Quantifying the Effect of Corporate Taxes on the Life Cycle of Firms

Neira, Julian and Singhania, Rish

University of Exeter, University of Exeter

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Quantifying the Effect of Corporate Taxes on the Life Cycle of Firms∗

Julian Neira  
University of Exeter

Rish Singhania  
University of Exeter

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Abstract

How does corporate taxation affect the life cycle of firms? A change in profit-tax rates affects the life cycle of firms through wages and through firm selection. We quantify these effects by looking at the average size of young and mature US firms 30 years after the Reagan Tax Cuts. We disentangle the wage and the selection effects using a model of firm dynamics. We find that the wage effect of profit tax cuts is about six times stronger than the selection effect. A change in population growth affects average firm size by changing the composition of surviving firms. We find that the effect of declining population growth on average firm size is three times stronger for mature firms than for young firms.

Keywords: Incidence; Corporate Taxation; Firm Lifecycle; Calibration

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1 Introduction

The firm lifecycle has been proposed to be an important determinant of macroeconomic outcomes (Hsieh and Klenow, 2014). Because it captures how quickly new businesses grow as they age, the firm lifecycle is indicative of the quality of entering firms and the degree of competition from incumbents. A policy instrument that directly affects the firm lifecycle is corporate taxation. Changes to US corporate tax policy provide an interesting case study. As noted by Auerbach and Slemrod (1997), US corporate taxes underwent a major tax reform in the 1980s. Since then, the lifecycle of US firms has also changed: Table 1 shows that US firms of all ages have been shrinking in size. Motivated by these observations, this paper studies how corporate taxes affect the firm lifecycle. We quantify the effect of corporate taxes by looking at post-1980 US data through the lens of a firm dynamics model.

<table>
<thead>
<tr>
<th>Table 1: Average Firm Size</th>
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<tbody>
<tr>
<td>Young</td>
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<tr>
<td>1980s</td>
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<td>2010s</td>
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<td>Percentage Change</td>
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Notes. Young firms are ages 0 to 10, mature firms are ages above 10. The above-age-10 group is observed starting in 1987. The 2010s includes years 2010 to 2016, the last year available in BDS data. Table 7 in Appendix A shows that the pattern is robust to different date and age cutoffs.

A drop in corporate taxes affects the firm lifecycle along both intensive and extensive margins. If the drop in taxes is passed onto workers in the form of higher wages, the cost of hiring labor goes up and firms shrink along the intensive margin; see Suárez Serrato and Zidar (2016) for evidence of tax passthrough in US states. The effect on the extensive margin is due to taxes affecting firm selection via the firm entry-exit decision. Firm selection determines the composition of surviving firms and therefore affects average size of all firm ages. The effect of corporate taxes along the intensive and extensive margins interact with each other: firm entry-exit decisions depend on profitability, which in turn depends on wages. A general equilibrium model with firm entry and exit dynamics captures these interactions. The workhorse model of firm dynamics, Hopenhayn (1992a), is one such model. However, the contribution of profit taxes to the extensive margin in this model is zero because the model features inelastic labor supply.\(^1\) In order to allow a nontrivial

\(^1\)When the outside option of exiting firms is untaxed, wages in the canonical Hopenhayn (1992a) completely undo the effect of taxes, leaving firm profits and entry-exit decisions unchanged. Appendix B.2 provides a formal proof.
role for the extensive margin, we introduce occupational choice between employment and entrepreneurship as in Lucas (1978) to the workhorse Hopenhayn model. Our occupational choice setting has the feature that it allows a drop in taxes to affect firm entry-exit decisions in either direction, depending on parameter values. We can then let the data determine the parameter values, and therefore the direction of the effect along the extensive margin.

As in Lucas, agents in our model choose whether to be employees or entrepreneurs. As in Hopenhayn, the model features a stationary firm-size distribution, along with firm growth and entry-exit dynamics. An agent who decides to be an entrepreneur pays an entry cost that includes forgone wages, and draws the productivity of his firm from a distribution that is iid across startups. After the productivity realization, the entrepreneur decides whether to operate his firm or exit. If he operates the firm, he receives after-tax firm profits and redraws his productivity next period. If he exits, he receives an exit payoff and chooses his occupation again next period. The exit payoff also depends on wages and captures the opportunity cost of operating a firm.

In this setting, a drop in profit taxes is passed onto workers in the form of higher wages. The increase in the cost of hiring lowers average size for all age groups, which shows up as a change along the intensive margin. Average size by age is also affected by the size threshold at which firms exit, which shows up as a change along the extensive margin. The effect of taxes on the exit threshold is determined by how taxes affect the exit payoff relative to the entry cost. Because they depend on forgone wages, both the exit payoff and the entry cost increase when profit taxes drop. Intuitively, the exit payoff relative to the entry cost captures the effective benefit of shutting down an existing firm and replacing it with a new firm. When the drop in taxes lowers the effective benefit, the exit threshold declines reflecting the decreased benefit of replacing existing firms. If we interpret firms in the model as capital, the effective benefit is similar to Tobin’s q. Under this interpretation, the exit threshold captures the rate at which entrepreneurs invest in new firms. The rate of investment declines when the drop in profit taxes lowers Tobin’s q.

For the quantitative analysis, we calibrate the model economy to match key features of US firm entry-exit dynamics and the firm-size distribution in the 1980-89 period. The profit-tax rate is set to 32 percent, the average of the effective corporate tax rate in the data over the same time period. We then quantify the role of the intensive and extensive margins using a counterfactual exercise in which we decrease profit taxes to 24 percent, the 2010-16 average corporate tax rate in the data. The intensive margin reduces average size for all age groups by 12 percentage points. Because the intensive margin operates through an increase in wages which affects all firms equally, its effect is identical in percentage terms for both young and mature firms. The extensive margin, however, affects young and mature firms differently. Firm selection along the extensive margin is stronger for young firms because
these firms tend to be closer to the size threshold at which firms exit, reflecting the fact that entrants start small and grow over time. Quantitatively, the effect of the extensive margin is approximately one-sixth of the intensive margin: it reduces average size of young firms by 2.2 pp and of mature firms by 1.9 pp.

Recent work by Hopenhayn, Neira and Singhania (2018) shows that changes in the rate of population growth are of first-order importance in determining the evolution of the firm-age distribution. These authors show that the effects of population growth operate only through the extensive margin, not the intensive margin. The average size of young and mature firms is an aggregate of average size by age for the underlying ages, weighted by the firm-age distribution. Therefore a change in the rate of population growth affects average size of the young and mature groups through the age distribution.

We introduce population growth into the calibrated model and compare its effects to that of changes in firm selection due to profit taxes. We find that population growth and firm selection work in opposite directions. A decline in population growth affects young and mature firms differently. It increases average size of young firms by 1.2pp and that of mature firms by 3.4pp. The increase occurs because population growth shifts the age distribution towards older firms, which are larger. The aging effect is stronger for mature firms because that group includes all firms with age above 10, and therefore does not have an upper bound on age. The main takeaway from these counterfactual exercises is that the wage effect of profit tax cuts is six times larger than the selection effect. The effect of population growth is about three times stronger for mature firms than it is for young firms.

We extend the analysis to consider the case of profit tax cuts that disproportionately benefit large firms, and the case of labor tax cuts. Both these extensions reinforce the takeaway from the benchmark counterfactual. The wage effect is much stronger than the selection effect. The effects of population growth are stronger for mature firms than for young firms.

