

The Role of Corporate Taxes in the Decline of the Startup Rate*

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Abstract

The business startup rate in the United States has exhibited a large secular decline in recent decades. The reasons behind the decline are not well understood. This paper hypothesizes that the startup rate declined in large part because corporate taxes raised the opportunity cost of entrepreneurship. We formalize this thesis using a model of occupational choice that features firm entry and exit. Quantitatively, the model accounts for much of the decline in the startup rate. Taxes alone account for one-fifth of the decline. Cross-sectoral patterns in US data support our results.

J.E.L. Codes: E13, L16, L26

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1 Introduction

The startup rate—defined as the ratio of zero-year-old firms to the total number of firms—has declined from 14% to 8% in the United States in the last four decades.¹ The decline in startup activity is a source of growing concern. It has been linked to a decline in the dynamism and vitality of the US economy (Decker et al., 2014). A decline in startups has also been connected to productivity slowdowns (Clementi and Palazzo, 2016), jobless recoveries (Pugsley and Sahin, 2014), and overall persistent effects on the macroeconomy (Gourio et al., 2016). Nevertheless, the reasons behind the decline in the startup rate are not well understood.

What drives the decline in the startup rate? A natural candidate is taxes. An increase in corporate taxes decreases business profitability, which in turn discourages business formation. The data, however, tell a different story. A look at taxes paid by US corporations reveals that the effective corporate tax rate *decreased* from 41% to 20% over the same time period; see McGrattan and Prescott (2005) and Zucman (2014). The coincidence of the decline in the effective corporate tax rate and the decline in the startup rate is striking; see Figure 1.

Whereas an increase in business profitability acts as a force that increases the startup rate, another force acts in the opposite direction: the potential entrepreneur’s outside option. For example, a computer scientist can either start a technology firm or work for Google. A retailer can either open a store or work for Amazon. If a drop in the corporate tax rate increases competition for labor, raising wages, potential entrepreneurs might choose employment over entrepreneurship. To understand the interaction between these competing forces, we need a general equilibrium model that features the employment-entrepreneurship tradeoff.

We propose such a model. The model builds on the seminal work of Lucas (1978) and Hopenhayn (1992). As in Lucas (1978), agents in our model choose whether they want to be workers or entrepreneurs. As in Hopenhayn (1992), our model features a stationary firm-size distribution, along with firm entry and exit every period. Agents are ex-ante identical and decide whether to be entrepreneurs or workers. All workers are identical in ability. An entrepreneur forgoes wages, pays an entry cost, and draws the productivity of his firm from a distribution that is *iid* across entrants. Once drawn, firm productivity does not change until the firm exits. After the productivity realization, the entrepreneur decides whether to operate his firm or exit. If he operates the firm, he receives firm profits net of profit taxes. If he exits, he receives an exit payoff and chooses his occupation again next

¹Reedy and Strom (2012) first documented the decline in the startup rate. The decline in startup rates is widespread across geographic areas and sectors (Hathaway and Litan, 2014; Pugsley and Sahin, 2014), including the high-tech sector (Haltiwanger et al., 2014).

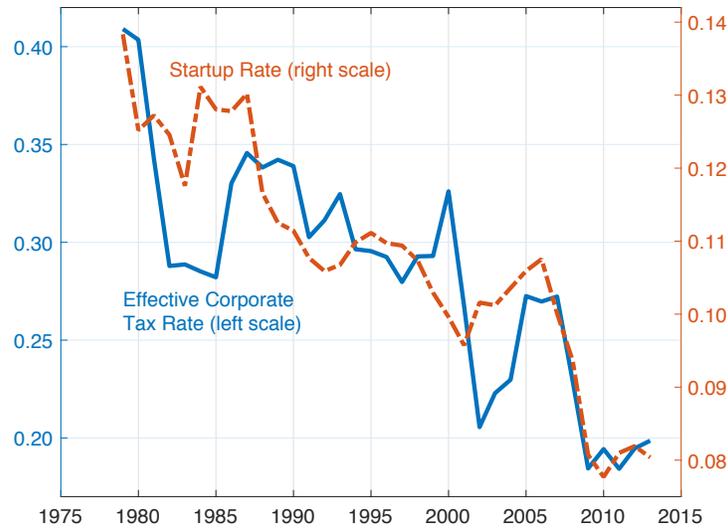


Figure 1

Sources. Startup rates are from US Business Dynamics Statistics. Effective corporate tax rates are from the National Income and Product Accounts. See Data Appendix.

Notes. The startup rate is the number of zero-year-old firms divided by the total number of firms. The effective corporate tax rate includes both domestic (federal, state, and local) and foreign taxes paid by US resident corporations.

period. The entrepreneur exits if firm productivity is below a threshold, such that firm value is less than the exit payoff.

We provide conditions under which a drop in the profit tax rate leads to a decline in the startup rate. The decline occurs despite the fact that lower taxes increase the number of startups. The startup rate declines because the drop in the tax rate increases the total number of firms by more than the number of startups. The mechanism is the following. A lower tax rate implies higher firm values. Firms exit at a lower rate, so the total number of firms is higher. Wages are higher because there is more competition for labor. With free entry, higher profitability implies a higher number of startups. However, startups increase by less than the total number of firms because the higher wage rate makes potential entrepreneurs' outside option more attractive and raises the opportunity cost of entrepreneurship.

What happens to aggregate output as the startup rate declines? Aggregate output increases despite the decline in the startup rate, reflecting the fact that profit taxes distort the entry-exit margin.

For the quantitative analysis, we calibrate the model economy to match key features of US startups and the firm-size distribution in the 1980-89 period. The profit-tax rate is set to 32%, the average of the effective corporate tax rate in the data over the same period. The calibration procedure targets the startup rate, average startup size, employment at top 15% of startups, and average firm size. We recalibrate the model economy to match the

same moments, except the startup rate, in the 2010-13 period. The profit-tax rate in the 2010s economy is set to 19%, the corresponding number in the data. Even though we do not target the startup rate in 2010-13, the recalibrated model economy is able to generate most of the startup-rate decline observed in the data. The model economy almost perfectly matches another non-targeted moment: the percentage change in the number of startups between the 1980s and 2010s.

The model is then used to assess how a change in the profit-tax rate by itself affects the startup rate. In our counterfactual experiment, we decrease the profit tax rate from 32% to 19% in the 1980s model economy. There is no a priori reason why a drop in the profit tax rate should lower the the startup rate. The calibration procedure lets the data determine whether the conditions required for such a decline hold. They do. We find the drop in the tax rate accounts for 20% of the startup-rate decline. Our quantitative finding is robust to various measures of the effective corporate tax rate. Because the choice between entrepreneurship and employment is central to our mechanism, we evaluate whether the introduction of labor taxes affects our quantitative findings. It does not.

Disaggregated US data support our results. In sectoral data, we find sectors with the largest decline in the effective corporate tax rate exhibit the largest declines in the startup rate. At the firm level, recent work by [Bollard et al. \(2016\)](#) suggests the opportunity cost of entrepreneurship has increased. The authors find that firm-entry costs, measured as average discounted profits after entry, have increased in recent decades. In our model, higher firm-entry costs imply a higher opportunity cost of entrepreneurship. Therefore, an increase in firm-entry costs in the data is consistent with our prediction of an increase in the opportunity cost of entrepreneurship.

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. 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 dynamic model. Section 3 presents the calibration and counterfactual experiments. Section 4 presents firm exit rates in the data and provides cross-sectoral evidence in support of our findings. Section 5 concludes. The Appendix contains information on the data sources and proofs.

2 Model

Firms in the model economy produce a single good. A firm produces output using one entrepreneur and a set of workers. The production function is

$$f(z, n) = z^{1-\alpha} n^\alpha, \quad (1)$$

where $z^{1-\alpha}$ represents firm productivity and n is the number of workers. The exponent $1 - \alpha$ on the productivity index z helps simplify expressions. It is, however, without loss of generality. Because it does not lead to any confusion, we refer to the productivity index z as firm productivity. We assume $\alpha < 1$. Therefore, the production function exhibits decreasing returns in labor, the variable input.

Given productivity z and the wage rate w , a firm chooses the number of workers n to maximize profits. Let $\pi(z)$ denote the maximized value of profits. We have

$$\pi(z) = \max_n [z^{1-\alpha} n^\alpha - wn]. \quad (2)$$

The economy is populated by a unit mass of infinitely-lived agents who discount future payoffs at the rate r . 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 an entry cost of c_e units of output and forgo the opportunity to work until the firm exits. After agents pay the entry cost, firm productivity z is drawn from a distribution with support $[\underline{z}, \infty)$ and CDF Γ . The productivity draw is *iid* across entrants. Once drawn, the productivity of a firm does not change over the lifetime of the firm.

