of				
Revenue	0.1	0.1	2.0	2.9
Profit	−0.7	−1.5	1.0	−1.5
50th percentile of value	4.3	1.8	1.7	7.8
99th percentile of value	2.8	−1.5	1.7	−0.5

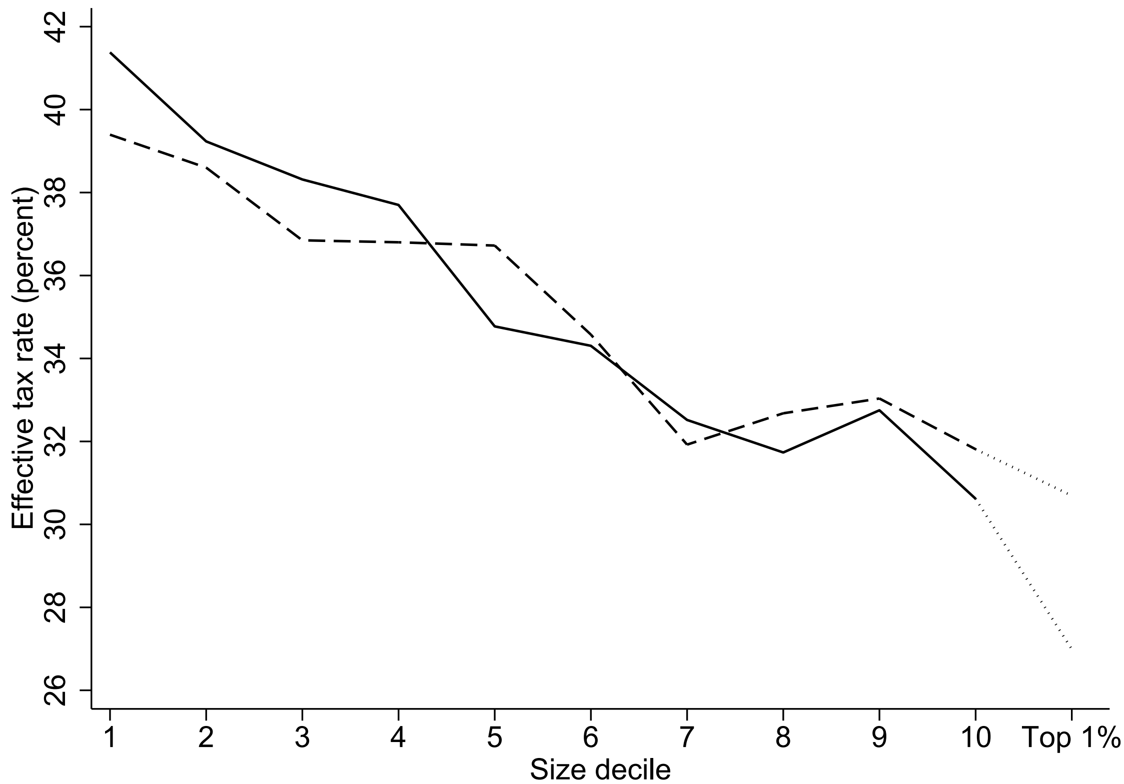


Fig. 1. **Effective tax rate by size.** Plots the average ten-year cash effective tax rate by firm size decile. Size is measured as either the market value of assets (solid line) or the book value of assets (dashed line). The 10-year cash ETR is calculated for each firm and year as the sum of cash taxes paid (TXPD) over the previous 10 years divided by the sum of pre-tax income (PI) over that same period. See Section 2 for details of construction. Each year, firms are sorted into deciles based on the average market or book value of assets over the ten-year period. The average ETR of firms in the top 1% of the size distribution is reported with a dotted line.

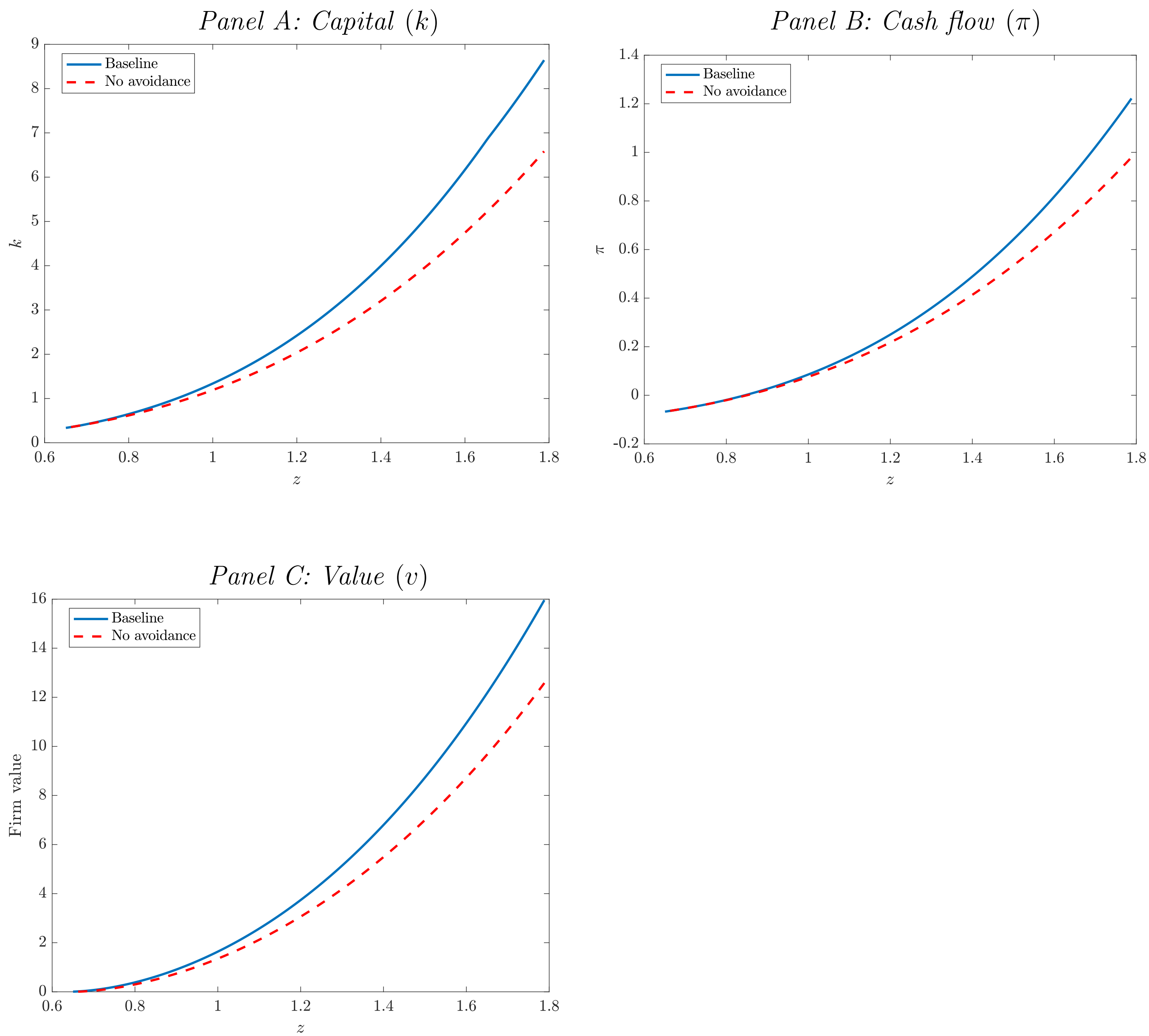


Fig. 2. **Policy functions: production** The figure plots the policy functions for the firm's optimal choice of capital (Panel A), cash flow (Panel B), and firm value (Panel C) as a function of the underlying productivity shock, z. In each panel we plot the policy function for the baseline case with tax avoidance (solid blue line) and the no avoidance case (dashed red line). The wage is held fixed across these two cases and values are normalized by the firm's output in the baseline case with $z = z_0$.

