Reviving American Entrepreneurship? Tax Reform and Business Dynamism*

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Petr Sedláček† and Vincent Sterk‡

†University of Oxford and CEPR
‡University College London and CEPR

Abstract

The 2017 Tax Cuts and Jobs Act slashed tax rates on business income and introduced immediate expensing of investments. Using a quantitative heterogeneous-firms model, we investigate the long-run effects of such tax reforms on firm dynamics. We find that they can substantially increase business dynamism, potentially offsetting the large decline in the U.S. startup rate observed over recent decades. This result is driven by indirect equilibrium forces: the tax reform stimulates firm entry, leading to an increase in labor demand and wages, which in turn makes firm selection more stringent. Related to this is a large boost of the number of firms and of aggregate output, investment and employment.

JEL: D21, E22, E24, H25

Key words: Taxation, Business Dynamism, Aggregate Productivity

*In preparation for the NYU-Carnegie-Rochester Conference Series on Public Policy. Sedláček: Department of Economics, University of Oxford, Manor Road Building. Email: petr.sedlacek@economics.ox.ac.uk. Sterk: Department of Economics, University College London, Drayton House. Email: v.sterk@ucl.ac.uk. We thank François Beaudry for useful comments.

1 Introduction

Recently, the United States have implemented a far-reaching package of tax laws, commonly known as the "Tax Cuts and Jobs Act of 2017", henceforth TCJA. A hallmark of this reform is a reduction in the corporate tax rate from 35 to 21 percent, alongside similarly large cuts in tax rates on other forms of business income. A second important change is the introduction of immediate expensing of investments, replacing depreciation allowances. This means that firms can now deduct their investments from taxable income immediately upon purchase, instead of doing so gradually as the invested capital depreciates.

Some claim that these reforms could reinvigorate the increasingly sclerotic U.S. business climate.[1] Figure 1 shows that the startup rate has almost halved since the late 1970s, and that the exit rate has also declined somewhat. Other indicators of business dynamism have declined as well, see for example Decker et al. (2016). These trends are a cause for concern, since a less dynamic economy is often associated with less creative destruction, which may have important macroeconomic repercussions.

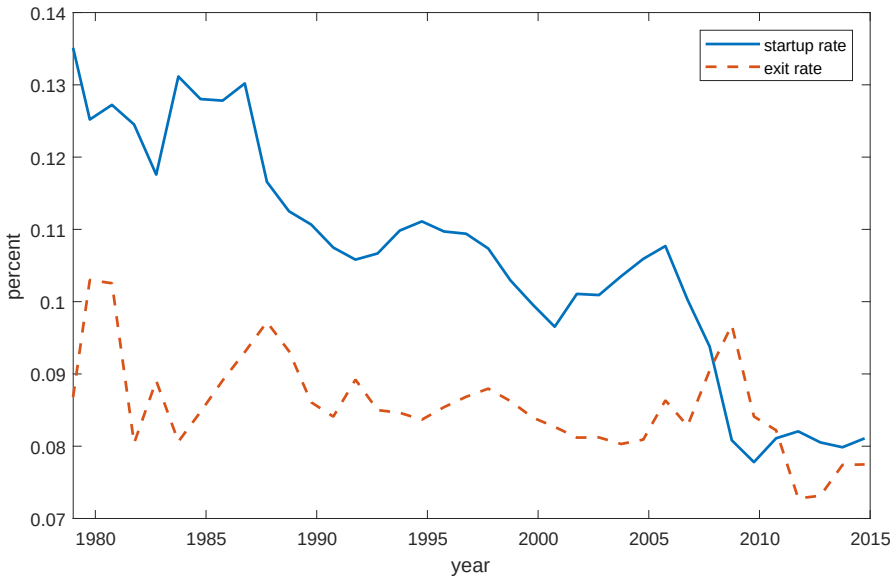
Although it seems likely that a tax reform of this scale will leave a significant mark on the U.S. economy, little is known about what exactly will be its impact. Data to be released over the next few years may reveal how the U.S. economy is changing, but even then it will be difficult to attribute these changes to particular aspects of the tax reform.[2]

In this paper, we use a firm dynamics model to understand the *long-run* effects of the business tax cuts and the introduction of immediate expensing on business dy-

[1] Claims along these lines have for example been made during the U.S. Congress committee meeting "The Startup Slump: Can Tax Reform Help Revive American Entrepreneurship?", held on October 3, 2017.

[2] Many policy changes were implemented simultaneously. For example, the structure of individual income taxes has also been reformed as part of the Tax Cuts and Jobs Act of 2017. In this paper, we focus on the taxation of firms, more specifically corporate and pass-through entities.

Figure 1: The firm startup rate and exit rate in the United States.