After the productivity realization, agents in their role as entrepreneurs choose whether to operate their firm or to exit. Entrepreneurs operating the firm choose labor n to maximize firm profits. Entrepreneurs who exit recover $b \leq c_e$ units of the entry cost and pay a one-time cost equal to a fraction δ of future payoffs. The positive *exit payoff*—equal to the recovery b plus future payoffs net of the one-time cost—generates endogenous exit in the model. As we will see later, a threshold level of productivity exists such that a firm with productivity below that threshold exits. A firm with productivity that exceeds the threshold will operate.

After producing, firms that operate in the current period draw a Bernoulli random variable that determines whether they exit involuntarily. The probability of involuntary exit is $\lambda > 0$. As was the case for firms that exited voluntarily, firms that exit involuntarily recover b units of output and pay a one-time cost equal to a fraction δ of future payoffs. Entrepreneurs of firms that exit, either voluntary or involuntarily, join the mass of agents who

were workers this period. All agents not operating firms at the end of the current period return to the pool of potential entrepreneurs, and face the occupational choice decision at the beginning of the next period.

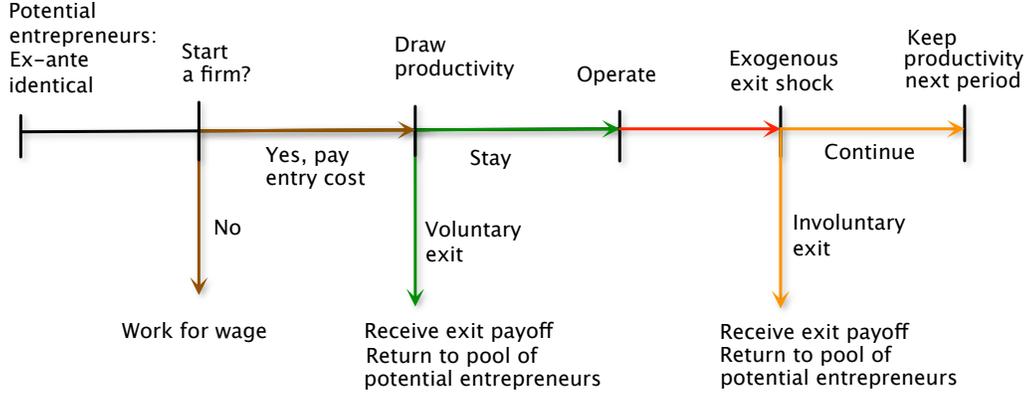


Figure 2: Intraperiod Timeline

A government authority taxes firm profits at the rate τ . Entrepreneurs who operate a firm in the current period receive after-tax firm profits, $(1 - \tau)\pi(z)$. Tax revenues are returned as lump-sum transfers to all agents such that the government balances its budget every period.

The timing of events is summarized in Figure 2.

Value functions. Let $V(z)$ denote the value of a firm with productivity z . Let W denote the value function of an agent before he chooses his occupation. We have

$$W = \max \left\{ \mathbb{E}[V(z)] - c_e, w + \frac{1}{1+r}W' \right\}. \quad (3)$$

The agent compares the expected payoff from starting a firm, $\mathbb{E}[V(z)] - c_e$, to the payoff from working for the wage w today and choosing his occupation again the next period, $W'/(1+r)$.

The value of a firm with productivity z is

$$V(z) = \max \left\{ (1 - \tau)\pi(z) + \left[(1 - \lambda)\frac{V'(z)}{1+r} + \lambda \left(b + \frac{1 - \delta}{1+r}W' \right) \right], b + \frac{1 - \delta}{1+r}W' \right\}. \quad (4)$$

The value function $V(z)$ indicates the entrepreneur running the firm with productivity z chooses between operating and exiting. If he exits, the entrepreneur receives the exit payoff: his recovery b , minus the one-time cost $\delta W'/(1+r)$, plus the present value of the payoff

from choosing his occupation the next period $W'/(1+r)$. If the entrepreneur chooses to operate, he receives a period payoff equal to after-tax firm profits, $(1-\tau)\pi(z)$. The firm survives to the next period with probability $1-\lambda$. In that case, future firm value equals $V'(z)$. The firm is forced to exit after producing with probability λ . As with voluntary exit, the exiting entrepreneur gets the payoff $b + (1-\delta)W'/(1+r)$.

Firm profits are increasing in productivity z . Therefore, firm value is increasing in z . We anticipate the equilibrium and define a productivity threshold z^* such that firms with $z < z^*$ choose to exit voluntarily. Firms with $z > z^*$ choose to operate. Firms with $z = z^*$ are indifferent between operating and exiting. Let $\bar{x}(z)$ denote the policy function associated with $V(z)$. The function $\bar{x}(z)$ equals 1 if a firm with productivity z chooses to exit, and 0 otherwise. We have $\bar{x}(z < z^*) = 1$, and $\bar{x}(z \geq z^*) = 0$.

Evolution of the firm-productivity distribution. Let μ denote a measure over firm productivities before firms make the voluntary exit decision. The mass of firms with productivity less than z is denoted $\mu(z)$. The total mass of firms in the economy before the voluntary exit decision is denoted $M = \int_{\underline{z}}^{\infty} d\mu(z)$. Let x denote a measure over the productivities of exiting firms. The mass of firms with productivity less than z that exit, either because they decide against continuation or because of the involuntary exit shock, is denoted $x(z)$.² Let X denote the total mass of firms that exit. We have $X = \int_{\underline{z}}^{\infty} dx(z)$.

Let N denote the mass of employees. Because the total number of agents is normalized to 1, we have $N = 1 - M$. The entrepreneurs of exiting firms join the agents who were employees this period. Therefore, at the beginning of the next period, the mass of agents facing the occupational choice decision equals $N + X$. Each agent in that mass chooses whether to be an employee or an entrepreneur. The agents who choose to be entrepreneurs pay the entry cost c_e and create new firms, which we refer to as startups. Let S' denote the total mass of startups next period. Startups draw their productivity z from the distribution with CDF Γ . The mass of startups with productivity less than z next period is $s'(z) = S'\Gamma(z)$.

Prior to the exit decision next period, for each productivity level z , the mass of firms $\mu'(z)$ equals the mass of surviving incumbents $\mu(z) - x(z)$ plus the mass of startups $s'(z)$. We have

$$\mu'(z) = \mu(z) - x(z) + s'(z). \quad (5)$$

²Firms with productivity less than z^* choose to exit. Firms with productivity greater than z^* exit because of the involuntary shock. We have

$$x(z) = \begin{cases} \int_{\underline{z}}^z \bar{x}(\hat{z})d\mu(\hat{z}) & \text{if } z \leq z^* \\ \int_{\underline{z}}^{z^*} \bar{x}(\hat{z})d\mu(\hat{z}) + \lambda[\mu(z) - \mu(z^*)] & \text{if } z \geq z^*. \end{cases}$$

Stationary firm-productivity distribution. The model economy exhibits a *stationary firm-productivity distribution* when the distribution defined by μ is invariant across periods, $\mu'(z) = \mu(z)$ for all z . Equivalently, from (5), we have $s'(z) = x(z)$ for a stationary distribution. For each productivity level z , the mass of startups $s'(z)$ must replace the mass of exiting firms $x(z)$. Startups with productivity less than z^* replace firms that chose to exit last period. Startups with productivity greater than z^* replace firms that exited involuntarily last period. Because startups replace existing firms that exit, a stationary distribution of firm productivity allows for entry-exit dynamics at the individual firm level.

The total mass of startups S in a stationary equilibrium equals the mass of startups that chose to exit, $S\Gamma(z^*)$, plus the mass of startups that exit involuntarily, $\lambda[M - S\Gamma(z^*)]$. We have

$$S = S\Gamma(z^*) + \lambda[M - S\Gamma(z^*)]. \quad (6)$$

The *startup rate* is the mass of startups over the mass of total firms, S/M . The proposition below shows that, in a stationary equilibrium, the startup rate depends on the probability of the involuntary exit shock λ and the exit threshold z^* .