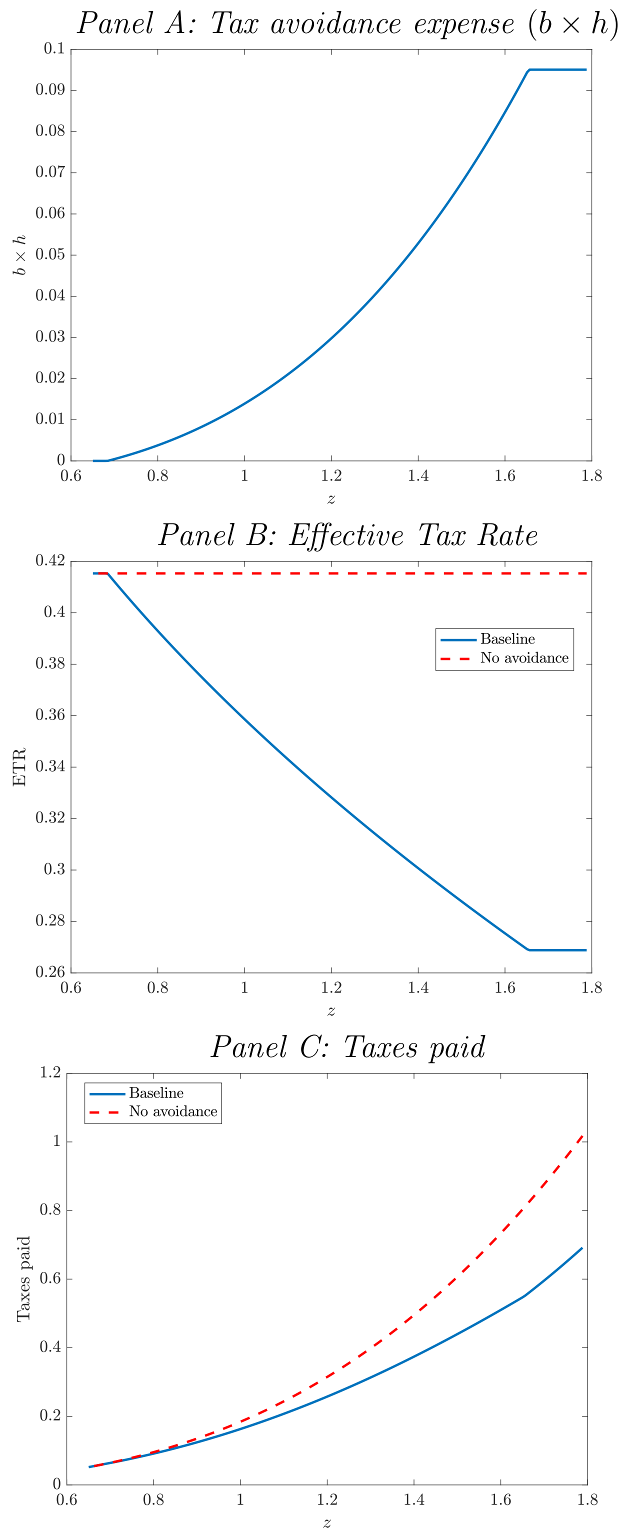


Fig. 3. **Policy functions: Taxes.** The figure shows firm-level tax measures as a function of the underlying level of productivity, z. In Panel A, we plot the optimal tax avoidance expenditure in the baseline model. In Panel B, we plot the effective tax rate, measured as taxes paid divided by taxable income. In Panel C we plot the taxes paid. In both Panels B and C the solid blue line represents the baseline model and the dashed red line shows the case in which tax avoidance is not allowed. The parameter values are listed in Table 2.