**Related Literature.** Our paper is related to the literature on the incidence of corporate taxation. Since at least Harberger (1962) the literature has identified that a decline in corporate tax rates leads to an increase in wages in closed economies. The traditional mechanism is that, because firms are capital, a decline in corporate taxes is equivalent to a decline in capital taxes. As capital taxes decline, investment increases, raising the stock of capital and the marginal product of labor, which in turn increases wages. Similarly, in our paper, a decline in corporate tax rates increases the number of firms, which raises the marginal product of labor and therefore wages. Recent empirical work finds evidence for this effect. Suárez Serrato and Zidar (2016) use data on US states and find that a 1 percent cut in business taxes increases real wages anywhere from 0.58 percent to 1.1 percent over a
ten-year period. Using German data, Fuest, Peichl and Siegloch (2018) find that a tax cut of 1 percent increases real wages by 0.39 percent.

Our paper is related to Sedláček and Sterk (2019) who analyze the effect of the Tax Cuts and Jobs Act on US business dynamism through the lens of the workhorse Hopenhayn model. In their paper, endogenous exit is generated via a fixed operating cost which is tax deductible. The feature of that setup is that corporate taxes affect firm selection in the same direction, regardless of parameter values. We generate endogenous exit through occupational choice, which has the feature that the direction of the effect is not built into the model.

The decline in the average firm size conditional on firm age has been documented earlier. Hopenhayn, Neira and Singhania (2018) document this decline and show that declining population growth increases average firm size in the aggregate by shifting the firm-age distribution towards older firms, which tend to be larger. Pugsley, Sedláček and Sterk (2019) document a decline in the proportion of high-growth entrants in the US, which also shows up as a change in the lifecycle of US firms. Ignaszak (2019) explores the role of the supply of college-educated workers for a similar change in the lifecycle of firms in Germany.

The setup of our model is closely related to Hopenhayn (2016). That paper combines occupational choice with firm entry-exit in a static setting to study firm size and its implications for cross-country TFP differences. Neira and Singhania (2018) use a similar model with permanent shocks to study how corporate taxes affect firm entry rates. The setup we use in this paper is more general in that it features occupational choice and firm dynamics with \( iid \) shocks. More broadly, our paper is related to studies that investigate the interaction between occupational choice and firm dynamics; see, for example, Buera and Shin (2013), Cagetti and De Nardi (2006) and Yurdagul (2017).

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 presents the calibration and the main counterfactual experiment. Section 4 extends the analysis to heterogeneous profit tax cuts and labor tax cuts. Section 5 concludes.

2 Model

Firms in the model economy produce a single good, which we denote as the numeraire. Firm output is produced using labor. The production function of a firm is

\[
f(z, n) = zn^\alpha, \tag{1}\]
where \( z \) represents firm productivity and \( n \) is the number of employees. The production function exhibits decreasing returns to scale, \( \alpha < 1 \). Each firm is run by one entrepreneur. Given productivity \( z \) and the wage rate \( w \), the entrepreneur chooses the number of employees \( n \) so as to maximize firm profits. Let \( n(z, w) \) and \( \pi(z, w) \) denote the corresponding employment and profit functions, respectively. Both functions are increasing in \( z \) and decreasing in \( w \).

The economy is populated by a unit mass of infinitely-lived agents with discount factor \( \beta \). Agents are ex-ante identical, risk neutral, and maximize the present value of lifetime payoffs. At the beginning of a period, agents choose between working for a wage or starting their own firm. Agents who decide to start their own firm pay a fixed entry cost of \( c_e \) units of output and forgo the opportunity to work until the firm exits. Therefore, the cost of entry includes a fixed component \( c_e \) and a variable component that depends on wages. After agents pay the entry cost, firm productivity \( z \) is drawn from a distribution with support \( Z \) and CDF \( G \). The productivity draw is iid across startups. Once drawn, the productivity of a firm evolves according to a persistent Markov process with conditional distribution \( F(z_{t+1}|z_t) \). The conditional distribution is continuous and nondecreasing.

After the productivity realization, agents in their role as entrepreneurs choose whether to operate their firm or to exit. Entrepreneurs operating the firm receive after-tax firm profits. Entrepreneurs who exit recover \( b \) units of output. The positive exit payoff—equal to \( b \) plus discounted future payoffs—generates endogenous exit in the model. One interpretation of \( b \) is that of a salvage value of a firm upon exit.\(^2\) In the next period, surviving firms redraw their productivity and again decide whether to exit or to continue. Entrepreneurs of firms that exit cannot work in the current period. These agents face the occupational choice decision at the beginning of the next period.

A government authority taxes firm profits at the rate \( \tau \). Tax revenues are returned as lump-sum transfers to all agents such that the government balances its budget every period.

Let \( V(z, w_t) \) denote the value of a firm with productivity \( z \) that faces a deterministic path of the wage rate \( w_t = \{w_\tau\}_{\tau \geq t} \). Let \( W(w_t) \) denote the value function of an agent before he chooses his occupation. We have

\[
W(w_t) = \max \left\{ w_t + \beta W(w_{t+1}), \int V(z, w_t)G(dz) - c_e \right\}.
\]

The agent compares his payoff from working for the wage \( w_t \) today and choosing his occupation again next period, to the expected payoff from starting a firm net of the fixed

\(^2\)Another interpretation is that \( b \) determines the operating cost of keeping the firm alive for another period. More precisely, the value function can be written such that \( (1 - \beta)b + \beta w \) is the operating cost each period; see Appendix B. This operating cost can be thought of as the opportunity cost of not being an employee next period \( \beta w \) and current entrepreneurial effort \( (1 - \beta)b \).
cost of entry.

The value of a firm is

\[ V(z, w_t) = \max \left\{ b + \beta W(w_{t+1}), (1 - \tau)\pi(z, w_t) + \beta \int V(z', w_{t+1}) F(dz'|z) \right\}. \tag{3} \]

The value function \( V(z, w_t) \) indicates that the entrepreneur running the firm with productivity \( z \) chooses between operating and exiting. If he exits, the entrepreneur receives the payoff \( b \) plus the present value of choosing his occupation next period \( \beta W'(w_{t+1}) \). If the entrepreneur chooses to operate, he receives a period payoff equal to after-tax firm profits, \( (1 - \tau)\pi(z, w_t) \) and the expected discounted future value of the firm.

Firm profits, and therefore firm values, are increasing in productivity \( z \). There exists a productivity threshold \( z^*_t \) such that firms with \( z \leq z^*_t \) exit. Let \( \bar{x}(z, w_t) \) denote the policy function associated with \( V(z, w_t) \). Define \( \bar{x}(z, w_t) \) to equal 1 if a firm has productivity \( z \leq z^*_t \) and chooses to exit. The policy function equals 0 for firms that do not exit, those with \( z \geq z^*_t \).

Let \( \mu_t \) denote the measure of firms operating in period \( t \). The measure gives us the mass of firms with productivity below \( z \), \( \mu_t(z) = \int_{z \leq z^*_t} d\mu_t(z) \). The total mass of operating firms at time \( t \) is \( M_t = \int d\mu_t(z) \). Let \( s_t \) denote the measure of operating startups in period \( t \). We have \( s_t(z) = \int_{z \leq z^*_t} dG(z) \). The total mass of operating startups in period \( t \) is \( S_t = \int ds_t(z) \). Because the fraction \( G(z^*_t) \) of startups exit without operating, the total mass of entering startups is \( S_t / (1 - G(z^*_t)) \). Let \( x_t \) measure incumbent firms that exit at the beginning of period \( t \). Given the policy function for exit, we have \( x_t(z) = \int \int_{z \leq z^*_t} \bar{x}(z, w_t) dF(z'|z) d\mu_{t-1}(z) \). The total mass of exiting firms is denoted \( X_t \). Note that we only count firms that have operated for at least one period amongst exiting firms. The mass of startups that exit immediately, \( S_t G(z^*_t) / (1 - G(z^*_t)) \), is not included in \( X_t \).