Proposition 1. *In a stationary firm-productivity distribution,*

(i) *the startup rate is given by*

$$\frac{S}{M} = \frac{\lambda}{1 - (1 - \lambda)\Gamma(z^*)}, \quad (7)$$

(ii) *a reduction in the exit threshold z^* reduces the startup rate.*

Proof. Part (i) follows from the stationarity condition (6). Part (ii) follows immediately from Part (i). ■

The intuition for the startup rate expression in (7) follows from the fact that $\Gamma(z^*)$ represents the proportion of startups that exit voluntarily. The difference between the mass of startups S and the mass of total firms M depends on voluntary exit, captured by $\Gamma(z^*)$. Two limiting cases illustrate this point. As $\Gamma(z^*)$ approaches 1, all startups exit voluntarily and there is no difference between the mass of startups and the mass of firms, $S = M$. In that case, the startup rate equals its upper bound of 1. When $\Gamma(z^*)$ equals 0, no startups exit voluntarily. In that case, the difference between the mass of startups and the mass of total firms is the largest, and the startup rate equals its lower bound λ .

Because λ and Γ are exogenous, Proposition 1 shows the exit threshold z^* is the only endogenous variable that matters for the startup rate under stationarity. Therefore, the question of how changes in the profit-tax rate affect the startup rate can be restated: How do changes in the profit-tax rate affect the exit threshold?

Definition of equilibrium. A *stationary competitive equilibrium* consists of a wage rate w , an exit threshold z^* , value functions $\pi(z)$, $V(z)$, and W , labor demand function $\bar{n}(z)$, exit-policy function $\bar{x}(z)$, an aggregate distribution of firm productivity μ , a mass of startups S , a mass of firms M , a mass of workers N , a mass of exiting firms X , and lump-sum taxes T such that

1. **Profit maximization:** $\bar{n}(z)$ maximizes period profits,
2. **Exit:** $(1 - \tau)\pi(z^*) + \left[(1 - \lambda)\frac{V'(z^*)}{1+r} + \lambda \left(b + (1 - \delta)\frac{W'}{1+r} \right) \right] = b + (1 - \delta)\frac{W'}{1+r}$,
3. **Entry:** $\mathbb{E}[V(z)] - c_e = w + \frac{W'}{1+r}$,
4. **Labor-market clearing:** $\int_{z^*}^{\infty} \bar{n}(z)d\mu(z) = N$,
5. **Government budget balance:** $T + \tau \int_{z^*}^{\infty} \pi(z)d\mu(z) = 0$,
6. **Stationary distribution:** $\mu' = \mu$ solves (5).

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 $z < z^*$ to exit and for firms with $z > z^*$ to operate. The entry condition states that an individual agent is indifferent between starting a firm, payoff $\mathbb{E}[V(z)] - c_e$, and working for a wage this period and choosing his occupation again next period, for the payoff $w + W'/(1+r)$.

The labor-market-clearing condition states that aggregate labor demand by operating firms, $\int_{z^*}^{\infty} \bar{n}(z)d\mu(z)$, equals aggregate labor supply, N . 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.

Solving for equilibrium. We solve the model in two steps. First, we characterize the solution to the profit-maximization problem of a firm with productivity z . Then we consider entrepreneurs' exit and entry decisions.

Firms choose labor n to maximize pre-tax profits (2). Let $\bar{n}(z)$ denote labor demand by a firm with productivity z , given the wage rate w . We have

$$\bar{n}(z) = \left(\frac{\alpha}{w} \right)^{1/(1-\alpha)} z. \quad (8)$$

The maximized value of pre-tax firm profits follows. We have

$$\pi(z) = (1 - \alpha) \left(\frac{\alpha}{w} \right)^{\alpha/(1-\alpha)} z. \quad (9)$$

Both labor demand and firm profits are increasing in productivity z .

In equilibrium, each individual agent is indifferent between working today and choosing his occupation again tomorrow, and starting a firm. The value of being an agent who is yet to choose an occupation is found by applying the indifference condition to (3). We obtain $W = w + W'/(1 + r)$. In a stationary equilibrium, the agent's occupational problem next period is identical to the problem today, $W = W'$. Therefore, we have

$$W = W' = \frac{w(1 + r)}{r}. \quad (10)$$

The value of a firm with productivity z after entry, but before the exit decision, is given by

$$V(z) = \begin{cases} b + (1 - \delta) \frac{w}{r} & \text{if } z \leq z^*, \\ \left(\frac{1+r}{r+\lambda} \right) [(1 - \tau)\pi(z) + \lambda (b + (1 - \delta) \frac{w}{r})] & \text{if } z \geq z^*. \end{cases} \quad (11)$$

The expression for $V(z)$ follows from substituting (10) in (4) and using the fact that $V'(z) = V(z)$ in a stationary equilibrium. The firm value function indicates firms with $z \leq z^*$ exit and receive the exit payoff, $b + (1 - \delta)w/r$. Firms with $z \geq z^*$ prefer to operate. The value of those firms is equal to the expected discounted value of after-tax profits, with an adjustment for the possibility of involuntary exit.

We solve for wage rate w and the exit threshold z^* using the entry and exit conditions; see Appendix B for details. Once we obtain w and z^* , we need the invariant firm-size distribution μ to solve for the other equilibrium variables. In a stationary equilibrium, entrants replace firms that exit. It follows that an invariant firm-productivity distribution must satisfy

$$\mu(z) = \begin{cases} S\Gamma(z), & z \leq z^*, \\ S\Gamma(z^*) + \frac{S}{\lambda}[\Gamma(z) - \Gamma(z^*)], & z \geq z^*. \end{cases} \quad (12)$$

The proportion $\Gamma(z^*)$ of startups replaces firms that realized low values of productivity, $z \leq z^*$, and exited voluntarily last period. The remaining startups replace the high-productivity firms, $z \geq z^*$, that exited involuntarily last period.

Before we present how taxes impact the startup rate, we need to specify the distribution from which entrants draw their productivity. As is standard in the literature, we assume

entrants draw their productivity from a Pareto distribution.³

Assumption 1. Γ is the CDF of a Pareto distribution with shape parameter $\rho > 1$ and lower bound \underline{z} .

The following corollary summarizes how a change in the profit tax rate τ affects the wage rate w and the exit threshold z^* .

Corollary 1. *The comparative statics with respect to τ satisfy*

(i) $dw/d\tau < 0$,

(ii) $dz^*/d\tau > 0$ iff $b/(1 - \delta) > c_e/(1 + r)$.

Proof. See Appendix B. ■

The intuition for why a decrease in the profit-tax rate τ increases the wage rate w is as follows. The decrease in τ increases after-tax profits and spurs entry. The corresponding decrease in labor supply, and increase in labor demand, increases the wage rate.

Next we discuss why a decrease in τ decreases the exit threshold z^* . We present the argument in two steps. First we show the exit threshold z^* is determined by the ratio of average startup value to marginal startup value. Second, we show how the profit tax rate affects the average-to-marginal ratio through wages.

Average startup value is a weighted average of the value of startups that choose to exit, those with $z \leq z^*$, and the expected value of startups that choose to operate, those with $z \geq z^*$. The value of the marginal startup is $V(z^*)$. Therefore, the ratio of average to marginal startup values is given by

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

where we have used the fact that the value of an exiting startup equals $V(z^*)$. When z follows a Pareto distribution, the ratio $\mathbb{E}[V(z)|z \geq z^*]/V(z^*)$ is independent of z^* . That ratio exceeds 1, reflecting the fact that the value of startups that choose to operate, those with $z > z^*$, exceeds the value of the marginal startup, $V(z^*)$. Therefore, the equilibrium average-to-marginal ratio of startup values is a weighted average of 1, with weight $\Gamma(z^*)$, and a number greater than 1, with weight $1 - \Gamma(z^*)$. An increase in the average-to-marginal ratio must be accompanied by a decrease in z^* , which corresponds to an increase in the weight $1 - \Gamma(z^*)$ on the number greater than 1.

³Axtell (2001) finds that the US firm-size distribution is well approximated by a Pareto distribution.

The effect of a change in the profit-tax rate on the average-to-marginal ratio is as follows. From the equilibrium entry and exit conditions, the ratio of average to marginal startup values is

$$\frac{\mathbb{E}[V(z)]}{V(z^*)} = \left(\frac{1+r}{1-\delta} \right) \left[\frac{\frac{c_e}{1+r} + \frac{w}{r}}{\frac{b}{1-\delta} + \frac{w}{r}} \right]. \quad (13)$$

When $b/(1-\delta) > c_e/(1+r)$, an increase in the wage rate w increases the right-hand side of (13). The corresponding increase in the equilibrium ratio of average to marginal startup values is accompanied by a decrease in the exit threshold z^* .