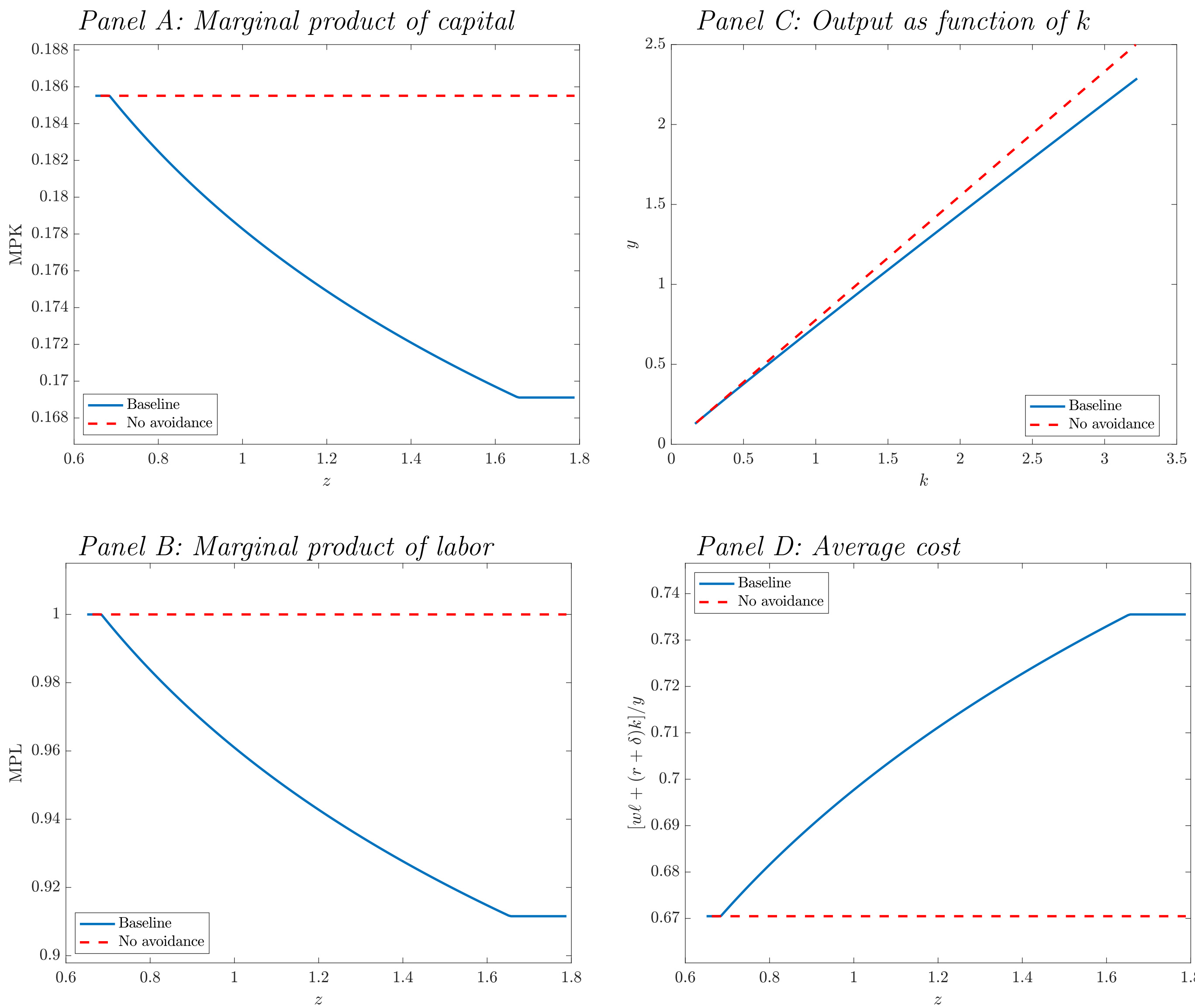


Fig. 4. **Productivity.** The figure plots measures of firm-level productivity. In each panel we compare the baseline case with tax avoidance (solid blue line) to the model with no tax avoidance (dashed red line). In Panels A and B we plot the marginal revenue products of capital and labor, respectively, as functions of the underlying productivity shock z. In Panel C, we plot the firm's output as a function of its optimal capital choice, k. In Panel D we plot the firm's average cost (depreciation and rental expense on capital plus the labor expense) divided by its output as a function of the productivity shock z.

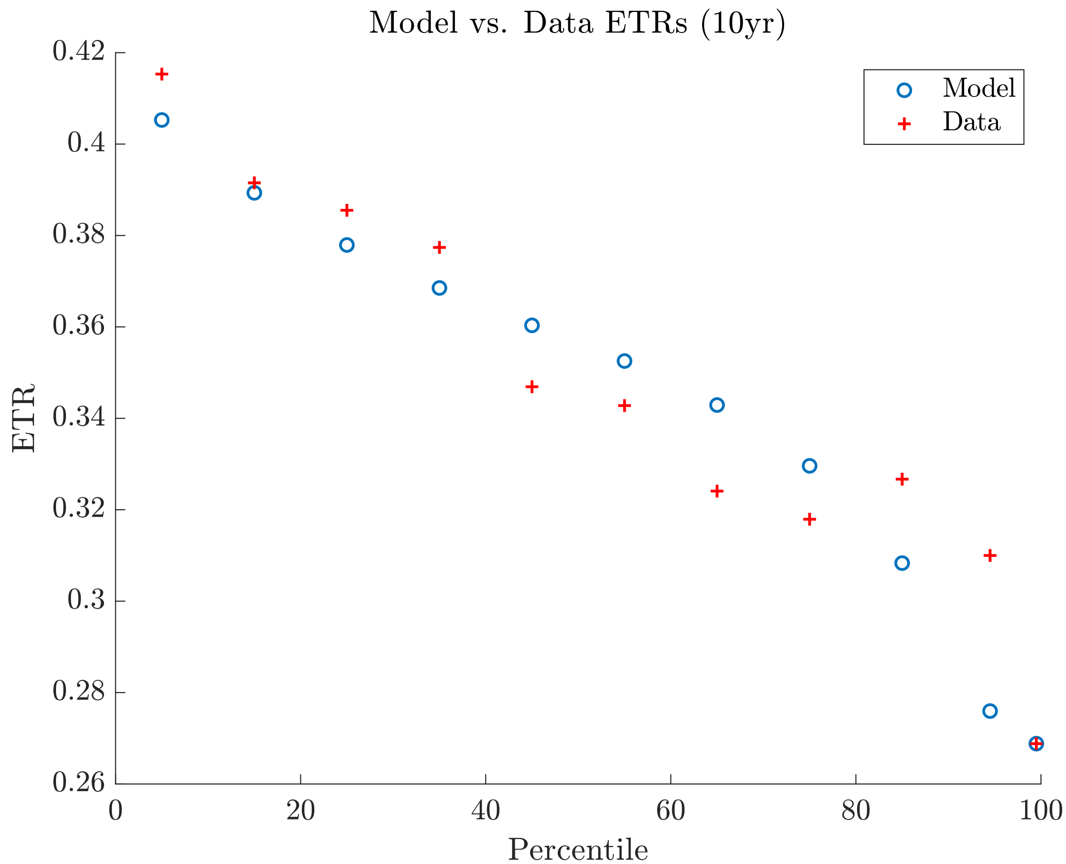


Fig. 5. **Effective tax rate by size: model and data.** The figure shows the effective tax rate (ETR) across firm size percentiles for the data and the estimated model. The blue circles correspond to the model estimated moment and the red crosses represent the data. The figure shows the mean ETR for each of the ten size deciles as well as the top percentile of firm size. See Section 2 for a description of the construction of the ETR measure in the data and 4 for a description of the estimation.

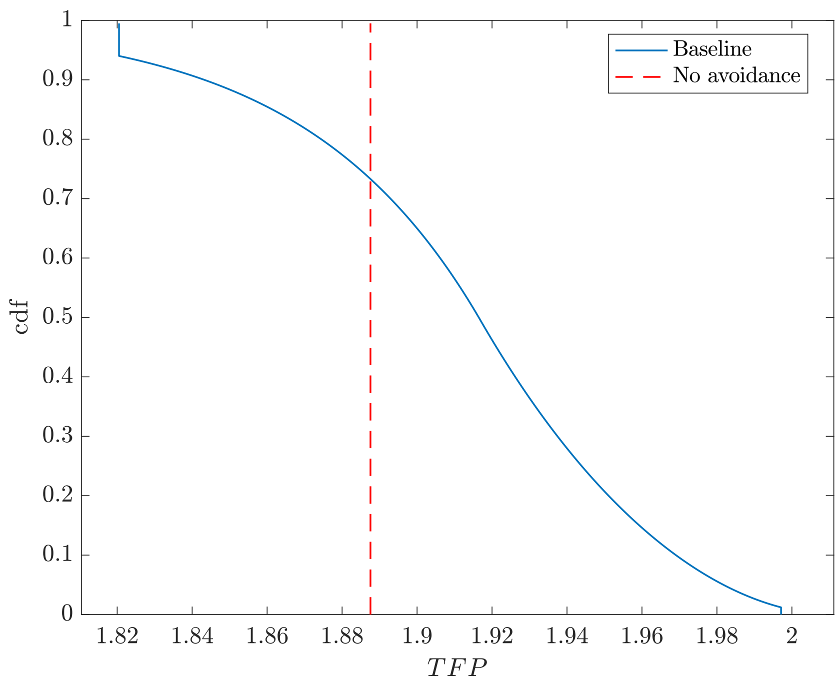


Fig. 6. **Distribution of total factor productivities.** The figure plots the cumulative distribution function for the stationary distribution of the total factor productivity (TFP) for the baseline model with tax avoidance (solid blue line) and the model with no tax avoidance (dashed red line). The model parameter values are given in Table 2.