The mass of operating firms in period \( t + 1 \) equals the mass of surviving incumbents \( \mu_t(z) - x_{t+1}(z) \) plus the mass of operating startups \( s_{t+1}(z) \). We have

\[ \mu_{t+1}(z) = \mu_t(z) - x_{t+1}(z) + s_{t+1}(z). \tag{4} \]

Let \( N_t \) denote the mass of employees in period \( t \). Because the total number of agents is normalized to 1, we have the following resource constraint,

\[ N_t = 1 - M_t - X_t - \frac{S_t}{1 - G(z^*_t)} G(z^*_t). \]

At the end of the current period, the entrepreneurs of non-operating firms join the agents who were employees in the current period. Therefore, at the beginning of the next period, the mass of agents facing the occupational choice decision equals \( N_t + X_t + \)
\[ S_t G(z_t^*) / [1 - G(z_t^*)] \], or equivalently 1 - \( M_t \).

The model economy exhibits a stationary firm-productivity distribution when the measure \( \mu \) is invariant across periods, \( \mu_{t+1}(z) = \mu_t(z) \) for all \( z \). Equivalently, from (4), we have \( s_{t+1}(z) = x_{t+1}(z) \) for a stationary distribution. For each \( z \), the mass of operating startups \( s_{t+1}(z) \) must replace the mass of exiting firms \( x_{t+1}(z) \). Because startups replace existing firms that exit, a stationary distribution of firm productivity allows for entry-exit dynamics at the individual firm level.

A stationary competitive equilibrium consists of a constant sequence of wages \( w_t = w^* \), exit threshold \( z^* \), value functions \( V(z, w^*) \), and \( W(w^*) \), labor demand function \( n(z, w^*) \), exit-policy function \( \pi(z, w^*) \), aggregate measure \( \mu^* \), mass of startups \( S \), mass of firms \( M \), mass of employees \( N \), mass of exiting firms \( X \), and lump-sum transfers \( T \) such that

1. **Exit:** \((1 - \tau)\pi(z^*, w^*) + \beta \int V(z', w^*)F(dz'|z^*) = b + \beta W(w^*) \),
2. **Entry:** \( \int V(z, w^*)G(dz) - c_e = w^* + \beta W(w^*) \),
3. **Labor-market clearing:** \( \int_{z^*}^{\infty} n(z, w^*)\mu^*(dz) = N \),
4. **Resource constraint:** \( N + M + X + \frac{S}{1 - G(z^*)}G(z^*) = 1 \),
5. **Government budget balance:** \( T + \tau \int_{z^*}^{\infty} \pi(z, w^*)\mu^*(dz) = 0 \),
6. **Stationary distribution:** \( \mu' = \mu = \mu^* \) solves (4).

The exit condition indicates an agent operating a firm with productivity \( z^* \) is indifferent between operating and exiting. Because firm value is increasing in productivity \( z \), it is optimal for firms with \( z \leq z^* \) to exit and for firms with \( z \geq z^* \) to operate. The entry condition states that an individual agent is indifferent between starting a firm, payoff \( \int V(z)G(dz) - c_e \), or working for a wage this period and choosing his occupation again next period, for the payoff \( w^* + \beta W(w^*) \). The value of being an agent who is yet to choose an occupation is found by applying the indifference condition to (2). We obtain \( W(w_t) = w_t + \beta W(w_{t+1}) \).

In a stationary equilibrium, the wage rate is invariant over time, so we have

\[ W(w^*) = \frac{w^*}{1 - \beta} \tag{5} \]

The labor-market-clearing condition states that aggregate labor demand by operating firms, \( \int_{z^*}^{\infty} n(z, w^*)\mu(dz) \), equals aggregate labor supply, \( N \). The resource constraint states that the total number of employees and entrepreneurs in the economy equals the size of the population. The government-budget-balance condition states that lump-sum transfers equal total tax revenues. Because lump-sum transfers are paid to agents regardless of
whether they work or start a firm, and regardless of what the firm does subsequently, these transfers do not affect any other equilibrium variables.

**Proposition 1.** In a stationary equilibrium, a decrease in the profit-tax rate $\tau$ increases the wage rate $w^*$.

**Proof.** Suppose the wage rate does not change with $\tau$. Then the decrease in $\tau$ increases after-tax profits and therefore firm value. Because the outside option does not change, the exit condition implies that $z^*$ must decrease. However, the entry condition cannot hold at the lower value of $z^*$. This is because the expected value of the startup increases, but the cost of entry is unchanged. It follows that the wage rate must change with $\tau$. A decrease in the wage rate cannot be consistent with equilibrium because it raises firm values, exacerbating the effect of the initial decrease in $\tau$. Therefore, $w^*$ must increase. Intuitively, a decrease in the profit tax rate raises firm values, which spurs entry. The corresponding increase in labor demand raises wages. ■

To determine how profit taxes affect the exit threshold, we look at the effect of profit taxes on the costs and benefits of exiting. In equilibrium, the entry and exit conditions hold with equality. This implies that

$$\frac{V(z^*, w^*)}{\mathbb{E}[V(z, w^*)]} = \frac{b + \frac{\beta w^*}{1-\beta}}{c_e + w^* + \frac{\beta w^*}{1-\beta}},$$

(6)

where we use equation (5) to substitute for $W(w^*)$. The mathematical expectation on the left-hand side is taken over the startup distribution $G$. This formulation captures the fact that the relevant costs and benefits of exit are defined relative to the value of the outside option. The effective cost of exit is the value of the marginal firm normalized by the value of the average firm. Similarly, the effective benefit of exit is the exit payoff normalized by the entry cost. Notice we can manipulate equation (6) to write

$$\frac{V(z^*, w^*)}{b + \frac{\beta w^*}{1-\beta}} = \frac{\beta \mathbb{E}[V(z, w^*)]}{\beta \left( c_e + w^* + \frac{\beta w^*}{1-\beta} \right)},$$

(7)

which has a neat economic interpretation. The left-hand-side is the rate of return from operating the marginal firm today and the right-hand-side is the rate of return from shutting down the marginal firm and creating a startup tomorrow. Therefore, equation (6) implies that the exit threshold $z^*$ is such that the marginal entrepreneur is indifferent between operating his firm today, and shutting down and creating a startup tomorrow.

The expected value of an entrant, $\mathbb{E}[V(z, w^*)]$, is a weighted average of the value of
startups that do not operate, those with \( z \leq z^* \), and the average value of operating startups, those with \( z \geq z^* \). It follows that the inverse of the effective cost of exit can be written as

\[
\frac{\mathbb{E}[V(z, w^*)]}{V(z^*, w^*)} = G(z^*) + [1 - G(z^*)] \frac{\mathbb{E}[V(z, w^*)|z \geq z^*]}{V(z^*, w^*)}
\]

where we have used the fact that the value of a non-operating startup is \( V(z^*, w^*) \). Notice that \( \mathbb{E}[V(z, w^*)|z \geq z^*]/V(z^*, w^*) > 1 \), corresponding to the fact that the value of operating startup exceeds the value of the marginal startup. Therefore, the inverse of the effective cost of exit in (6) is a weighted average, with the weight \( G(z^*) \) on unity and the weight \( 1 - G(z^*) \) on a number greater than unity.