The following proposition summarizes the effect of a change in the profit tax rate on the startup rate.

Proposition 2. *A reduction in the profit tax rate τ lowers the startup rate iff $b/(1-\delta) > c_e/(1+r)$.*

Proof. The result follows from Proposition 1 and Corollary 1. ■

The startup rate declines because a drop in the profit-tax rate increases the mass of firms M by more than the mass of startups S . The mechanism is the following. A lower profit-tax rate implies higher firm values. Firms exit at a lower rate, so the mass of firms is higher. With more firms, labor supply is lower and labor demand is higher. The higher competition for labor implies that the labor market clears at a higher wage rate. Because of free entry, higher profitability implies a higher mass of startups. However, the mass of startups increases by less than the mass of firms because the higher wage rate increases the attractiveness of the outside option of potential entrepreneurs.

The effect on the outside option is captured by the right-hand side of (13), which indicates the opportunity cost of entrepreneurship: the effective cost of entry, equal to the entry cost c_e plus foregone wages $w + w/r$, relative to the exit payoff $b + (1-\delta)w/r$. When $b/(1-\delta)$ is greater than $c_e/(1+r)$, a decline in the profit tax rate raises the opportunity cost of entrepreneurship. Therefore, it leads to a decline in the startup rate. If the reverse inequality holds, a decline in the profit tax rate lowers the opportunity cost of entrepreneurship and therefore increases the startup rate. If $b/(1-\delta)$ is equal to $c_e/(1+r)$, changes in the profit tax rate do not affect the startup rate.

3 Quantitative Analysis

We assume the US economy was at stationary equilibria in the 1980-89 period and the 2010-13 period. We calibrate the model economy to match key moments related to US startups and firm-size distribution in the 1980-89 period. In particular, we target the average startup

rate in the 1980s. The possibility that the parsimonious model can match the targets is not a foregone conclusion. To assess goodness of fit, we recalibrate the model to all moments, except the startup rate, in the 2010-13 period. We use the startup rate in 2010s and other non-targeted moments to assess model performance.

We present our quantitative findings using two complementary counterfactual experiments. First, we consider the model economy calibrated to the 1980s and lower the profit-tax rate to the effective corporate tax rate observed in the data for the 2010-13 period. This experiment allows us to isolate the effect of corporate taxes on the startup rate, when all other parameters remain unchanged. Second, we consider the model economy calibrated to the 2010-13 period and raise the profit-tax rate to the effective corporate tax rate in the 1980s. This experiment allows us to isolate the effect of all changes in the US economy, except the change in the corporate tax rate.

Calibration. A model period is set to one year. The parameters r and α are identical in both the 1980-89 and 2010-13 calibrations. The discount rate r is set to the standard value of 4% to match the annual real rate of interest. The returns-to-scale parameter α is set to 0.65. That parameterization implies an aggregate labor share of 0.65, which is broadly consistent with labor’s share of national income. In the existing literature, the parameter α is often modeled as the product of two parameters: a span-of-control parameter and the labor’s share of firm-level income. The chosen value is consistent with a span-of-control parameter of 0.95 multiplied by a firm-level labor share of 0.68. Following the estimates in [Basu and Fernald \(1997\)](#), the literature usually sets α to correspond to a span-of-control parameter to a value between 0.85-0.95; see, for example, [Atkeson and Kehoe \(2007\)](#) and [Restuccia and Rogerson \(2008\)](#). Our choice of α is on the higher end of the values commonly used in the literature. As we report later, a smaller value of α leads to changes in the profit tax rate having stronger quantitative effects.

The remaining parameters depend on the calibration period. In a steady state, startups employ λ of the labor force in the model economy. Formally,

$$\frac{\text{Total employment at startups}}{\text{Total employment}} = \frac{S \int_{z^*}^{\infty} n(z, w) d\Gamma(z)}{\int_{z^*}^{\infty} n(z, w) d\mu(z)} = \lambda,$$

where $d\mu(z) = S/\lambda d\Gamma(z)$ from (12). The intuition behind this equality is simple: incumbents exit uniformly at the rate λ . In a stationary equilibrium, the mass of workers that lose their jobs as a result must be re-employed by startups. We set $\lambda_{1980} = 3.7\%$ and $\lambda_{2010} = 2.04\%$ to match the average fraction of the labor force employed by startups in the respective time periods.

Next we consider the mapping between the profit tax rate in the model and the data. In the model, the average and marginal tax rates on profits equal each other. In the data, however, they do not. Because it is average taxes that matter for lumpy decisions such as entry and exit, we map the profit tax rate in the model to the average effective corporate tax rate in the data. From the calculations in [Zucman \(2014\)](#), we have $\tau_{1980} = 32\%$ and $\tau_{2010} = 19\%$.

For both calibrations, we set $b = c_e$. This restriction implies the entrepreneurs recover the entry cost on exit. Because we calibrate the parameter δ , setting $b = c_e$ does not restrict the exit payoff. Given that we do not restrict the value of δ , the possibility that [Proposition 2](#) applies in the calibrated economy is not a foregone conclusion. We let the data determine whether a decline in the profit tax rate increases or decreases the startup rate in the calibrated economy.

Parameter	Definition	Basis
$r = 4\%$	Discount Rate	Annual Real Interest Rate
$\alpha = 0.65$	Returns to Scale	Span of Control \times Firm Labor Share
$\lambda_{1980} = 3.7\%, \lambda_{2010} = 2.05\%$	Involuntary Exit Rate	Startup Employment Share
$\tau_{1980} = 32\%, \tau_{2010} = 19\%$	Profit Tax Rate	Zucman (2014)
$\delta_{1980} = \delta_{2010} = 19.25\%$	Exit Cost	Calibrated to fit 1980s targets
$c_{e,1980} = 36.34, c_{e,2010} = 49.50$	Entry Cost	Calibrated to fit targets
$\underline{z}_{1980} = 0.71, \underline{z}_{2010} = 0.76$	Pareto Dist. Scale	Calibrated to fit targets
$\rho_{1980} = 5.20, \rho_{2010} = 7.08$	Pareto Dist. Shape	Calibrated to fit targets

Table 1: Parameter values

We calibrate the remaining parameters $\{\delta_{1980}; c_{e,1980}; \underline{z}_{1980}; \rho_{1980}\}$ to match 1980-89 averages of the startup rate, average startup size, average firm size, and employment at the top 15% of startups relative to total startup employment. The calibration procedure requires us to solve a system of four nonlinear equations for the four parameters. The procedure determines the parameters simultaneously, but certain parameters play a key role in matching each of the data targets. The entry and exit payoff parameters, c_e and δ , primarily determine the startup rate and average startup size. The parameter \underline{z} primarily determines average firm size. The shape parameter ρ primarily determines employment at the top 15% of startups.

To calibrate to the 2010s, we set the exit-payoff parameter δ_{2010} to its 1980s value and recalibrate the parameters $\{c_{e,2010}; \underline{z}_{2010}; \rho_{2010}\}$. Our strategy of recalibrating c_e is guided by recent work that suggests firm entry costs have increased in the United States; see, for example, [Davis and Haltiwanger \(2014\)](#). We let the parameters governing the firm-productivity distribution change to reflect changes in US productivity. Because we do not have evidence on exit costs, we assume the exit-payoff parameter δ does not change between

Target	Data	Model
<i>1980-89</i>		
Startup Rate	12.41%	12.41%
Average Startup Size	6.05	6.11
Average Firm Size	20.55	20.49
Relative Employment at Top 15% of Startups	62%	62.02%
<i>2010-13</i>		
Average Startup Size	5.82	5.48
Average Firm Size	22.89	23.23
Relative Employment at Top 13% of Startups	64.04%	64.70%

Table 2: Targets in the data and model

the two steady states. We recalibrate the parameters $\{c_{e,2010}; z_{2010}; \rho_{2010}\}$ to match 2010-13 values of average firm size, average startup size, and relative employment at the top 13% of startups. We do not calibrate to the startup rate in the 2010s. Not doing so allows us to assess how the model performs along a key non-targeted moment.

Table 1 summarizes parameter values for both calibrations. The calibrated value of δ is such that the conditions for Proposition 2 hold. A decline in the profit tax rate in the calibrated economy leads to a decline in the startup rate.