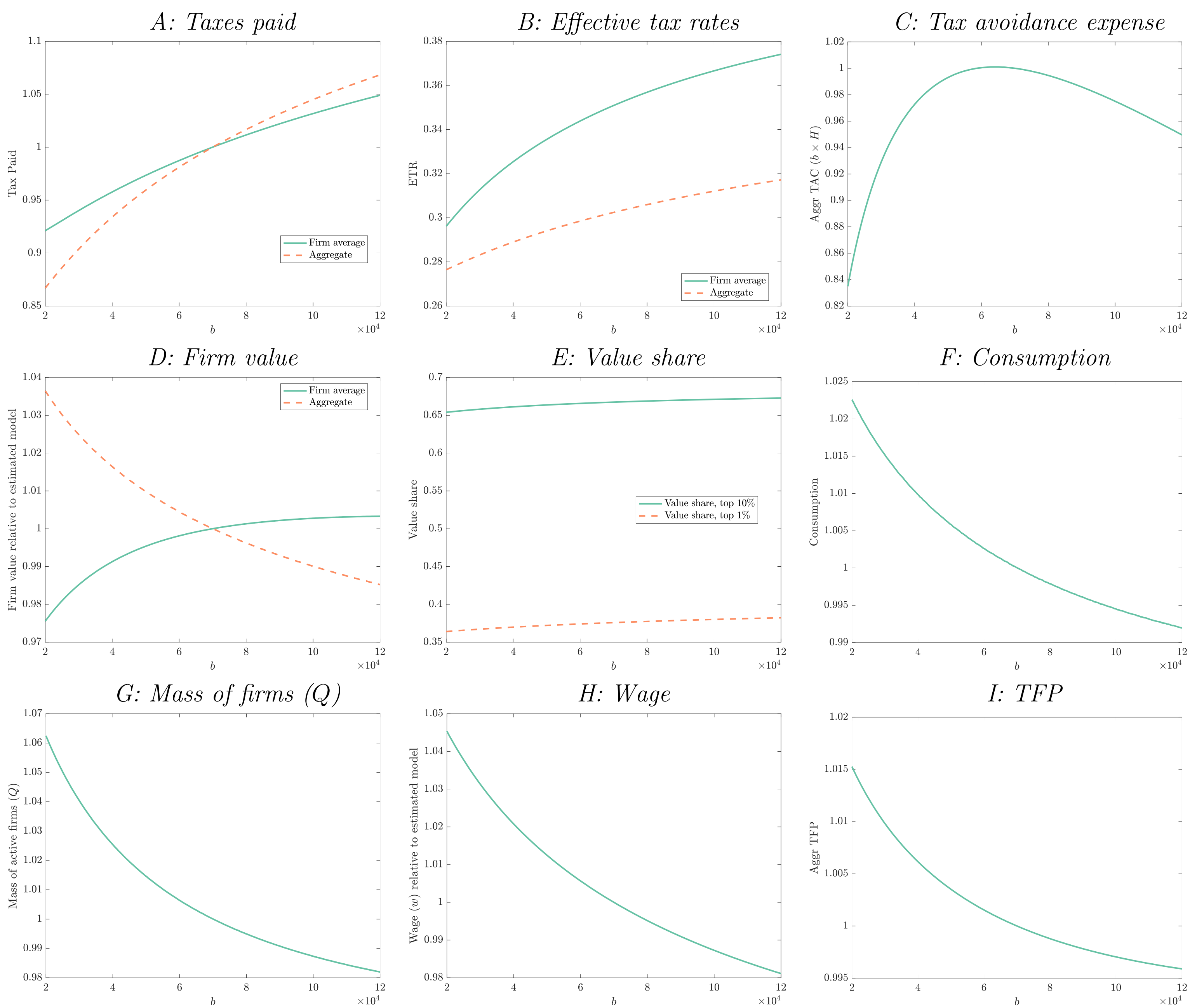
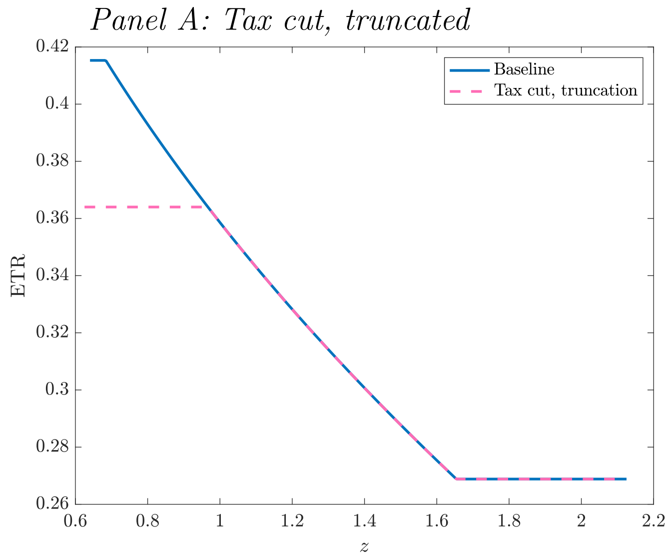


Fig. 7. **Comparative statics for b.** The figure plots comparative statics for the cost of tax avoidance parameter, b. Each panel, with the exception of panels B and E, plots the ratio of a particular model statistic to its value in the estimated baseline model, as a function of the tax avoidance parameter, b. All other parameters are held fixed at their estimated values reported in Table 2. Panels B (effective tax rates) and E (value share) report the level of the model statistic rather than its value relative to the value in the estimated model.



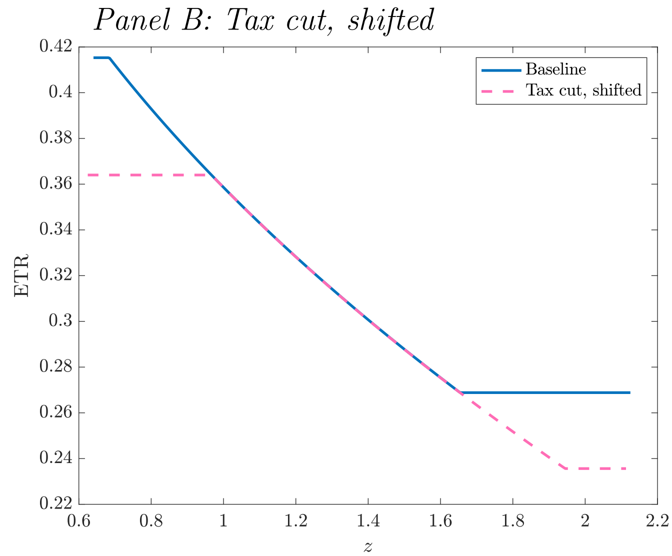


Fig. 8. **Effective tax rates on productivity for truncated and shifted tax cuts** The figure plots the firm's effective tax rate on its productivity. The ETR in the model is computed as $ETR = \frac{\tau^* y - \tau_0(\delta k + w\ell)}{y - \delta k - w\ell}$ In Panel A, we compare the ETR in the baseline calibrated model to the ETR in the case of a tax cut where we truncate the tax rate function. In Panel B, we compare the baseline case ETR to the case of a tax cut where we shift the tax function. In both panels, the solid blue line corresponds to the baseline calibrated model and the dashed pink line corresponds to the case of a 5 p.p. tax cut. See Section 5.3 for further discussion.