A change in the profit tax rate affects the exit threshold \( z^* \) if it alters either the effective cost or the effective benefit of exit. In what follows, we provide conditions under which a change in taxes affects the effective benefit of exit. We then show that the exit threshold \( z^* \) must change for the effective benefit to equal the effective cost. We then discuss the role of occupational choice in obtaining these results. Finally, we discuss the decomposition that allows us to quantify the role of the intensive and extensive margins of corporate taxes on the firm lifecycle.

**Corollary 1.** Consider a drop in profit taxes. The effective benefit of exit (i) remains unchanged if \( b = \beta c_e \), (ii) decreases if \( b > \beta c_e \), and (iii) increases if \( b < \beta c_e \).

**Proof.** Differentiate the effective benefit of entry with respect to \( \tau \) and use Proposition 1. ■

The results in Corollary 1 can be understood by writing the effective benefit as follows,

\[
\text{Effective benefit of exit} = \beta \times \left( \frac{b + \frac{\beta w}{1-\beta}}{\beta c_e + \frac{\beta w}{1-\beta}} \right)
\]

This formulation highlights that, when \( b = \beta c_e \), the relative benefit of the marginal firm exiting and an re-entering next period simply equals the time discount factor \( \beta \). This is because the present value of the entry cost paid next period, \( \beta c_e + w\beta/(1-\beta) \), exactly equals the cost of exit \( b + w\beta/(1-\beta) \) this period. In that case, the effective benefit of exit is independent of wages and therefore unaffected by changes in the profit tax.

If \( b \neq \beta c_e \), a drop in the profit-tax rate changes the effective benefit of exit through wages. The direction of the change depends on how sensitive the entry cost and the exit payoff are to the increase in wages. If \( b < \beta c_e \), the exit payoff is more sensitive to the increase in wages. As a result, the numerator in (9) increases by more than the denominator and the effective benefit of exit increases. The opposite is true if \( b > \beta c_e \): when wages increase the denominator increases by more than the numerator leading to a decrease in
the effective benefit of exit. The parameters $b$ and $\beta c_e$ determine what proportion of the entry cost and the exit payoff consist of wages, and therefore control the sensitivity of these variables to the increase in wages.

Consider a drop in profit taxes. Suppose $b > \beta c_e$ and the corresponding increase in wages reduces the effective benefit of exit. To restore equilibrium, the effective cost of exit must decrease to equal the lower effective benefit. From (8), the effective cost can decrease either because the relative value of operating startups increases, or because $z^*$ drops raising the weighted average. The following corollary shows that, keeping $z^*$ fixed, the change in the relative value of operating startups is not enough to restore equilibrium. Therefore, $z^*$ must decrease when taxes lower the effective benefit of exit.

**Corollary 2.** Consider a drop in the profit tax rate $\tau$. For a fixed $z^*$, we have

$$
\frac{d}{d\tau} \left( \frac{\mathbb{E}[V(z, w^*)]}{V(z^*, w^*)} \right) \bigg|_{z^*} \geq \frac{d}{d\tau} \left( \frac{\mathbb{E}[V(z, w^*]|z \geq z^*]}{V(z^*, w^*)} \right) \bigg|_{z^*}.
$$

**Proof.** See Appendix B.1.

Corollary 2 shows that the change in the inverse of the effective cost of exit is greater than the change in the relative value of operating startups. This result implies that the exit threshold $z^*$ must change when a drop in taxes lowers the effective cost of exit. Because $\mathbb{E}[V(z, w^*]|z \geq z^*]/V(z^*, w^*) > 1$, the threshold $z^*$ must decrease so as to increase the weight $1 - G(z^*)$ until the effective cost equals the lower effective benefit. This result is easy to see in a permanent shock economy in which startups draw their productivity from a Pareto distribution; see Neira and Singhania (2018). In this economy, the relative value of operating startups is independent of taxes, and so unaffected by the drop in $\tau$. The decrease in the effective benefit must therefore be accommodated entirely by a decrease in $z^*$, which leads to an increase in the weight $1 - G(z^*)$.

The following proposition summarizes how a change in profit taxes affects the exit threshold.

**Proposition 2.** Consider a drop in profit taxes. The exit threshold $z^*$ (i) remains unchanged if $b = \beta c_e$, (ii) decreases if $b > \beta c_e$, and (iii) increases if $b < \beta c_e$.

**Proof.** Follows from Corollaries 1, 2 and Proposition 1.

Firms in the model are similar to capital. The effective benefit of exiting is the market value of the firm divided by the cost of replacing the firm next period. This ratio is similar to Tobin’s q. When $b = \beta c_e$, taxes do not affect the q-ratio so firm entry-exit are unaffected. When $b > \beta c_e$, a drop in profit taxes lowers Tobin’s q making it less attractive to shut down
an existing firm and create a new firm next period. This implies that the exit threshold declines. With \( b > \beta c_e \), the effect of lower taxes on the exit threshold is the same as that of a higher fixed cost of entry, \( c_e \). Both these changes lower the effective benefit of exit leading to a decrease in the exit threshold. There is, however, a crucial difference: lowering taxes raises wages, whereas increasing \( c_e \) leads to a drop in wages. This difference leads to the two experiments having opposite implications for firm size.

The Role of Occupational Choice. The exit threshold is neutral to changes in profit taxes in a standard firm-dynamics model that does not feature occupational choice; see Appendix B.2 for details. This model corresponds to a version of Hopenhayn (1992a). It features inelastic labor supply and a pool of potential startups, instead of a mass of people who face an employment-entrepreneurship tradeoff. The rest of the setup is identical to the model presented in this paper. Without occupational choice, a drop in profit taxes raises the wage rate as in Proposition 1. However, the increase in wages does not change the effective benefit of exiting, which in this case is equal to \( c_e/b \). Because labor supply is perfectly inelastic, the increase in wages exactly offsets the initial drop in taxes, leaving firm profits and therefore the effective benefit of exiting unchanged. Taxes do not change the effective cost or benefit of exit, so the exit threshold is unaffected. In the presence of the occupational choice, however, labor supply is not perfectly inelastic. Therefore the passthrough of the drop in profit taxes to wages is incomplete, and the exit threshold is affected as discussed above.

We generated firm exit by providing entrepreneurs with the outside option of working. A commonly employed version of the Hopenhayn model generates firm exit by assuming that firms face a fixed cost of operation, which they can avoid by exiting. If firms pay taxes on profits net of operating costs, a decrease in the profit-tax rate increases the exit threshold. The intuition is simple: a drop in profit taxes increases wages, without increasing operating costs, and therefore the productivity threshold at which firms break even goes up; see Sedláček and Sterk (2019). Instead, if firms pay taxes on gross profits, which include operating costs, then we recover the result that the exit threshold is neutral to changes in taxes. As Proposition 2 shows, introducing occupational choice allows a drop in taxes to affect the exit threshold in both directions, depending on parameter values.

Intensive vs Extensive Margins. To measure the effect of corporate taxes on the firm lifecycle, we look at how average size by firm age changes across steady states pre- and post-reform. Let \( AFS \) denote average size of firms for a generic age group. We have

\[
AFS = \int n(z, w^*)\mu(dz)
\]
where $\mu$ denotes the productivity distribution of firms in that group. The percentage change in average size by age in pre- and post-reform steady states can be decomposed as follows

$$\%\Delta AFS = \frac{1}{AFS_{pre}} \int [n(z, w^*_{post}) - n(z, w^*_{pre})]\mu_{pre}(dz)$$

Intensive margin

$$+ \frac{1}{AFS_{pre}} \int n(z, w^*_{post})[\mu_{post} - \mu_{pre}](dz).$$

(11)

Extensive margin

The decomposition follows by adding and subtracting $\frac{1}{AFS_{pre}} \int n(z, w^*_{post})\mu_{pre}(dz)$ on the right hand side of the definition of the percentage change in average firm size.