Source: Business Dynamics Statistics (BDS). The BDS are a snapshot taken in March of each year. The figure centers entry and exit rates rate around the middle of the observation year.

namism, and the macro economy in general. Our framework builds on the canonical firm-dynamics models of Hopenhayn (1992) and Hopenhayn and Rogerson (1993), in which firms are subject to idiosyncratic productivity shocks and entry and exit of firms are endogenous outcomes. We integrate capital investment (see also Bartelsman et al. (2013)) and adjustment costs (see also Clementi and Palazzo (2016)) into this framework. Moreover, we introduce a tax on business income and model explicitly the two expensing regimes. The model is then used to analyze qualitatively the various transmission channels of the tax reform. Moreover, we calibrate the model to the U.S. economy, and evaluate the quantitative effects using numerical simulations.

Our analysis complements recent work of Barro and Furman (2018) and Mertens (2018), who consider the effects of the TCJA on real activity, but do not focus on business dynamism. Barro and Furman (2018) analyze the tax reform through the lens of a neoclassical growth model with an infinitely-lived, representative firm. Our

results highlight that considering firm dynamics brings forward new channels through which the fiscal reform may affect the aggregate economy. In particular, key effects of the reform operate through the incentives to start or terminate firms, a channel that is absent in representative-firm models. Mertens (2018) uses a reduced-form empirical model to make projections on the effects of the TCJA. Finally, our quantitative model builds on Hopenhayn and Rogerson (1993), who study the effects of firing restrictions, but do not model capital investments or the taxation of business income.

To understand the transmission channels of the tax reform, we differentiate between *direct* and *indirect* effects. The direct effects operate via the responses of incumbent firms to the change in taxation, abstracting from the responses of equilibrium wages. The indirect channels capture the responses of incumbents to changes in equilibrium wages and changes in the number of operating businesses. They also encompass how changing incentives to start a business affect the number of firms that enter in equilibrium.

We show that the *direct* effects are either absent or push towards *less* dynamism. Since the taxes are levied on firm profits, a reduction in the tax rate does not directly distort marginal decisions regarding hiring, investment and exit, provided that investments can be immediately expensed. Similarly, a switch from gradual to immediate expensing has no direct effects, provided that it does not change the present value of tax deductions. Realistically, however, immediate expensing increases the present value of tax deductions, as firms discount deductions to be received in the future. Barro and Furman (2018) estimate that the move towards immediate expensing increased the present value of deductions on equipment by about 20 percent.[3] In that case, the in-

[3]The present value might be affected for several reasons. One is that firms discount future income at a positive rate. Provided that firms discount future profits with a positive rate, they will prefer to receive tax deductions sooner rather than later. Similarly, the present value of deductions might be affected if the depreciation schedule assumed by the fiscal authority does not coincide with economic depreciation.

troduction of immediate expensing substantially lowers the user cost of capital. This reduction in costs directly discourages firms from exiting, which lowers economic dynamism.

On the other hand, the *indirect* effects of the tax reform push towards a *more* dynamic economy. In particular, the reduction in the tax rate increases firm values and hence encourages entry. As a result, labor demand increases, which drives up equilibrium wages. The latter makes the process of firm selection more stringent as only relatively productive firms are capable of surviving in the more competitive economy. Exiting firms then make way for new entrants increasing firm churn, a primary measure of business dynamism. Similarly, the introduction of immediate expensing increases wages and fosters dynamism, provided that it lowers the user cost of capital. In this case, the increase in wages happens for two distinct reasons. First, the reduction in the cost of capital triggers more firm entry, which increases aggregate labor demand. Second, a lower cost of capital increases investment, which raises the marginal product of labor and hence wages.

Using quantitative simulations, we evaluate the net impact of the tax reform in the long run. Our findings show that, overall, the indirect effects dominate and that the reform increases economic dynamism dramatically. The increase in dynamism is potentially large enough to entirely offset the decline in the startup rate observed in the U.S. since the 1970s.

We also find that the reform creates a large increase in aggregate output, investment and employment. These outcomes are due to both the introduction of immediate expensing and the cut in the tax rate. The large output effects of a cut business tax rates contrasts typical findings in representative-agent models, in which such taxes tend to create few or no distortions.[4] Our analysis thus underscores the importance of ac-

[4]The underlying reason is that in representative-agent models, profit taxes proportionally affect net revenues and costs, the latter via tax deductions. In a firm-dynamics model this is not the case. The

counting for firm dynamics and the associated equilibrium effects when evaluating the macroeconomic impact of tax reforms.