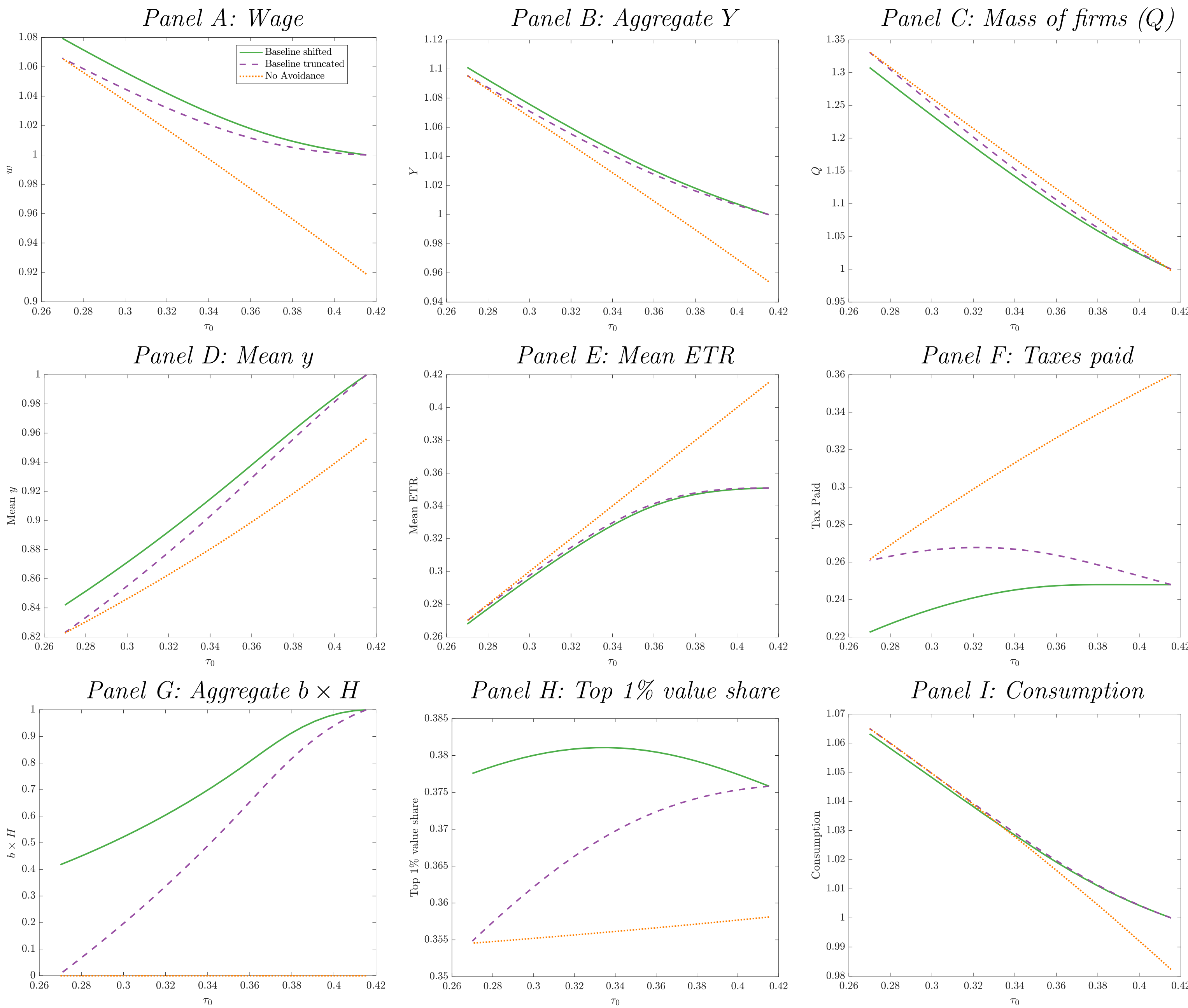


Fig. 9. **Comparative statics for a change in the statutory tax rate.** The figure plots model quantities as a function of the statutory tax rate (τ_0). In each subplot, we show three different cases: *i)* the model with no avoidance (dotted orange line) *ii)* the baseline model with avoidance where we "shift" the ETR schedule (solid green line), and *iii)* the baseline model with avoidance where we "truncate" the ETR schedule (dashed purple line). In cases *ii* and *iii* we adjust the parameters b, γ, τ_L^{ETR} jointly with the change in τ_0. See Section 5.3 for details. All other parameters are held at their estimated values given in Table 2. The equilibrium is recomputed for each change in the parameters.

Appendix A. Model Appendix

A.1. Derivation of optimal firm policies and cash flows

Plugging in $h^*_{i,t}$ from Eq. (6) into the profit function in Eq. (4) and collecting terms gives

$$\pi_{i,t} = \max_{k_{i,t},\ell_{i,t}} \begin{cases} (1-\tau_0)y_{i,t} - (1-\tau_0)(\delta k_{i,t} + w\ell_{i,t}) - rk_{i,t} - c_f & \text{if } z_{i,t} \leq z_l \\ (1-\gamma)\left(\frac{\gamma}{b}\right)^{\frac{\gamma}{1-\gamma}} (y_{i,t})^{\frac{1}{1-\gamma}} - (1-\tau_0)(\delta k_{i,t} + w\ell_{i,t}) - rk_{i,t} + bh_0 - c_f & \text{if } z_l < z_{i,t} < z_h \\ (1-\tau_L)y_{i,t} - (1-\tau_0)(\delta k_{i,t} + w\ell_{i,t}) - rk_{i,t} - b\bar{h} - c_f & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{A-1}$$

Taking first order conditions with respect to capital and labor for each region yields the optimal input choices in terms of $z_{i,t}$:

$$k^*_{i,t} = \begin{cases} \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{1-\beta} \left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta} (1-\tau_0)z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \leq z_l \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{1-\beta-\gamma} \left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta} \left(\frac{\gamma}{b}\right)^{\gamma} z_{i,t}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} & \text{if } z_l < z_{i,t} < z_h \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{1-\beta} \left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta} (1-\tau_L)z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \geq z_h \end{cases} \tag{A-2}$$

$$\ell^*_{i,t} = \begin{cases} \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)}\right)^{1-\alpha} (1-\tau_0)z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \leq z_l \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)}\right)^{1-\alpha-\gamma} \left(\frac{\gamma}{b}\right)^{\gamma} z_{i,t}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} & \text{if } z_l < z_{i,t} < z_h \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)}\right)^{1-\alpha} (1-\tau_L)z_{i,t}\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{A-3}$$

Optimal output $y^*_{i,t}$ is then given by the following expression:

$$y^*_{i,t} = \begin{cases} \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} (1-\tau_0)^{\alpha+\beta} \quad z_{i,t} \right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \leq z_l \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha(1-\gamma)} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta(1-\gamma)} \left(\frac{\gamma}{b} \right)^{\gamma(\alpha+\beta)} \quad z_{i,t}^{1-\gamma} \right]^{\frac{1}{1-\alpha-\beta-\gamma}} & \text{if } z_l < z_{i,t} < z_h \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} (1-\tau_L)^{\alpha+\beta} \quad z_{i,t} \right]^{\frac{1}{1-\alpha-\beta}} & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{A-4}$$