The intensive margin isolates the contribution of the change in the number of employees within firms in response to the change in wages, by keeping the weights of the productivity distribution at their pre-reform values. The employment function is given by

$$n(z, w) = \left(\frac{zw^a}{w^{1-a}}\right)^{1/(1-a)}.$$

Because the employment function is log-linear, the percentage decrease in employment following an increase in wages is identical for all productivities $z$. We refer to this as the wage effect. By itself the wage effect leads to identical percentage declines in average size by age for all firm ages.

The extensive margin isolates the contribution of the weights of the productivity distribution to the change in average size of the group, by keeping firm employment at its post-reform values. The weights change because taxes affect the exit threshold and therefore the degree of firm selection. We refer to this as the selection effect. The impact of the selection effect on average size is easiest to see for entrants. The average size of entrants is $\int_{z^*}^{\infty} n(z, w)dG(z)$. A higher value of the exit threshold $z^*$, increases the size of the smallest operating startup without affecting the distribution $G$. Because firm selection determines the composition of surviving firms, the average size of older ages is also affected.

3 Quantitative Analysis

We next evaluate the quantitative importance of the intensive and extensive margins of corporate tax changes. The quantitative exercise consists of calibrating the model to a balanced growth path corresponding to the US economy in the 1980-89 period. Hopenhayn, Neira
and Singhania (2018) show that population growth dynamics are of first-order importance for firm dynamics. We introduce population growth in our baseline calibration to study how the effects of corporate taxes on the firm lifecycle interact with population growth. We run a counterfactual in which we compute a balanced growth path with lower profit tax rates and lower population growth, corresponding to their 2010-16 averages, while keeping all other parameters unchanged. We then quantify the effects along the extensive and intensive margins and further decompose our results into the wage and selection effect of taxes and the effects of population growth.

Table 2

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
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<tbody>
<tr>
<td><strong>Assigned</strong></td>
</tr>
<tr>
<td>Value</td>
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<tr>
<td>β 0.96</td>
</tr>
<tr>
<td>α 0.64</td>
</tr>
<tr>
<td>δ 1.65%</td>
</tr>
<tr>
<td>g 1.64%</td>
</tr>
<tr>
<td>τπ 32%</td>
</tr>
<tr>
<td>τℓ 20%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Jointly Calibrated</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameters</strong></td>
</tr>
<tr>
<td>Value</td>
</tr>
<tr>
<td>c_e 66.57</td>
</tr>
<tr>
<td>b 66.43</td>
</tr>
<tr>
<td>µ_G −1.18</td>
</tr>
<tr>
<td>µ_z −0.004</td>
</tr>
<tr>
<td>ρ 0.971</td>
</tr>
<tr>
<td>σ_e 0.229</td>
</tr>
</tbody>
</table>

**Calibration.** A model period is set to one year. The discount factor β is set to its standard value of 0.96, which corresponds to an annual interest rate of 4 percent. The curvature parameter of the production function α is set to its standard value of 0.64. This value of α implies an aggregate labor share of 0.64, which is broadly consistent with labor’s share of national income. We set the growth rate of population to 1.64 percent, equal to the average rate of labor force growth for the 1980-89 period. In the model, firms larger than a certain size are unlikely to exit endogenously because they are too far from the exit threshold. In the data, however, large firms have positive exit rates. In order to be consistent with this fact, we introduce an exogenous exit rate into the model. It is set to 1.65 percent to match the exit rate of larger firms (20 employees or more) for the 1980-89 period. The profit tax
The rate is set to the average effective corporate tax rate calculated in Zucman (2014) for the 1980-89 period. Because labor income is taxed in the data and taxes on labor income matter for the employment-entrepreneurship margin, we introduce a flat-tax on labor income and map it to the aggregate labor income tax rate in McDaniel (2007).

Log-productivity follows an AR(1) process,

\[
\log(z_{t+1}) = \mu_z + \rho \log(z_t) + \epsilon_{t+1}; \quad \epsilon_{t+1} \sim \mathcal{N}(0, \sigma^2_{\epsilon})
\]

with \( \rho \) as the persistence parameter, \( \mu_z \) as the drift parameter and \( \sigma^2_{\epsilon} \) as the variance of shocks. The distribution of startup productivities \( G \) is lognormal with mean \( \mu_G \) and variance \( \sigma^2_G \). We reduce the number of parameters by tying the variance of startup productivity to the variance of the AR(1) process, \( \sigma^2_G = \sigma^2_{\epsilon} / (1 - \rho^2) \), as in Hopenhayn (1992b).

We calibrate the remaining parameters \( \{c_e, b, \mu_G, \mu_s, \rho, \sigma_{\epsilon}\} \) to jointly match 1980-89 averages of the startup rate, average startup size, average firm size, and 5-year exit rates. We normalize wages to unity in the benchmark calibration, as in Hopenhayn and Rogerson (1993). Doing so addresses the identification issue that arises because prices and productivity enter multiplicatively in first order conditions, implying that changes in prices and productivity cannot be disentangled. In order to discipline the response of wages to corporate tax cuts, we target the lower bound of the wage-response estimate in Suárez Serrato and Zidar (2016, Table 5).

All calibrated parameters jointly influence all the targets. We highlight certain parameters that play a more important role in matching certain targets. The fixed entry cost \( c_e \) primarily determines the entry rate. The parameter \( \mu_G \) controls the mean of the startup distribution, and therefore plays an important role in the average size of startups. The drift of the AR(1) process, \( \mu_z \), primarily determines average productivity and therefore average firm size. The variance of shocks to the AR(1) process determines the size of the exit region, so this parameter gets at the 5-year exit rate.

Table 2 summarizes the calibrated parameters along with the targets and the corresponding match. We saw in Proposition 2 that the effect of tax cuts on the exit threshold, and therefore on the direction of the selection effect, depends on the relationship between \( b \) and \( \beta c_e \). We do not impose any restrictions on the parameter space and let the data determine the relationship between these parameters. The calibrated value of \( b \) implies that the salvage value of a firm is slightly lower than the fixed entry cost \( c_e \). Because \( b \) is greater than \( \beta c_e \) in the calibration, a drop in profit taxes by itself will lower the exit threshold in the calibrated model.
3.1 Findings

Table 3: Average Firm Size

<table>
<thead>
<tr>
<th></th>
<th>Young Model</th>
<th>Young Data</th>
<th>Mature Model</th>
<th>Mature Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>11.95</td>
<td>10.00</td>
<td>39.07</td>
<td>43.27</td>
</tr>
<tr>
<td>2010s</td>
<td>10.39</td>
<td>8.76</td>
<td>34.92</td>
<td>38.80</td>
</tr>
<tr>
<td>Percentage Change</td>
<td>−13.1%</td>
<td>−12.3%</td>
<td>−10.6%</td>
<td>−10.3%</td>
</tr>
</tbody>
</table>

Notes. Firms aged 0 to 10 are classified as young, whereas firms aged above 10 are classified as mature. The model values for the 1980s are nontargeted moments in the benchmark calibration, with a profit tax rate of 32 percent and a population growth rate of 1.64 percent. The model values for the 2010s are generated by running a counterfactual with a profit tax rate of 24 percent and a population growth rate of 0.59 percent. All other parameters are kept at their 1980s levels.

Average Firm Size by Age. Given that we are quantifying the effect of corporate tax changes on the lifecycle of US firms, it is important that we start off with a reasonable match to the US firm life cycle. The first row of Table 3 compares average size of young and mature firms in the 1980s benchmark calibration to US data over the same time period. The model does a decent job of capturing the average size of both young and mature firms, even though these were not directly targeted moments.