Results. Table 2 presents the data and the model-implied values of the calibration targets. The parsimonious model does an excellent job of matching the targeted moments for both the steady states.

Table 3 compares the performance of the model along some non-targeted moments. The model generates 86% of the decline in the startup rate between the 1980s and the 2010s. The startup rate in the data declined from 12.41% in the 1980s to 8.04% in the 2010s. The corresponding decline in the model is from 12.41% to 8.65%. Because our focus is the startup rate, it is important that the model capture most of the startup-rate decline observed in the data.

Non-targeted moment	Data	Model
Startup Rate in the 2010s	8.04%	8.65%
Change in Number of Startups	-37.78%	-38.18%
Change in Number of Firms	-3.50%	-11.31%

Table 3: Non-targeted moments in the data and model

We compare the percentage change in the number of startups between the 1980s and

Employees	Startups				Firms			
	Size		Employment		Size		Employment	
	Data	Model	Data	Model	Data	Model	Data	Model
<i>1980-89</i>								
< 50	99.68	99.85	88.58	98.56	96.09	99.52	32.52	98.56
50–249	0.30	0.14	9.10	1.44	3.31	0.47	16.10	1.44
> 250	0.013	0.0003	2.31	0.0017	0.60	0.0001	51.38	0.0017
<i>2010-13</i>								
< 50	99.46	99.94	76.52	99.42	95.61	99.77	27.39	99.42
50–249	0.49	0.054	14.64	0.575	3.60	0.229	15.26	0.575
> 250	0.05	0.0002	8.84	0.00	0.79	0.000	57.35	0.00

Table 4: Size and employment distributions. All numbers are percentages.

the 2010s in the data with the percentage change in the mass of startups in the calibrated models. Because the model does not feature population growth, we detrend the number of startups in the data by the growth rate of the US population.⁴ We find that startups declined by 37.78% between the 1980s and the 2010s in the data. The model does an excellent job matching the percentage decline in the number of startups: the corresponding decline in the model is 38.18%. Because the model matches the decline in startups and undershoots the decline in the startup rate, it overshoots the percentage decline in the mass of firms. The number of firms declined in the data by 3.5%, whereas the decline in the model is 11.31%.

Table 4 compares the startup-size and employment distributions in the model with the data. The model does an excellent job of capturing the startup-size distribution in both the 1980-89 and the 2010-13 steady states. The fit of the startup-employment distribution is decent in the 1980-89 steady state, but deteriorates in the 2010-13 steady state. In both the steady states, the model undershoots employment at startups with 50 or more employees.

Table 4 also shows the firm-size and employment distributions in the model and the data. The model does a decent job matching the firm-size distribution in both the steady states. However, as before, the model undershoots the fraction of firms with 50 or more employees. The model fails to match the distribution of employment at firms. In the data, firms with 250 or more employees account for more than 50% of the employment. That number is close to zero in the model.

The failure of the model in matching the firm-employment distribution reflects differences in the firm and the startup-employment distributions in the US data. Notice the model-implied firm and startup-employment distributions are identical. That equal-

⁴Data on US population growth rates are from the [World Bank](#).

ity arises because startups must replace exiting incumbents in a stationary equilibrium. In the data, however, the startup-employment distribution and the firm-employment distribution differ from each other. In other words, models that feature a stationary firm-size distribution with non-trivial firm dynamics along the lines of [Hopenhayn \(1992\)](#) match the firm-employment distribution well. These models, however, would fail to match the startup-employment distribution.

The calibrated value of the shape parameter ρ provides another perspective on how our model compares to the existing literature. In our model, the calibrated values of ρ are 5.20 in the 1980s and 7.08 in the 2010s. In the literature, however, ρ is generally calibrated to, or estimated to be, a value closer to 1; see [Axtell \(2001\)](#). The difference arises because we are calibrating ρ to match the tail of the startup-employment distribution, whereas the rest of the literature infers the value of ρ from the tail of the firm-employment distribution. As [Table 4](#) shows, the tail of the startup-employment distribution is thinner than the tail of the firm-employment distribution. For a Pareto distribution, a thinner tail corresponds to a higher value of the shape parameter, which is why our calibration procedure leads to values of ρ higher than those in the literature.

The role of taxes. We study the effect of a change in the profit tax rate using two counterfactual experiments. First, we ask how a change in the tax rate affects the startup rate when all other parameters remain unchanged. We answer this question by decreasing the profit tax rate from 32% to 19% in the model economy calibrated to the 1980s. We find the decline in the profit tax rate from 32% to 19% reduces the startup rate by 0.76 percentage points. The corresponding decline in the model recalibrated to the 2010s is 3.76 percentage points. Therefore, the change in the effective corporate tax rate accounts for 20.21% of the decline in the startup rate. When compared to the decline observed in data, the change in the tax rate accounts for 17.39% of the decline. The decline in the profit tax rate leads to a decline in the exit threshold and an increase in wages, as outlined in [Corollary 2](#). In the counterfactual experiment, the exit threshold z^* declines by 1.37% and the wage rate increases by 8.50%.

What happens to the masses S and M in the counterfactual experiment? When taxes decline from 32% to 19% in the model economy calibrated to the 1980s, S increases by 17.64% and M increases 25.35%. Note the startup rate in the counterfactual experiment declines despite an increase in the mass of startups S .

Second, we ask how a change in all parameters except the tax rate affects the startup rate. We answer this question by increasing the tax rate from 19% to 32% in the model economy calibrated to the 2010s steady state. We find the increase in the tax rate from 19% to 32% increases the startup rate by 0.63 percentage points. Therefore, the change in

	Data	Model	Counterfactuals	
			Only Taxes	All but Taxes
Decline in startup rate	4.37	3.76	0.76	0.63
Comparison to data	100%	–	17.39%	14.42%
Comparison to model	–	100%	20.21%	16.76%

Table 5: Counterfactual experiments

all parameters except the tax rate accounts for 83.24% of the model-generated decline in the startup rate. It follows that the change in the effective corporate tax rate accounts for 16.76% of the decrease in the startup rate. The fact that the impact of a change in corporate tax rates is quantitatively similar in both experiments is reassuring. Table 5 summarizes our findings.

3.1 Discussion

In this section, we discuss how alternative values of α , effective corporate tax rates, and labor taxes affect our findings. We also discuss how taxes affect aggregate output.

Sensitivity to α . If we consider a span-of-control parameter of 0.85, which is on the lower end of the values commonly used in the literature, then α is equal to 0.56. In that case, profit taxes have stronger quantitative effects. We recalibrate the model economy to the 1980s, with $\alpha = 0.56$, and repeat the counterfactual experiment in which the profit tax rate drops from 32% to 19%. We find the startup rate declines by 1.14 percentage points. Therefore, profit taxes account for 26.08% of the startup-rate decline observed in the data.

Global vs. domestic profits. The benchmark effective corporate tax rate, which includes taxes on domestic and foreign profits, dropped from 32% to 19% from the 1980s to the 2010s. Because the majority of startups are unlikely to earn foreign profits, the effective corporate tax rate on domestic profits might be the relevant measure for startups. If we consider taxes on domestic profits only, the effective corporate tax rate is 37% in the 1980s and 27% in the 2010s. We recalibrate the model economy using the tax rate on domestic profits, and consider the counterfactual experiment in which the profit tax rate drops from 37% to 27%. We find the startup rate declines by 0.63 percentage points. The decline in the profit tax rate accounts for 13.26% of the startup-rate decline observed in the data.

C-corporations vs. S-corporations. As reported by [Zucman \(2014\)](#), the measure of the effective corporate tax rate in NIPA is biased downward because it includes profits of S-

corporations, which pay zero corporate taxes. If we exclude the income of S-corporations, the effective corporate tax rate is 33% in the 1980s and 22% in the 2010s. We recalibrate the model economy to the 1980s using the 33% profit tax, and consider the effect of a drop in the profit tax rate to 22%. We find the startup rate declines by 0.66 percentage points. The decline in the profit tax rate accounts for 13.89% of the startup-rate decline observed in the data.

Labor tax rate. Because our model features occupational choice between entrepreneurship and employment, changes in the US labor-income tax rate might affect our quantitative findings. We find that introducing labor-income taxes does not affect our findings.