This in turn gives the optimal spending on tax reduction:

$$h^*_{i,t} = \begin{cases} 0 & \text{if } z_{i,t} \leq z_l \\ \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} \left(\frac{\gamma}{b} \right)^{1-\alpha-\beta} z_{i,t} \right]^{\frac{1}{1-\alpha-\beta-\gamma}} - h_0 & \text{if } z_l < z_{i,t} < z_h \\ \bar{h} & \text{if } z_{i,t} \geq z_h \end{cases} \tag{A-5}$$

and the optimal tax rates:

$$\tau^*_{i,t} = \begin{cases} \tau_0 & \text{if } z_{i,t} \leq z_l \\ 1 - \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} \left(\frac{\gamma}{b} \right)^{1-\alpha-\beta} z_{i,t} \right]^{\frac{\gamma}{1-\alpha-\beta-\gamma}} & \text{if } z_l < z_{i,t} < z_h \\ \tau_L & \text{if } z_{i,t} \geq z_h. \end{cases} \tag{A-6}$$

Finally, the profit function for the firm at the optimal choice of tax reduction, capital, and labor is

$$\pi^*_{i,t} = \begin{cases} (1-\alpha-\beta) \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{w(1-\tau_0)} \right)^{\beta} (1-\tau_0) z_{i,t} \right]^{\frac{1}{1-\alpha-\beta}} - c_f & \text{if } z_{i,t} \leq z_l \\ (1-\alpha-\beta-\gamma) \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{\omega(1-\tau_0)} \right)^{\beta} \left(\frac{\gamma}{b} \right)^{\gamma} \quad z_{i,t} \right]^{\frac{1}{1-\alpha-\beta-\gamma}} + bh_0 - c_f & \text{if } z_l < z_{i,t} < z_h \\ (1-\alpha-\beta) \left[\left(\frac{\alpha}{r+\delta(1-\tau_0)} \right)^{\alpha} \left(\frac{\beta}{\omega(1-\tau_0)} \right)^{\beta} (1-\tau_L) z_{i,t} \right]^{\frac{1}{1-\alpha-\beta}} - b\bar{h} - c_f & \text{if } z_{i,t} \geq z_h \end{cases} \tag{A-7}$$

We can solve for z_l, the highest $z_{i,t}$ at which the firm optimally chooses $h_{i,t} = 0$, by setting the middle expression for $h^*_{i,t}$ in Eq. (A-5) equal to zero and solving for $z_{i,t}$. This yields

$$z_l = \left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{-\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{-\beta}\left(\frac{\gamma}{b}\right)^{-(1-\alpha-\beta)} h_0^{1-\alpha-\beta-\gamma} \tag{A-8}$$

$$= \left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{-\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{-\beta}\left(\frac{\gamma}{b}\right)^{-(1-\alpha-\beta)} (1-\tau_0)^{\frac{1-\alpha-\beta-\gamma}{\gamma}} \tag{A-9}$$

Similarly, we can solve for z_h, the lowest $z_{i,t}$ at which the firm optimally chooses $h_{i,t} = \bar{h}$, by setting the same expression equal to $\bar{h}$ and solving for $z_{i,t}$. This gives

$$z_h = \left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{-\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{-\beta}\left(\frac{\gamma}{b}\right)^{-(1-\alpha-\beta)} (\bar{h}+h_0)^{1-\alpha-\beta-\gamma} \tag{A-10}$$

$$= \left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{-\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{-\beta}\left(\frac{\gamma}{b}\right)^{-(1-\alpha-\beta)} (1-\tau_L)^{\frac{1-\alpha-\beta-\gamma}{\gamma}} \tag{A-11}$$

A.2. Firm valuation (Proposition 1)

Define $\eta = 1-\alpha-\beta$ and

$$A_1 = \eta\left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta}(1-\tau_0)\right]^{\frac{1}{\eta}} \tag{A-12}$$

$$A_2 = (\eta-\gamma)\left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta}\left(\frac{\gamma}{b}\right)^{\gamma}\right]^{\frac{1}{\eta-\gamma}} \tag{A-13}$$

$$A_3 = \eta\left[\left(\frac{\alpha}{r+\delta(1-\tau_0)}\right)^{\alpha}\left(\frac{\beta}{w(1-\tau_0)}\right)^{\beta}(1-\tau_L)\right]^{\frac{1}{\eta}} \tag{A-14}$$

Then we can write the cash flows, $\pi(z;w)$ as

$$\pi(z;w) = \begin{cases} A_1 z^{1/\eta} - c_f & \text{if } z_{i,t} \le z_l \\ A_2 z^{\frac{1}{\eta-\gamma}} + b h_0 - c_f & \text{if } z_l < z_{i,t} < z_h \\ A_3 z^{1/\eta} - b\bar{h} - c_f & \text{if } z_{i,t} \ge z_h \end{cases} \tag{A-15}$$

Firm value is given by

$$v(z;w) = \sup_{\{k_t,\ell_t,h_t\}_{t\ge 0},\mathcal{T}_D} \int_0^{\mathcal{T}_D} e^{-(r+\lambda)t}\pi(z_t;w)dt. \tag{A-16}$$

The firm's optimal stopping time can be expressed as a threshold, z_D, such that the firm exits when its productivity $z = z_D$. Given this endogenous exit threshold, we divide the productivity space into three regions: $(z_D, z_L], (z_L, z_H], (z_H, \infty)$.

Region 1: $z_D < z \leq z_L$

Define $\eta = 1 - \alpha - \beta$. The value of the firm in this region satisfies the ordinary differential equation (ODE):

$$(r + \lambda)v(z; w) = \mu z v_z(z; w) + \frac{\sigma^2}{2} z^2 v_{zz}(z; w) + A_1 z^{1/\eta} - c_f \tag{A-17}$$

The solution in this region takes the form

$$v(z; w) = B_1 z^{\xi_1} + B_2 z^{\xi_2} + \frac{A_1 z^{1/\eta}}{r + \lambda - \frac{\mu}{\eta} - \frac{\sigma^2}{2}(1/\eta)(1/\eta - 1)} - \frac{c_f}{r + \lambda}, \tag{A-18}$$

where ξ_1, ξ_2 are the roots of the fundamental quadratic, given by

$$\xi_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r + \lambda)}{\sigma^2}}, \quad \xi_2 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r + \lambda)}{\sigma^2}}, \tag{A-19}$$

with $\xi_1 > 1$ and $\xi_2 < 0$. The coefficients B_1 and B_2 are determined by solving the boundary conditions, which are shown below.

Region 2: $z_L < z < z_H$

The value of the firm in this region satisfies the ODE:

$$(r + \lambda)v(z; w) = \mu z v_z(z; w) + \frac{\sigma^2}{2} z^2 v_{zz}(z; w) + A_2 z^{\frac{1}{\eta - \gamma}} + b h_0 - c_f \tag{A-20}$$

The solution in this region takes the form

$$v(z; w) = C_1 z^{\xi_1} + C_2 z^{\xi_2} + \frac{A_2 z^{\frac{1}{\eta - \gamma}}}{r + \lambda - \frac{\mu}{\eta - \gamma} - \frac{\sigma^2}{2}(\frac{1}{\eta - \gamma})(\frac{1}{\eta - \gamma} - 1)} + \frac{b h_0 - c_f}{r + \lambda} \tag{A-21}$$

where C_1 and C_2 are determined by the boundary conditions given below.