The second row of Table 3 reports the benchmark counterfactual exercise, which we label the 2010s economy. In this counterfactual all parameters are the same as in the 1980s economy except for two changes. First, the profit-tax rate drops from 32 percent in the 1980s to 24 percent in the 2010s. The 8pp drop in the profit-tax rate corresponds to the observed drop in the data for corporate taxes paid on the domestic income of C-corporations from the 1980s to the 2010s (Zucman, 2014). Second, the population growth rate drops from 1.64 percent in the 1980s to 0.59 percent in the 2010s, the average US labor force growth rate from 2010 to 2016. The third row reports the percentage change in the average size of each age group between the 1980s and the 2010s.

We compare the decline in average size in the counterfactual economy to the decline in the data. The purpose of this comparison is not to claim that profit tax cuts were responsible

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3Zucman (2014) reports values up until the year 2013. We extend the calculations of Zucman (2014) to the year 2016 and consider the difference between the 1980-89 average to the 2010-16 average. Our extension of Zucman’s calculations is available on our websites. There are several measures of effective corporate tax rates. We consider the most conservative measure of the tax change, Effective Corporate Tax Rates on Domestic Income Excluding S-Corps, which results in an 8 percentage point drop. The drop in taxes increases to 11pp if we include S-Corps. The inclusion of taxes paid on foreign corporate income increases the tax drop by a further 1pp.
for the decline in average size observed in US data. Rather, the comparison serves as a check that the decline in average size generated by the model is plausible, in that it is within the ballpark of the change in the data. Young firms in the model shrink by 1.56 employees versus 1.24 in the data, and mature firms in the model shrink by 4.15 employees versus 4.47 in the data. In percentage terms, young firms in the model shrink by 13.1 percent versus 12.3 percent in the data, and mature firms in the model shrink by 10.6 percent versus 10.3 percent in the data.

Table 4: Profit Tax Counterfactual

<table>
<thead>
<tr>
<th></th>
<th>Young</th>
<th>Mature</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTENSIVE MARGIN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage Effect</td>
<td>−12.04</td>
<td>−12.04</td>
<td>0</td>
</tr>
<tr>
<td><strong>EXTENSIVE MARGIN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Effect</td>
<td>−2.17</td>
<td>−1.94</td>
<td>0.23</td>
</tr>
<tr>
<td>Population Growth</td>
<td>1.16</td>
<td>3.39</td>
<td>2.23</td>
</tr>
<tr>
<td>Interaction</td>
<td>−0.03</td>
<td>−0.04</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Total Change</strong></td>
<td>−13.08</td>
<td>−10.63</td>
<td>2.45</td>
</tr>
</tbody>
</table>

Notes. The values indicate percentage changes in average firm size.

What is behind the drop in average size for each age group? Table 4 decomposes the change in average size in the counterfactual for each age group into intensive and extensive margins, as in (11). The wage effect of profit taxes acts along the intensive margin and generates a 12 percent drop in average size for both young and mature firms. The effects along the extensive margin combine two separate effects. First, because \( b \) is greater than \( \beta c_e \) in the calibrated model, the selection effect of profit taxes lowers the exit threshold which lowers average size for both age groups. The decline in average size is greater for the young group, 2.5 percent vs 2.2 percent, reflecting the fact that young firms tend to be closer to the exit threshold. The second effect along the extensive margin is the change in composition arising from a decline in population growth. As shown in Hopenhayn, Neira and Singhania (2018), a decline in population growth shifts the firm age distribution towards older firms, which are larger on average. The effect of population growth works in the opposite direction: it increases the average size of young and mature firms by 1.3 and 3.9 percent, respectively.

Decomposing the change in average size in the counterfactual exercise conveys two messages. First, the wage effects of profit tax cuts generate most of the decline in average
firm size by age in the counterfactual economy. In terms of magnitudes, the wage effect is roughly four to six times as large as the selection or population growth effect, depending on the age group. The second message is that the differential decline in average size of young and mature firms that we observe in the counterfactual is generated mostly by changes in population growth. While both the selection and population growth effects generate a differential decline in average size, the two effects operate in different ways. The selection effect works by reducing the average size of the young age group, whereas the population growth effect works by increasing the average size of the mature group.

4 Extensions

Table 5: Heterogeneous Tax Cuts Counterfactual

<table>
<thead>
<tr>
<th></th>
<th>Young</th>
<th>Mature</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTENSIVE MARGIN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage Effect</td>
<td>−10.71</td>
<td>−10.71</td>
<td>0</td>
</tr>
<tr>
<td>EXTENSIVE MARGIN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Effect</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Population Growth</td>
<td>1.18</td>
<td>3.44</td>
<td>2.26</td>
</tr>
<tr>
<td>Interaction</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Change</td>
<td>−9.53</td>
<td>−7.27</td>
<td>2.26</td>
</tr>
</tbody>
</table>

Notes. The values indicate percentage changes in average firm size.

Heterogeneous Tax Cuts. In the benchmark counterfactual, taxes were reduced by 8 percentage points uniformly for all firms. How do the effects along the extensive and intensive margins change when profit-tax cuts disproportionately benefit larger firms? We explore this scenario by considering a tax reform in which the aggregate decline in the profit tax rate is the same, 8 percentage points, but the magnitude of the decline increases linearly with firm size. The linear tax function is such that the smallest firms do not benefit from tax cuts and pay a 32 percent tax on profits, whereas the largest firms benefit maximally from the tax cut and pay no taxes on their profits.4

4In particular, we consider the tax function \( \tau_\pi(z) = \max\{0, 0.32 - m \cdot n(z)\} \), where \( m = 1.65 \times 10^{-4} \). This function implies that the tax rate for the smallest firms is 32 percent. Firms with more than 1960 employees pay zero profit taxes.
As in the benchmark counterfactual, we reduce both profit taxes and population growth in the heterogeneous tax cut counterfactual. Table 5 decomposes the resulting decline in average size along the intensive and extensive margins. The table reiterates the messages from the benchmark counterfactual with uniform reduction in profit taxes. The wage effects along the intensive margin mostly generate the magnitude of the decline in average firm size for both the age groups, and the effects due to population growth mostly generate the difference between young and mature firms. The primary difference from the case with uniform tax cuts is that the role of selection is muted. This reflects the fact that the exit threshold is determined by the change in value of the smallest firms. The heterogeneous tax cuts benefit the smallest firms only in expectation, which is why the exit threshold moves little.

Table 6: Profit Tax vs. Labor Tax Counterfactuals

<table>
<thead>
<tr>
<th>Panel A: Profit Tax Cuts</th>
<th>Panel B: Labor Tax Cuts</th>
<th>Panel C: Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young</td>
<td>Mature</td>
</tr>
<tr>
<td><strong>INTENSIVE MARGIN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage Effect</td>
<td>-12.04</td>
<td>-12.04</td>
</tr>
<tr>
<td>Labor Tax Effect</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interaction</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>EXTENSIVE MARGIN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Effect</td>
<td>-2.17</td>
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<td>Population Growth</td>
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<tr>
<td>Interaction</td>
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<td>-0.04</td>
</tr>
<tr>
<td><strong>Total Change</strong></td>
<td>-13.08</td>
<td>-10.63</td>
</tr>
</tbody>
</table>

Notes. The values indicate percentage changes in average firm size.