The remainder of this paper is organized as follows. Section 2 discusses some of the important features of the Tax Cuts and Jobs Act in more detail. Section 3 discusses how business dynamism evolved following two large tax reforms in the 1980s. Section 4 presents the model and a number of qualitative results. In Section 5, we calibrate the model to the U.S. economy and evaluate the quantitative effects of the tax reform. In Section 6 we discuss some limitations of the model and offer suggestions for extensions. Section 7 concludes.

2 The Tax Cuts and Jobs Act of 2017

The Tax Cuts and Jobs Act (TCJA) of 2017 is one of the most sweeping tax reforms in modern U.S. history. There are many aspects to this tax reform, all of which could potentially leave a mark on business dynamism. In this section, we discuss in more detail some of the largest changes. We focus on changes which directly affect firms, and are therefore likely to be particularly important in affecting business dynamism.

Taxation of C corporations

The taxation of U.S. firms depends on their legal form. A prominent category is formed by so called C corporations, which pay corporate income tax on their profits. C corporations only make up a modest fraction of the total number of firms, but are nonetheless important contributors to the total U.S. tax bill since they are relatively large. Over the last few decades, between 60 and and 90 percent of total tax receipts from U.S.

entry cost, an important cost component for startups, is borne by the entrepreneur before the firm is created. Therefore, entry costs do not qualify as tax-deductable costs and are thus insensitive to a tax change. A cut in the tax rate increases net revenues, but does not proportionately increase net costs for prospective entrants. Therefore, entry increases.

firms were paid by C corporations, see for instance Dyrda and Pugsley (2018).

Prior to the TCJA, corporate income has been taxed at a statutory top rate of 35 percent for over two decades. However, the effective tax rate has been lower for many firms due to progressivity and various deductions and exemptions, see GAO (2016). The TCJA permanently lowered the corporate tax rate to a flat 21 percent, while at the same time reducing or eliminating certain deductions. The Congressional Budget Office (CBO) expects revenues from corporate income taxes to fall by 18 percent, from 1.5 percent of GDP to 1.2 percent of GDP, largely due to the enactment of the TCJA, see CBO (2018). In addition to the federal tax there are also state-level corporate taxes which vary across states.

Taxation of pass-through businesses

Most U.S. businesses, and in particular small firms, are organized as so called S corporations, partnerships or sole proprietorships. These firms, also known as pass-through businesses, do not pay corporate income tax. Rather, their owners pay individual income taxes based on the profits of their business. Under the TCJA, also personal income taxes are reduced substantially, via both a reduction in rates and a shift in tax brackets. Pass-through businesses benefit directly from this reduction. In addition, the TCJA stipulates a new 20 percent deduction especially for certain pass-through businesses. As for C corporations, the TCJA thus creates a substantial reduction in the tax burden on these firms.

Note also that firms can always change their legal form to their own benefit. In addition, the cuts in individual taxation are currently subject to a sunset clause, from 2025 onward, but may become permanent.

Expensing of investments

Finally, the TCJA benefits firms via a change in the expensing rules of investments. Under the TCJA, firms are allowed to deduct investments in equipment from taxes in the year of purchase, rather than gradually over time and in tandem with depreciation. In previous years, immediate expensing was allowed only partially. From 2013 until 2017, firms could deduct 50 percent of their investments immediately.

Under the current law, immediate expensing will be phased out between 2022 and 2026, but it may become a permanent feature of the tax law. The CBO reports a budgetary impact of the change in expensing rules that is comparable to the budgetary impact of the reduction in corporate income tax rates.

3 Tax reforms and business dynamism in the 1980s

Tax systems are complex and can change along many dimensions. Moreover, tax reforms occur only infrequently and may be designed in part in response to the state of the economy. These factors make it difficult to unequivocally estimate the effects of tax reforms from the data. It is nonetheless useful to consider what happened following previous reforms. Arguably, two of the largest reforms of business taxation in post-war U.S. history, aside from the TCJA, were implemented under president Ronald Reagan in the 1980s. The first is the Economic Recovery Act of 1981 (implemented in August) and the second is the Tax reform Act of 1986 (implemented in October).

Table 3 shows the effects of these reforms on tax revenues, as projected by the Congressional Budget Office at the time of implementation. The 1981 reform slashed both individual and corporate income taxes, implying a large decline in the tax burden on both households and businesses. In this sense, the reform was similar to the TCJA of 2017. By contrast, the 1986 reform strongly reduced individual income taxes, but

Table 1: Effects of the 1981 and 1986 reforms on tax revenues, CBO projections.