Region 3: $z_H \leq z < \infty$

The value of the firm in this region satisfies the ODE:

$$(r + \lambda)v(z; w) = \mu z v_z(z; w) + \frac{\sigma^2}{2} z^2 v_{zz}(z; w) + A_3 z^{1/\eta} - b\bar{h} - c_f \tag{A-22}$$

The solution in this region takes the form

$$v(z;w) = D_1 z^{\xi_1} + D_2 z^{\xi_2} + \frac{A_3 z^{\frac{1}{\eta}}}{r + \lambda - \frac{\mu}{\eta} - \frac{\sigma^2}{2}(1/\eta)(1/\eta - 1)} - \frac{b\bar{h} + c_f}{r + \lambda}, \tag{A-23}$$

where again the coefficients D_1 and D_2 are determined by the boundary conditions.

We need to solve for the coefficients $B_1, B_2, C_1, C_2, D_1, D_2$ and the optimal exit threshold z_D. First, note that to ensure that firm value is finite, we require that $D_1 = 0$. The five remaining coefficients and the optimal exit threshold solve the following system of equations:

$$v(z_D; w) = 0 \tag{A-24}$$

$$\frac{\partial v(z_D; w)}{\partial z} = 0 \tag{A-25}$$

$$\lim_{z \uparrow z_L} v(z; w) = \lim_{z \downarrow z_L} v(z; w) \tag{A-26}$$

$$\lim_{z \uparrow z_L} \frac{\partial v(z; w)}{\partial z} = \lim_{z \downarrow z_L} \frac{\partial v(z; w)}{\partial z} \tag{A-27}$$

$$\lim_{z \uparrow z_H} v(z; w) = \lim_{z \downarrow z_H} v(z; w) \tag{A-28}$$

$$\lim_{z \uparrow z_H} \frac{\partial v(z; w)}{\partial z} = \lim_{z \downarrow z_H} \frac{\partial v(z; w)}{\partial z} \tag{A-29}$$

The first pair of equations are the value-matching and smooth-pasting conditions, respectively, for the optimal exit threshold z_D. These reflect our assumption that firms have zero recovery at exit. The four remaining equations impose that the firm value is continuously differentiable at z_L and z_H.

A.3. Firm distribution (Proposition 2)

Firms optimally choose to exit when their productivity falls to the level z_D, which implies the stationary distribution of firms has support on $[z_D, \infty)$. The stationary distribution of firms satisfies the Kolmogorov forward equation

$$-\frac{\partial}{\partial z}\left[\mu z \phi(z)\right] + \frac{\partial^2}{\partial z^2}\left[\frac{1}{2}\sigma^2 z^2 \phi(z)\right] - \lambda \phi(z) = 0, \tag{A-30}$$

for all $z \neq z_0$. At z_0, new firms enter. We solve the Kolmogorov forward equation separately over two regions: $[z_D, z_0)$ and (z_0, ∞). The ODE can be rewritten as

$$\frac{1}{2}\sigma^2 z^2 \phi''(z) - (\mu - 2\sigma^2) z \phi'(z) - (\mu - \sigma^2 + \lambda)\phi(z) = 0. \tag{A-31}$$

This ODE has a general solution

$$\phi(z) = \begin{cases} H_1 z^{\zeta_1 - 1} + H_2 z^{\zeta_2 - 1} & \text{if } z_D < z < z_0 \\ J_1 z^{\zeta_1 - 1} + J_2 z^{\zeta_2 - 1} & \text{if } z > z_0 \end{cases} \tag{A-32}$$

where

$$\zeta_1 = \frac{\mu}{\sigma^2} - \frac{1}{2} + \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \qquad \zeta_2 = \frac{\mu}{\sigma^2} - \frac{1}{2} - \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}. \tag{A-33}$$

The coefficients H_1, H_2, J_1, J_2 are solved by imposing the boundary conditions. To ensure that $\phi(z)$ remains finite as $z \to \infty$, we require $J_1 = 0$. The remaining three coefficients solve the following three boundary conditions:

$$\phi(z_D) = 0 \tag{A-34}$$

$$\lim_{z \uparrow z_0} \phi(z) = \lim_{z \downarrow z_0} \phi(z) \tag{A-35}$$

$$\int_{z_D}^{\infty} \phi(z) dz = 1 \tag{A-36}$$

The first equation states that there is zero mass of firms at the exit threshold, z_D. The second equation imposes continuity at z_0 and the third equation requires that $\phi(z)$ is a probability density function that integrates to 1.

Appendix B. Estimation

In this appendix we provide additional details on our approach to estimating the model. We estimate the model using the generalized method of moments (GMM) (Hansen, 1982).

B.1. Parameter estimates and standard errors

The GMM estimator finds the vector of model parameters that minimizes the distance, subject to a choice of moment weights, between the empirical moments and the moments computed from the model. Formally, the vector of GMM parameter estimates, $\hat{\Theta}$, is given by

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} \left(\tilde{h} - h(\Theta)\right)' \hat{W} \left(\tilde{h} - h(\Theta)\right), \tag{A-37}$$

where $\tilde{h}$ denotes the vector of empirical moments, $h(\Theta)$ denotes the vector of model moments for parameter vector Θ, and $\hat{W}$ is a positive-definite weighting matrix.

For the weighting matrix, $\hat{W}$, we use the inverse of the covariance matrix of the empirical moments, constructed using the influence function approach from Erickson and Whited (2002). To compute standard errors, we use a two-way clustered covariance matrix, denoted by $\hat{\Omega}$, where we cluster by firm and year. Letting G denote the Jacobian matrix for the moment conditions and $\hat{W}$ the weighting matrix described above, the covariance matrix for the model parameters is given by

$$(G'\hat{W}G)^{-1}G'\hat{W}\hat{\Omega}\hat{W}G(G'\hat{W}G)^{-1}. \tag{A-38}$$

B.2. Computing moments in the model and data

Here we provide details on the computation of the moments used in our estimation. We use a total of seventeen moments: the mean and volatility of earnings growth, the Pareto tail coefficient for the right tail of the firm size distribution, the turnover rate, the firm-level mean and aggregate ETR, the mean ETR for each of the 10 deciles of firm size, and the mean ETR for the 99th percentile of firm size.