**Profit Tax Cuts vs. Labor Tax Cuts.** The benchmark specification abstracted from changes in labor income taxes. Agents in our model choose between entrepreneurship and employment so, in addition to profit taxes, any changes in taxes on labor income will also affect the firm lifecycle. In this section we extend our decomposition exercise to the case of labor tax cuts. Our goal is to compare the effects of labor tax cuts to those of profit tax cuts, and study their interactions.

Unlike profit taxes, labor taxes show up directly in first-order condition of firms. Therefore, a decline in labor taxes affects the intensive margin via the direct effect and via its effect on wages. Some of the decline in labor taxes passes through to firms, so firm selection is also affected. To compare the effect of labor-tax cuts to profit-tax cuts, we run a
counterfactual in which we reduce labor taxes in the benchmark economy by 9.3pp. As with the other counterfactuals, we simultaneously change the rate of population growth to 0.59 percent, the average value of labor force growth in the 2010s. Table 6 presents the comparison. Panel A of that table reproduces the results for the benchmark counterfactual, while Panel B shows the results for the labor-tax counterfactual. The drop in labor taxes, combined with the drop in population growth, increases average size for young and mature firms by 4.66 percent and 7.71 percent, respectively. The direct effect of the decline in labor taxes is to reduce wages and increase average size for both age groups. This effect dominates the other effects, resulting in an increase in average size for both age groups. Both the magnitude and the direction of the wage, selection and population growth effects are similar to the benchmark counterfactual.

Table 6 Panel C shows the results for the case in which we combine profit-tax and labor-tax cuts. In this counterfactual, we start with the benchmark and uniformly reduce both profit taxes and labor taxes, by 8pp and 9.3pp respectively, along with population growth. We find that average size for young and mature firms drops by 10.16 and 7.35 percentage points, respectively. The drop in average size for both age groups is less than the profit-tax case in Panel A because the direct effect of labor taxes increases average size, counteracting the wage effect. The simultaneous reduction in both profit and labor taxes generates an interaction effect along the intensive margin, which was not present in the earlier counterfactual exercises. This interaction effect is about one-fourth of the wage effect. Labor tax cuts reinforce the selection effect of profit tax cuts, doubling the overall contribution of this effect. The effects of declining population growth on average size do not change much with the introduction of labor tax cuts.

There are two takeaway messages from this section. First, the introduction of labor tax cuts dampens the overall effect of profit tax cuts along the intensive margin, but enhances the selection effect along the extensive margin. The second takeaway is that the exercise in this section reinforces the message from the earlier counterfactual exercises. When both profit taxes and labor taxes are reduced simultaneously, it is the intensive margin that generates the bulk of the decline in average size by age. The differences in the magnitude of the decline are primarily due to the effects of population growth, which acts along the extensive margin.

\footnote{According to the Congressional Budget Office (2019), the lowest quintile of the population saw a 9.3pp decline in effective labor taxes from the 1980s to the 2010s. To illustrate the role of labor taxes, we consider the extreme case in which labor taxes in the benchmark economy drop by 9.3pp for all workers.}
5 Conclusion

This paper asks how do changes in corporate taxation affect the lifecycle of firms. We address this question using a model of firm dynamics that features occupational choice. In this setting, a drop in profit taxes always increases wages, but the effects on firm selection depend on parameter values. To pin down parameter values, we calibrate the model to the US in the 1980s. We then perform counterfactual exercises and quantify the effects of profit tax cuts along the intensive and extensive margins. We find that profit tax cuts operate mostly through the intensive margin. If we consider changes in population growth, the effects along the extensive margin are stronger for mature firms than for young firms.

In this paper we took corporate taxes as given and studied the optimal response of firms to tax cuts along intensive and extensive margins. More generally, corporate taxes are chosen to meet certain objectives of the taxing authority. These objectives involve considerations such as meeting revenue targets, redistributing income and reducing tax avoidance. The response of firms to changes in taxes affects the tax base, which might feedback into the optimization problem of the tax authority. Future work could explore how such feedback effects alter the incidence of corporate taxation.
Appendix A  Table

Table 7: Percentage Change in Average Firm Size

<table>
<thead>
<tr>
<th>Age ≤ 6</th>
<th>Age &gt; 6</th>
<th>Age ≤ 10</th>
<th>Age &gt; 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>87-89 to 10-16</td>
<td>−12.3%</td>
<td>−10.3%</td>
<td>−13.4%</td>
</tr>
<tr>
<td>87-89 to 10-13</td>
<td>−13.4%</td>
<td>−10.8%</td>
<td>−14.8%</td>
</tr>
<tr>
<td>87-89 to 14-16</td>
<td>−10.9%</td>
<td>−9.6%</td>
<td>−11.5%</td>
</tr>
<tr>
<td>82-89 to 10-16</td>
<td>—</td>
<td>—</td>
<td>−8.7%</td>
</tr>
<tr>
<td>82-89 to 10-13</td>
<td>—</td>
<td>—</td>
<td>−10.1%</td>
</tr>
<tr>
<td>82-89 to 14-16</td>
<td>—</td>
<td>—</td>
<td>−6.7%</td>
</tr>
</tbody>
</table>


Appendix B  Proofs

The value function of a firm is given by

\[ V(z, w_t) = \max \left\{ b + \frac{\beta w}{1 - \beta} (1 - \tau) \pi(z, w_t) + \beta \mathbb{E}[V(z', w_{t+1})|z] \right\} \]

It is useful to redefine the value function such that the outside option is zero. Let \( v \) denote the new value function. We have

\[ V(z, w_t) - b - \frac{\beta w}{1 - \beta} = \max \left\{ 0, (1 - \tau) \pi(z, w_t) - (1 - \beta)b - \beta w + \beta \mathbb{E} \left[ V(z', w_{t+1}) - b - \frac{\beta w}{1 - \beta} | z \right] \right\} \]

\[ v(z, w_t) = \max \left\{ 0, \tilde{\pi}(z, w_t, \tau) + \beta \mathbb{E}[v(z', w_{t+1})|z] \right\} \]

where we have redefined the flow of profits as \( \tilde{\pi} \). The standard properties of the profit function hold here, e.g. \( \partial \tilde{\pi} / \partial w < 0 \) and \( \partial \tilde{\pi} / \partial z > 0 \). The first order conditions of the profit maximization problem do not get modified so optimal size is unaffected.

Notice that the entry and exit conditions get modified with the redefinition of the value.
function. The exit condition is now \( v(z^*, w_t) = 0 \). Define
\[
\nu_t^e(w_t) = \int v(z, w_t) \Gamma(dz)
\]
The entry condition is \( \nu_t^e(w_t) = c_e + w - b \).

For the comparative static exercise, it is helpful to define age-related variables. Let \( \lambda_a \) denote the (unconditional) probability that a firm survives to age \( a \). Let \( \tilde{\mu}_a \) denote the (unconditional) probability distribution over the set of productivity shocks for the firm. This distribution tells us what is the probability that a firm will have productivity \( z \) at a particular age \( a \). With these definitions in hand, we can write firm values as the expected discounted value of profits. The value of a potential startup is
\[
\nu_t^e(w_t) = \int v(z, w_t) \Gamma(dz) = \sum_{a=0}^{\infty} \beta^a \lambda_a \int \tilde{\pi}(z, w_a, \tau) \tilde{\mu}_a(dz)
\]

From here on, we restrict our attention to a stationary equilibrium.