The labor-income tax rate, defined as the average tax rate on household income plus the average payroll tax rate, has stayed roughly constant at 20% since the 1980s, according to calculations from [McDaniel \(2007\)](#). We introduce labor-income taxes into the model and recalibrate the model economy to the 1980s. The calibrated parameters exhibit minor changes, but the fit of the model is unaffected. A reduction in profit taxes from 32% to 19% in the calibrated model economy reduces the startup rate by 0.79 percentage points. The corresponding number in the benchmark calibration without labor-income taxes was 0.76 percentage points. We conclude the introduction labor-income taxes does not affect our findings.

Aggregate output. Let Y denote aggregate output in the stationary equilibrium. The aggregate production function can be derived analytically; see [Appendix B](#). We have

$$Y = Z^{1-\alpha} M^{1-\alpha} N^\alpha,$$

where $Z = \left(\frac{1}{\lambda} \frac{S}{M}\right) \left[\int_{z^*}^{\infty} z d\Gamma(z)\right]$. A reduction in the profit tax rate from 32% to 19% in the model economy calibrated to the 1980s increases aggregate output by 7.16%. This effect occurs because profit taxes distort the entry-exit margin in our setting. At the 32% profit-tax rate, the model economy features an inefficiently high startup rate. The reduction in the profit-tax rate lowers the distortion, which brings the startup rate closer to its efficient level and increases aggregate output.

4 Further Evidence

Exit rate. One implication of the stationary firm-size distribution analysis we use is that both the startup rate and the exit rate decline together. We observe this decline of the exit rate in the data. The measure of exit in the data that is consistent with the law of motion

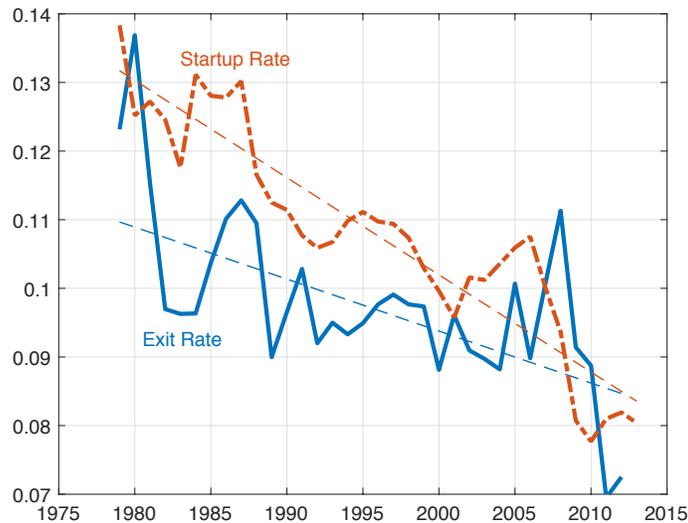


Figure 3

Source. BDS.

Notes. Dashed lines are best-fit trend lines.

(5) is total firms in year t , plus startups in year $t + 1$, minus total firms in year $t + 1$. Figure 3 plots the ratio of startups to total firms and the ratio of exiting firms to total firms. As the figure shows, since 1979, the firm exit rate has trended downward alongside the startup rate.

Cross-sectoral evidence. Our theory predicts that sectors with the largest drop in the effective corporate tax rate should have experienced the largest drop in startup rates. We find empirical support for this prediction. The correlation between changes in the effective corporate tax rate and changes in the startup rate across sectors is strong and positive; it equals 0.76. The correlation is even stronger for an alternative measure of startup activity: the startup employment share. The correlation in that case is 0.84.

Figure 4 plots the average annual change in the effective corporate tax rate for each sector from 1979 to 2014 against the change in the startup activity at the sector level over the same time period.⁵ The data presented here are for the nine broad private sectors in the Standard Industrial Classification. The two sectors that experienced the sharpest drop in effective corporate tax rates were Construction and Agriculture, with an average annual drop of 1.14 and 1.06 percentage points. These two sectors also saw the largest drop in startup rates and startup employment shares. The Manufacturing sector experienced the smallest drop in tax rates and the smallest drop in startup employment shares.

⁵NIPA does not report foreign profits or foreign taxes at the sectoral level. Therefore, effective tax rates at the sectoral level are calculated using data on domestic profits and taxes. The FIRE sector excludes the Federal Reserve Banks.

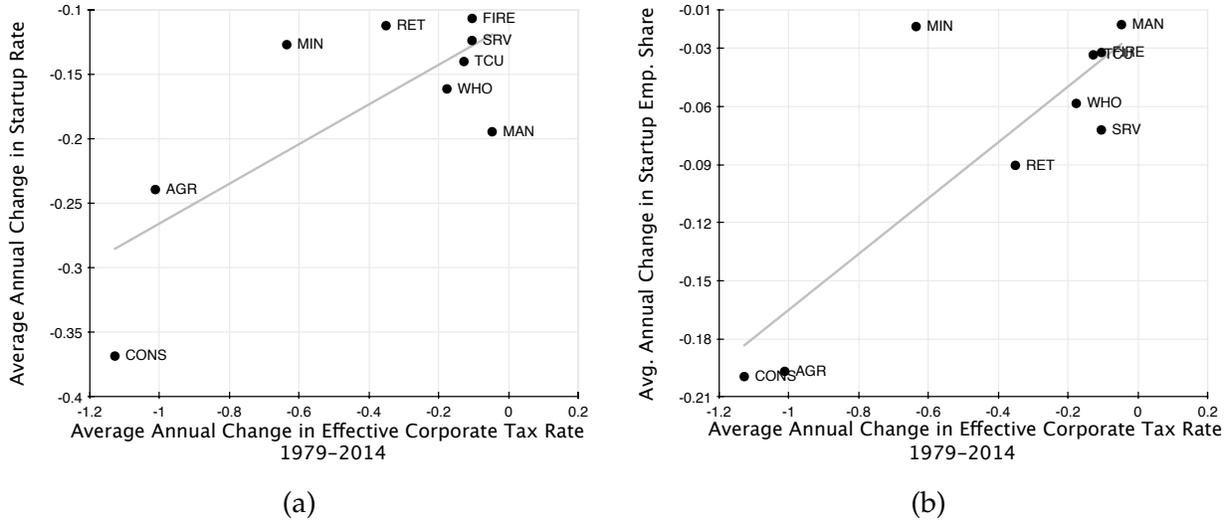


Figure 4

Source. Authors' calculations from NIPA and BDS.

Notes. For 4a, the correlation is 0.76. For 4b, the correlation is 0.84.

5 Conclusion

The United States has experienced a long-term decline in the startup rate. The forces behind this decline are not well understood. This paper explores the role of the long-term decline in corporate tax rates. Patterns in US sectoral data suggest corporate taxes played an important role: sectors that saw the biggest decline in corporate tax rates also experienced the largest decline in startup rates.

To explore the role of corporate taxes on the startup rate, we build a general equilibrium model of firm entry and exit with occupational choice. We proceed in two steps. First, we establish theoretically the conditions under which a decline in the corporate tax rate leads to a decline in the startup rate. We show that a decline in the corporate tax rate lowers the startup rate if it raises the opportunity cost of entrepreneurship. Second, we use the model to evaluate the quantitative impact of corporate tax rates on startup rates.

In our main specification, corporate taxes account for one-fifth of the decline in the startup rate. The remaining comes from changes in the underlying productivity distribution, entry costs, and exogenous exit probabilities. These changes may be due to demographics (Pugsley et al., 2015; Kopecky, 2017), regulations (Davis and Haltiwanger, 2014; Hsieh and Moretti, 2015), or market power (Loecker and Eeckhout, 2017). Studying the interaction between these forces and their combined impact on the startup rate is left for future work.

Appendix A Data Appendix

Startup Rates. Data to calculate startup rates comes from the Business Dynamics Statistics (BDS) produced by the [U.S. Census Bureau](#). The BDS dataset has near universal coverage of private sector firms with paid employees. BDS data starts in 1977, but best practice suggests dropping the years 1977 and 1978 due to suspected measurement error (e.g. [Moscarini and Postel-Vinay, 2012](#); [Pugsley and Sahin, 2014](#)). We follow the same practice, but note that including those extra years makes the drop in the startup rate even larger.