B.2.1. Mean and volatility of earnings growth

The first two moments are the mean and volatility of firm earnings growth. Let $\tilde{\pi}(z)$ denote the flow of a firm's earnings, which can be expressed as

$$\tilde{\pi}(z) = Az^{\theta} \tag{A-39}$$

where

$$\theta = \begin{cases} \dfrac{1}{1-\alpha-\beta} & \text{if} \quad z \in (z_D, z_L) \cup (z_H, \infty) \\ \dfrac{1}{1-\alpha-\beta-\gamma} & \text{if} \quad z \in [z_L, z_H] \end{cases} \tag{A-40}$$

and A is a constant that differs depending on the region of productivity. Applying Itô's Lemma, we can write the earnings growth as

$$\frac{d\tilde{\pi}}{\tilde{\pi}} = \left(\theta\mu + \frac{1}{2}\sigma^2\theta(\theta - 1)\right) dt + \sigma\theta dW_t. \tag{A-41}$$

From Equation (A-41), we see the mean earnings growth is given by $\left(\theta\mu + \frac{1}{2}\sigma^2\theta(\theta - 1)\right)$ and the volatility of earnings growth is $\sigma\theta$. As the value of θ depends on the region of productivity, these are conditional values. We use the values of z_L and z_H as well as the stationary distribution of productivity, $\phi(z)$ to compute the unconditional mean and volatility of earnings growth in the model. The preceding derivation highlights the fact that tax avoidance parameters b and γ affect "non-tax" moments, such as the mean and volatility of earnings growth.

In the data, reported earnings commonly switch sign or take a value of zero, complicating the estimation of earnings growth rates. To address this issue, we use two strategies. First, we measure earnings growth rates using the approach of Davis and Haltiwanger (1992) and Terry et al. (2020), specifically,

$$\Delta x_t = \begin{cases} 0 & \text{if} \quad x_{t-1} = 0 \text{ or } x_t = 0 \\ 2\dfrac{x_t - x_{t-1}}{|x_t| + |x_{t-1}|} & \text{otherwise.} \end{cases} \tag{A-42}$$

This approach limits growth rates to $[-2, 2]$. Second, we use the annualized three-year earnings growth rate. This approach helps to mitigate the effects of outliers and short-term earnings management (Terry, 2015). In order to help remove firm heterogeneity that is outside of the model, firm and year fixed effects are removed from the earnings growth rate prior to estimating its volatility.

B.2.2. Pareto tail of firm size

As discussed in Section 3.6, the stationary distribution for productivity, $\phi(z)$, has a right tail that follows a Pareto distribution with parameter $\zeta_2 < 0$. This means that the probability a firm's productivity z is above some value $\hat{z} > z_0$ is given by:

$$Pr[z > \hat{z}] = \left(\frac{-J_2}{\zeta_2}\right) \hat{z}^{\zeta_2}, \tag{A-43}$$

where ζ_2 is the coefficient of the Pareto tail,

$$\zeta_2 = \frac{\mu}{\sigma^2} - \frac{1}{2} - \frac{\sqrt{2\lambda\sigma^2 + \left(\mu - \frac{\sigma^2}{2}\right)^2}}{\sigma^2}, \tag{A-44}$$

and J_2 is solved for by imposing the boundary conditions.

Now consider a function of firm productivity, $f(z)$, of the form

$$f(z) = Az^{\theta}, \tag{A-45}$$

for $A, \theta > 0$. The probability that $f(z) > \overline{f}$ is

$$Pr\left[Az^{\theta} > \overline{f}\right] = Pr\left[z > \left(\frac{\overline{f}}{A}\right)^{1/\theta}\right] = \left(\frac{-J_2}{\zeta_2}\right)\left(\frac{\overline{f}}{A}\right)^{\frac{\zeta_2}{\theta}}. \tag{A-46}$$

Thus, $f(z)$ also has a Pareto right tail with coefficient $\frac{\zeta_2}{\theta}$. As shown in Equation (A-2), a firm's optimal capital can be written as the above function $f(z)$, where the value of A and θ depend on the region of firm productivity. Similar to other papers in the literature (e.g., Hartman-Glaser, Lustig, and Xiaolan, 2019), we use the largest 5% of firms in the data to estimate the Pareto right tail coefficient. In our estimated model, this corresponds to region three ($z > z_H$), which means the Pareto tail coefficient for capital in this region is

$$\frac{\zeta_2}{1 - \alpha - \beta}. \tag{A-47}$$

This implies the following relation in the model:

$$\log(\text{share of firms with size} > x) = a_0 + \frac{\zeta_2}{1 - \alpha - \beta}\log(x). \tag{A-48}$$

We estimate the Pareto tail coefficient by running this regression in the data:

$$\log(\text{share of firms with size} > x) = a_0 + a_1 \log(x) + e. \tag{A-49}$$

B.2.3. Exit rate

Firms exit for two reasons in the model: the firm is hit with a stochastic exit shock that arrives with intensity λ or its productivity falls to z_D such that its going concern value is zero and it optimally chooses to shut down. Given the fact that $\phi(z_D) = 0$, the flow of firms hitting the exit threshold z_D is given by

$$\frac{1}{2}\sigma^2 z_D^2 \phi'(z_D) Q. \tag{A-50}$$

The flow of firms leaving due to the exit shock is simply λQ. Combining these and using the expression for the distribution given in Equation (17) we can express the exit rate as

$$\text{Exit rate} = \lambda + \frac{1}{2}\sigma^2 \left(\zeta_1 H_1 z_D^{\zeta_1} + \zeta_2 H_2 z_D^{\zeta_2} \right). \tag{A-51}$$

In the data, the exit rate is estimated as the fraction of firms which leave our filtered Compustat sample each year.

B.2.4. Effective tax rates

The remaining moments use the effective tax rates faced by firms in the model. For a firm i at time t, we compute its ETR as

$$ETR(z) = \frac{\tau^*(z) y^*(z) - \tau_0(\delta k^*(z) + w\ell^*(z))}{y^*(z) - \delta k^*(z) - w\ell^*(z)} \tag{A-52}$$

where $\tau^*(z), y^*(z), k^*(z), \ell^*(z)$ are the optimal firm policies. See Appendix A for derivations of the optimal policies.

The mean firm ETR in the model is

$$\text{Mean ETR} = \int_{z_D}^{\infty} ETR(z)\phi(z) dz \tag{A-53}$$

The aggregate ETR is computed as

$$\text{Aggregate ETR} = \frac{\int \tau^*(z) y^*(z)\phi(z) dz - \tau_0(\delta K + wL)}{Y - \delta K - wL}, \tag{A-54}$$

where $K, L,$ and Y refer to aggregate quantities of capital, labor, and output, respectively, as defined in Section 3.8

The remaining ETR moments are the mean values by quantiles of firm size – the ten deciles and the top percentile. It is straightforward to show that measures of firm size such as capital, output, revenue, labor, or market value are all monotonic in z. Therefore, we use the distribution of productivity directly to define the size thresholds in the model. Let $\Phi(z)$

denote the cumulative density function for firm productivity. Then the level of productivity at the nth percentile, which we will write as z_n, can be computed as

$$z_n = \Phi^{-1}\left(\frac{n}{100}\right), \tag{A-55}$$

The mean ETR in decile j can be computed as

$$\text{Mean ETR in decile } j = \int_{z_{10(j-1)}}^{z_{10j}} ETR(z)\phi(z)dz, \tag{A-56}$$

for $j \in \{1, 2, \ldots, 10\}$. Similarly, the mean ETR in the 99th percentile is computed as

$$\text{Mean ETR in 99th percentile} = \int_{z_{99}}^{\infty} ETR(z)\phi(z)dz. \tag{A-57}$$

Details of the empirical estimates of ETR are provided in Section 2.