**B.1 Proof of Corollary 2.**

Recall the inverse of the effective benefit of exit is a weighted sum of unity and the ratio of average operating-firm value to the value of the marginal firm,
\[
\frac{\mathbb{E}[V(z, w^*)]}{V(z^*, w^*)} = \Gamma(z^*) + [1 - \Gamma(z^*)] \frac{\mathbb{E}[V(z, w^*) | z \geq z^*]}{V(z^*, w^*)} = \beta \left( \frac{\beta c_e + \beta w}{b + \beta w / (1 - \beta)} \right)
\]

Express this in terms of the modified value function \( \nu \) and write the mathematical expectations as integrals. Note that the conditional expectation is the expectation over the distribution of zero year olds, \( \tilde{\mu}_0 \). We have
\[
\frac{\mathbb{E}[b + \beta w^*/(1 - \beta) + \nu(z, w^*)]}{b + \beta w^*/(1 - \beta)} = \Gamma(z^*) + [1 - \Gamma(z^*)] \frac{\mathbb{E}[b + \beta w^*/(1 - \beta) + \nu(z, w^*) | z \geq z^*]}{b + \beta w^*/(1 - \beta)}
\]
\[
1 + \frac{\mathbb{E}[\nu(z, w^*)]}{b + \beta w^*/(1 - \beta)} = \Gamma(z^*) + [1 - \Gamma(z^*)] \left( 1 + \frac{\mathbb{E}[\nu(z, w^*) | z \geq z^*]}{b + \beta w^*/(1 - \beta)} \right)
\]
\[
1 + \int \frac{\nu(z, w^*)}{b + \beta w^*/(1 - \beta)} \Gamma(dz) = \Gamma(z^*) + [1 - \Gamma(z^*)] \left( 1 + \int \frac{\nu(z, w^*)}{b + \beta w^*/(1 - \beta)} \tilde{\mu}_0(dz) \right)
\]

Now consider how each side of the average-to-marginal ratio changes with taxes. Suppose \( b > \beta c_e \), so an increase in the wage rate leads to an increase in inverse of the effective
benefit of exit, and therefore the ratio on left hand side. Compare the derivative of both sides with respect to \(\tau\), while keeping \(z^*\) constant. We will abuse notation and simply write this as the derivative with respect to \(\tau\). Note that \(\tilde{\mu}_0\) first-order stochastically dominates \(\Gamma\). More generally, assume the following stochastic dominance property holds; see Hopenhayn (1992a) for further discussion.

**Assumption 1.** Assume \(\tilde{\mu}_t\) is increasing in \(t\) in the sense of first order stochastic dominance.

Under this assumption, the properties of the function inside the integral determines the direction of the inequality.

**Lemma 1.** The function \(\frac{d}{d\tau} \left( \frac{v(z, w^*)}{b + \beta w^*/(1 - \beta)} \right)\) is decreasing in \(z\).

**Proof.** The derivative can be written as

\[
\frac{d}{d\tau} \left( \frac{v(z, w^*)}{b + \beta w^*/(1 - \beta)} \right) = \frac{\frac{dv(z, w^*)}{d\tau} \left( b + \beta w^*/(1 - \beta) \right)}{(b + \beta w^*/(1 - \beta))^2} + \frac{\frac{\beta v(z, w^*)}{d\tau} \left( b + \beta w^*/(1 - \beta) \right)}{(b + \beta w^*/(1 - \beta))^2}.
\]

Now we show that each term on the right hand size is a decreasing function of \(z\). We drop the denominators because they do not depend on \(z\) and are positive. For the first function we have

\[
\frac{d}{d\tau} \left( \frac{dv(z, w^*)}{d\tau} \right) = \frac{d}{dz} \left( \sum_{t=0}^{\infty} \beta^t \lambda_t(z) \right) [ -\pi(z', w^*) + (1 - \tau) \pi_2(z', w^*) \frac{dw^*}{d\tau} - \beta \frac{dw^*}{d\tau} ] \tilde{\mu}_t(dz'|z) \]

Consider \(z_2 > z_1\). We have that \(\tilde{\mu}_t(dz'|z_2)\) first-order stochastically dominates \(\tilde{\mu}_t(dz'|z_1)\). The term inside the brackets is negative and therefore a decreasing function of \(z'\). It follows that integral is declining in \(z\). Because \(\lambda_t(z_2) > \lambda_t(z_1)\), reflecting the fact that higher productivity firms have higher survival probabilities, it follows that the product of the survival probability and the integral is decreasing in \(z\).

The second term is decreasing in \(z\) because \(v(z, w^*)\) is increasing in \(z\), and \(dw^*/d\tau < 0\). This implies that the product \(dv(z, w^*)/dz \times dw^*/d\tau < 0\).

Lemma 1 combined with the fact that \(\tilde{\mu}_0\) first-order stochastically dominates \(\Gamma\) implies the result in Corollary 2.

\[
\frac{d}{d\tau} \left( \frac{\mathbb{E}[V(z, w^*)]}{V(z^*, w^*)} \right) \bigg|_{z^*} \geq \frac{d}{d\tau} \left( \frac{\mathbb{E}[V(z, w^*)|z \geq z^*]}{V(z^*, w^*)} \right) \bigg|_{z^*}
\]
B.2 Profit taxes in a canonical Hopenhayn model.

Suppose we get rid of occupational choice. The resulting model is a Hopenhayn (1992a) model where the operating costs of a firm are not taxed, or equivalently paid from after taxes are deducted from variable profits. The operating costs in this setting are $(1 - \beta)b$.

We guess and verify that $z^*$ does not change with taxes in the canonical Hopenhayn model.

The wage elasticity of profits is given by

$$\eta \equiv \frac{d\pi(z, w)}{dw} \times \frac{w}{\pi(z, w)} = \frac{-\alpha}{1 - \alpha}$$

The fact that this elasticity is independent of $z$ will be useful in what follows. In this setting $\tilde{\pi}(z, w, \tau) = (1 - \tau)\pi(z, w) - (1 - \beta)b$.

We can now evaluate how a change in $\tau$ affects the equilibrium wage rate in this simpler model. Under the guess that $z^*$ does not change, the entry condition implies the following

$$\frac{dw^*}{d\tau} = \frac{\sum_{a=0}^{\infty} \beta^a \lambda_a \int \pi(z, w^*) \mu_a(dz)}{\sum_{a=0}^{\infty} \beta^a \lambda_a \int (1 - \tau)\pi(z, w^*) \mu_a(dz)}$$

Substitute for $\pi_2(.) = -\alpha/(1 - \alpha) \times \pi(.)/w^*$ using the expression for profit elasticity above. We obtain

$$\frac{dw^*}{d\tau} = -\frac{1 - \alpha}{\alpha} \times \frac{w^*}{1 - \tau} \times \frac{\sum_{a=0}^{\infty} \beta^a \lambda_a \int \pi(z, w^*) \mu_a(dz)}{\sum_{a=0}^{\infty} \beta^a \lambda_a \int \pi(z, w^*) \mu_a(dz)}$$

(A-4)

The integral terms cancel out and it follows that the elasticity of equilibrium wages with respect to taxes in this model is $(1 - \alpha)/\alpha$. Notice that the magnitude of the wage elasticity and the inverse of the profit elasticity. This is why a change in taxes has no effect on the exit threshold. Intuitively, the change in wages will undo the effect of the decrease in taxes. This implies that firm profits do not change with taxes. From the entry condition we have $dv^e/d\tau = 0$. Similarly, we have $dv(z^*)/d\tau = 0$. It follows that the exit threshold does not change with $\tau$.

---

6 We are defining the elasticity as $-dw/d\tau \times (1 - \tau)/w$. This corresponds to the elasticity of $w$ with respect to $1 - \tau$. It is convenient to refer to this elasticity as the elasticity of wages with respect to $\tau$.
References


———, “Firm Size and Development,” Economia 17 (2016), 27–49. 5