Effective Corporate Tax Rates. The effective corporate tax rate is from [Zucman \(2014\)](#), who calculates it using data from the National Income and Product Accounts. Data is available up until 2013. Detailed calculations can be found in the online data appendix to that paper. Briefly, the effective corporate tax rate is the worldwide corporate tax payments by US resident corporations divided by worldwide before-tax corporate profits by US resident corporations,

$$ECTR = \frac{\text{Federal Corp. Taxes} + \text{State and Local Corp. Taxes} + \text{Credits for Foreign Tax}}{\text{BT Domestic Prof. (excl. Fed. Banks)} + \text{AT Foreign Prof.} + \text{Credits for Foreign Tax}}$$

where BT and AT stand for before tax and after tax. Credits for foreign taxes paid are added to the denominator to get a measure of before-tax foreign profits.

The drop in effective corporate tax rates reflect a combination of factors. One factor is the decline in the top statutory corporate tax rate from 46% in the early 1980s to the current 35%. But other factors played a role as well. According to [Zucman \(2014, pg. 133\)](#): “Out of the 10 points decline in the effective tax rate between 1998 and 2013, 2 to 4 points can be attributed to changes in the US tax base and the Great Recession, leaving two-thirds or more of the decline to increased tax avoidance in low-tax countries. [...] [The rise in] S-corporations [which show up in NIPA but pay no corporate taxes] account for 2 percentage points of the fall in the effective tax rate from the 1980s to the 1990s, but they do not contribute to the 1998-2013 decline.”

Appendix B Solving for the Equilibrium

We start by characterizing the solution to the profit-maximization problem of the firm. Firms choose labor n to maximize gross profits (2). Let $\bar{n}(z)$ denote labor demand by firm with productivity z , given the wage rate w . We have

$$\bar{n}(z) = \left(\frac{\alpha}{w}\right)^{1/(1-\alpha)} z. \quad (\text{A-1})$$

Labor demand is increasing in productivity z . We can express labor demand at a firm with productivity z in terms of labor demand at the marginal firm. Doing so simplifies the calculation of aggregate labor demand. We have $n(z) = \bar{n}(z^*)z/z^*$.

The maximized value of firm profits after taxes is given by

$$\pi(z) = (1 - \alpha) \left(\frac{\alpha}{w}\right)^{\alpha/(1-\alpha)} z. \quad (\text{A-2})$$

Firm profits are also an increasing function of productivity z . As we did with labor demand functions, we can write $\pi(z) = \pi(z^*)z/z^*$.

We then solve for the equilibrium in two stages. In the first stage, we use the exit and entry conditions to solve for the exit threshold z^* and the wage rate w . In the second stage, we solve for the stationary distribution of firm productivities and the masses of startups and total firms. After solving for the stationary equilibrium, we discuss how profit taxes affect the startup rate.

Wage rate w and exit threshold z^* . In equilibrium, each individual agent is indifferent between working today and choosing his occupation again tomorrow, and starting a firm. The value of being an agent who is yet to choose an occupation is found by applying the indifference condition to (3). We obtain $W = w + W'/(1+r)$. In a stationary equilibrium, the agent's occupational problem next period is identical to the problem today, $W = W'$. Therefore, we have

$$W = W' = \frac{w(1+r)}{r}.$$

The value of a firm with productivity z before the exit decision is given by

$$V(z) = \begin{cases} b + (1 - \delta)\frac{w}{r} & \text{if } z \leq z^*, \\ \left(\frac{1+r}{r+\lambda}\right) [(1 - \tau)\pi(z) + \lambda(b + (1 - \delta)\frac{w}{r})] & \text{if } z \geq z^*, \end{cases}$$

where $\pi(z)$ is given by (A-2). The expression for $V(z)$ follows from substituting (10) in (4)

and using the fact that $V'(z) = V(z)$ in a stationary equilibrium. The firm value function indicates that it is optimal for firms with $z < z^*$ to take the exit payoff, $b + (1 - \delta)w/r$. Firms with $z > z^*$ strictly prefer to operate. The value of those firms is equal to the expected discounted value of future profits, with an adjustment for the possibility of involuntary exit. The firm with productivity equal to z^* is indifferent between exiting and operating. Therefore, we have

$$\begin{aligned} \left(\frac{1+r}{r+\lambda}\right) \left[(1-\tau)\pi(z^*) + \lambda \left(b + (1-\delta)\frac{w}{r} \right) \right] &= b + (1-\delta)\frac{w}{r}, \\ \pi(z^*) &= \frac{1}{1-\tau} \frac{r(1-\lambda)}{1+r} \left(b + (1-\delta)\frac{w}{r} \right). \end{aligned} \quad (\text{A-3})$$

We can solve (A-3) to obtain z^* in terms of the wage rate w . We have

$$z^* = \left(\frac{r(1-\lambda)}{(1+r)(1-\alpha)} \right) \left(\frac{1}{1-\tau} \right) \left(\frac{w}{\alpha} \right)^{\frac{\alpha}{1-\alpha}} \left(b + (1-\delta)\frac{w}{r} \right). \quad (\text{A-4})$$

The exit condition requires $W = \mathbb{E}[V(z)] - c_e$. The expected value of starting a firm $\mathbb{E}[V(z)]$ is given by

$$\mathbb{E}[V(z)] = \int_{\underline{z}}^{z^*} \left[b + (1-\delta)\frac{w}{r} \right] d\Gamma(z) + \left(\frac{1+r}{r+\lambda} \right) \int_{z^*}^{\infty} (1-\tau)\pi(z) + \lambda \left[b + (1-\delta)\frac{w}{r} \right] d\Gamma(z)$$

When Γ is Pareto with shape parameter ρ and scale parameter \underline{z} , we have

$$\begin{aligned} \mathbb{E}[V(z)] &= \left(b + (1-\delta)\frac{w}{r} \right) \Gamma(z^*) \\ &\quad + \left(\frac{1+r}{r+\lambda} \right) \left[\left(\frac{\rho}{\rho-1} \right) (1-\tau)\pi(z^*) + \lambda \left[b + (1-\delta)\frac{w}{r} \right] \right] [1 - \Gamma(z^*)], \end{aligned}$$

where we have used $\pi(z) = \pi(z^*)z/z^*$ along with the property of the Pareto distribution that $\mathbb{E}[z/z^* | z \geq z^*] = \rho/(\rho-1)$. Substitute for $\pi(z^*)$ using the exit condition (A-3) and simplify. We have

$$\mathbb{E}[V(z)] = \left(b + (1-\delta)\frac{w}{r} \right) \left[\Gamma(z^*) + \left[\frac{\rho(r+\lambda) - \lambda(1+r)}{(\rho-1)(r+\lambda)} \right] [1 - \Gamma(z^*)] \right].$$

The entry condition $\mathbb{E}[V(z)] - c_e = W$ follows. We have

$$\left(b + (1-\delta)\frac{w}{r} \right) \left[\Gamma(z^*) + \left[\frac{\rho(r+\lambda) - \lambda(1+r)}{(\rho-1)(r+\lambda)} \right] [1 - \Gamma(z^*)] \right] - c_e = w + \frac{w}{r}.$$

Subtract $b + (1 - \delta)w/r$ from both sides and simplify. We have

$$\left(b + (1 - \delta)\frac{w}{r}\right) \left[\frac{r(1 - \lambda)}{(\rho - 1)(r + \lambda)}\right] [1 - \Gamma(z^*)] = w \left(\frac{r + \delta}{r}\right) + c_e - b. \quad (\text{A-5})$$

The expression for z^* in (A-4) can be used to express $[1 - \Gamma(z^*)]$ in terms of w . We have

$$1 - \Gamma(z^*) = \underline{z}^\rho \left[(1 - \tau) \frac{(1 + r)(1 - \alpha)}{r(1 - \lambda)}\right]^\rho \left(\frac{\alpha}{w}\right)^{\frac{\rho\alpha}{1 - \alpha}} \frac{1}{(b + (1 - \delta)w/r)^\rho},$$

where we have used the assumption that Γ is the CDF of a Pareto distribution, $1 - \Gamma(z^*) = (\underline{z}/z^*)^\rho$.

Substitute for $[1 - \Gamma(z^*)]$ in (A-5). The entry condition can now be written as

$$\begin{aligned} w^{\frac{\rho\alpha}{1 - \alpha}} \left[b + (1 - \delta)\frac{w}{r}\right]^{\rho - 1} \left[w \left(\frac{r + \delta}{r}\right) + c_e - b\right] \\ = \underline{z}^\rho \alpha^{\frac{\rho\alpha}{1 - \alpha}} \left[(1 - \tau) \frac{(1 + r)(1 - \alpha)}{r(1 - \lambda)}\right]^\rho \left[\frac{r(1 - \lambda)}{(\rho - 1)(r + \lambda)}\right]. \end{aligned} \quad (\text{A-6})$$

Equation (A-6) is a nonlinear equation in w that can be solved numerically to obtain the equilibrium wage rate. The exit threshold z^* follows.

Comparative statics. We differentiate (A-6) with respect to τ to evaluate how a change in the corporate tax rate affects w and z^* . Take logs of both sides of (A-6), differentiate with respect to τ and solve for $dw/d\tau$. We have

$$\frac{dw}{d\tau} = \frac{-\rho}{(1 - \tau)} \left[\frac{\rho\alpha}{w(1 - \alpha)} + \frac{(\rho - 1)(1 - \delta)}{w(1 - \delta) + br} + \frac{r + \delta}{w(r + \delta) + (c_e - b)r} \right]^{-1} < 0. \quad (\text{A-7})$$

A sufficient condition for $dw/d\tau < 0$ is $w + w/r + c_e \geq b + (1 - \delta)w/r$. From the entry condition we have $\mathbb{E}[V(z)] = w + w/r + c_e$, so the inequality can be rewritten as $\mathbb{E}[V(z)] > b + (1 - \delta)w/r$. An entrepreneur's exit payoff is $b + (1 - \delta)w/r$. Therefore, the expected value of creating a firm is bounded below by $b + (1 - \delta)w/r$. The required inequality holds in equilibrium and we have $dw/d\tau < 0$.

To find $dz^*/d\tau$, take logs of both sides of (A-4) and differentiate with respect to τ . We have

$$\frac{dz^*}{d\tau} \frac{1}{z^*} = \frac{1}{1 - \tau} + \frac{dw}{d\tau} \left[\frac{\alpha(w(1 - \delta) + br) + (1 - \alpha)(1 - \delta)w}{w(1 - \alpha)(w(1 - \delta) + br)} \right].$$

Substitute $dw/d\tau$ using (A-7). We have

$$\begin{aligned}
\frac{dz^*}{d\tau} \frac{1}{z^*} &= \frac{1}{1-\tau} \left[1 - \frac{\rho\alpha(w(1-\delta) + br) + \rho(1-\alpha)(1-\delta)w}{w(1-\alpha)(w(1-\delta) + br) \left[\frac{\rho\alpha}{w(1-\alpha)} + \frac{(\rho-1)(1-\delta)}{w(1-\delta)+br} + \frac{r+\delta}{w(r+\delta)+(c_e-b)r} \right]} \right] \\
&= \frac{1}{1-\tau} \left[1 - \frac{\rho\alpha(w(1-\delta) + br) + \rho(1-\alpha)(1-\delta)w}{\rho\alpha(w(1-\delta) + br) + w(1-\alpha)(\rho-1)(1-\delta) + \frac{w(1-\alpha)(w(1-\delta)+br)(r+\delta)}{w(r+\delta)+(c_e-b)r}} \right] \\
&= \frac{1}{1-\tau} \left[\frac{-(1-\alpha)(1-\delta)w + \frac{w(1-\alpha)(w(1-\delta)+br)(r+\delta)}{w(r+\delta)+(c_e-b)r}}{\rho\alpha(w(1-\delta) + br) + w(1-\alpha)(\rho-1)(1-\delta) + \frac{w(1-\alpha)(w(1-\delta)+br)(r+\delta)}{w(r+\delta)+(c_e-b)r}} \right] \\
&= \frac{(1-\alpha)w}{1-\tau} \left[\frac{-(1-\delta) + \frac{w(1-\delta)+br}{w(r+\delta)+(c_e-b)r}}{\rho\alpha(w(1-\delta) + br) + w(1-\alpha)(\rho-1)(1-\delta) + \frac{w(1-\alpha)(w(1-\delta)+br)(r+\delta)}{w(r+\delta)+(c_e-b)r}} \right].
\end{aligned}$$

The sign of $dz^*/d\tau$ is determined by the numerator of the term inside the brackets. We have

$$\begin{aligned}
&\frac{(w(1-\delta) + br)(r+\delta)}{w(r+\delta) + (c_e-b)r} - (1-\delta) \\
&= \frac{r(b(1+r) - (1-\delta)c_e)}{w(r+\delta) + (c_e-b)r}.
\end{aligned}$$

It follows that $dz^*/d\tau > 0$ iff $b(1+r) > c_e(1-\delta)$, or equivalently if $b/(1-\delta) > c_e/(1+r)$.

Stationary firm-productivity distribution. An invariant firm-size distribution arises when startups replace firms that exit. Recall that $\mu(z)$ is the mass of firms with productivity less than z in the intermediate stage, before the exit decision is made. An invariant firm-productivity distribution must satisfy

$$\mu(z) = S\Gamma(z) \quad \text{when } z \leq z^*, \quad (\text{A-8})$$

$$\lambda(M - \mu(z)) = S(1 - \Gamma(z)) \quad \text{when } z \geq z^*. \quad (\text{A-9})$$

The first equation states that startups replace firms that realize low values of productivity and exited last period. The second equation says that startups that operate replace the high-productivity firms that exited last period because of the exogenous exit shock.

It follows that we need to know S and M , along with z^* , to obtain the firm-productivity distribution in a stationary equilibrium. Equations (A-8) and (A-9) both hold at the thresh-

old z^* . Setting the two equal to each other and solving for the mass of startups in the stationary equilibrium, we have

$$S = \frac{\lambda M}{1 - (1 - \lambda)\Gamma(z^*)}. \quad (\text{A-10})$$

We can use the labor-market clearing condition to obtain another relationship between S and M . The mass function $d\mu(z)$ is given by

$$d\mu(z) = \begin{cases} Sd\Gamma(z) & z \leq z^*, \\ \frac{S}{\lambda}d\Gamma(z) & z \geq z^*. \end{cases}$$

Because $N = 1 - M$, the labor-market clearing condition can be written as

$$\frac{S}{\lambda} \int_{z^*}^{\infty} n(z)d\Gamma(z) = 1 - M,$$

where $n(z)$ is given by (A-1). Substituting for M using (A-10) and solving the labor market condition for S , we have

$$S = \frac{\lambda}{\left(\frac{\rho}{\rho-1}\right) [1 - \Gamma(z^*)]n(z^*) + [1 - (1 - \lambda)\Gamma(z^*)]},$$

where we have used $n(z) = n(z^*)z/z^*$. It follows from (A-10) that the mass of total firms is given by

$$M = \frac{1 - (1 - \lambda)\Gamma(z^*)}{\left(\frac{\rho}{\rho-1}\right) [1 - \Gamma(z^*)]n(z^*) + [1 - (1 - \lambda)\Gamma(z^*)]}.$$

Now that we have z^* , w , S and M , we can calculate lump-sum taxes from the budget balancedness condition to finish solving for the equilibrium.

Aggregate production function. Let $y(z)$ denote the profit-maximizing level of output at a firm with productivity level z . We have $y(z) = z^{1-\alpha}[\bar{n}(z)]^\alpha$. Let Y denote aggregate output. It equals the sum of the output produced by all operating firms. We have $Y = \int_{z^*}^{\infty} y(z)d\mu(z)$. Substituting for $y(z)$ and then for $n(z)$ using (A-1), we have

$$Y = \left[\frac{\alpha}{w}\right]^{\alpha/(1-\alpha)} \int_{z^*}^{\infty} z d\mu(z).$$

The labor-market clearing condition implies that

$$\left[\frac{\alpha}{w}\right]^{1/(1-\alpha)} = \frac{N}{\int_{z^*}^{\infty} z d\mu(z)}.$$

In a stationary equilibrium we have $d\mu(z) = \frac{S}{\lambda} d\Gamma(z)$. It follows that aggregate output is given by

$$Y = \left[\int_{z^*}^{\infty} z d\Gamma(z) \right]^{1-\alpha} \left(\frac{S}{\lambda} \right)^{1-\alpha} N^\alpha.$$

Multiply and divide the term in parentheses by the mass of firms M . We have

$$Y = Z^{1-\alpha} M^{1-\alpha} N^\alpha,$$

where $Z = \left(\frac{1}{\lambda} \frac{S}{M} \right) \left[\int_{z^*}^{\infty} z d\Gamma(z) \right]$. When firm productivity follows a Pareto distribution, Z in a stationary equilibrium is given by

$$Z = \frac{1}{\lambda} \left(\frac{\rho}{\rho-1} \right) \frac{S}{M} [1 - \Gamma(z^*)] z^*.$$

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