Economic Recovery Act of 1981	**1982**	**1983**	**1984**	**1985**	**1986**
Individual Income Taxes, billions	-28 (-9%)	-74 (-20%)	-117 (-27%)	-147 (-30%)	-186 (-34%)
Corporate Income Taxes, billions	-11 (-18%)	-17 (-25%)	-25 (-29%)	-36 (-36%)	-28 (-43%)
Tax Reform Act of 1986	**1987**	**1988**	**1989**	**1990**	**1991**
Individual Income Taxes, billions	-15 (-4%)	-26.6 (-7%)	-29.6 (-7%)	-22.3 (-5%)	-18.8 (-4%)
Corporate Income Taxes, billions	+27 (+36%)	+25 (+27%)	+21 (+20%)	+23 (+20%)	+25 (+20%)

Note: The table shows the projected revenue effects of the specified tax changes in billions of dollars and in percent differences between pre- and post-reform budget estimates. Source: CBO (1998), Tables 4, 5, 10 and 11.

increased corporate taxes. The overall reform was roughly revenue neutral, but created a large shift of taxation from households to businesses.[5] From the perspective of businesses, the two reforms were therefore very different: the 1981 reform strongly reduced their tax bills, which surged again after the 1986 reform.

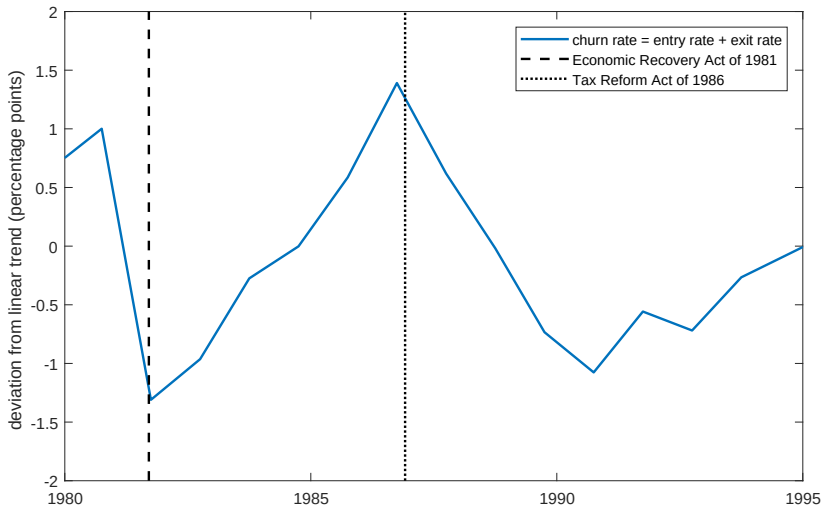
Figure 2 shows the evolution of business dynamism around the two tax reform, as measured by the firm churn rate in the Business Dynamics Statistics. The churn rate is defined as the sum of the firm entry and exit rates.[6] The figure shows a sharp increase in the churn rate following the Economic Recovery Act of 1981. Following the 1986 reform, and the associated increase in corporate taxes, the churn rate declined sharply.

Taking these facts at face value, the empirical behavior of the churn rate in the 1980s is consistent with the idea that a reduction in business taxation can substantially boost business dynamism. One should of course be careful interpreting these patterns, especially given that the 1980s were a rather turbulent period. For example, the 1981 reform was enacted at the onset of a deep recession and at the peak of a monetary tightening. Nonetheless, the sharp increase in dynamism following the 1981 tax cuts and the subsequent reversal after the 1986 reform are striking facts.

[5]The increase in corporate taxation occurred despite the fact that the statutory rate was actually reduced. However, the effects of this reduction was more than offset by a broadening of the corporate tax base, via the elimination of the investment tax credit, an increase in assumed depreciation lifetimes, and other measures; see for instance Poterba (1992).

[6]Since Figure 1 shows a clear downward trend in the entry and the exit rate we take out a linear trend, estimated over the period 1979 until 2015.

Figure 2: Business dynamism in the 1980s: churn rate.



Note: All data are taken from the Business Dynamics Statistics of the Census Bureau. The churn rate is defined as the sum of the firm entry and exit rate. The BDS are a snapshot taken in March of each year. The figure centres the churn rate around the middle of the observation year.

4 Model and qualitative results

We now consider a firm dynamics model, in order to better understand through which channels a tax reform like the TCJA can affect dynamism. The model is a straightforward extension of the model developed in Hopenhayn (1992) and Hopenhayn and Rogerson (1993). Firms produce using capital and labor and are hit by idiosyncratic productivity shocks over their lifetime. Importantly, business dynamism is endogenous as firm entry and exit are both the result of optimal firm decisions.

The model is used to analyze the long-run effects of changes in both the rate at which firm profits are taxed, and in the way investment expenses can be deducted. In doing so, we differentiate between the direct effects that changes in taxation have on the behavior of incumbent firms, and the indirect effects which occur in response to changes in wages and the number of entrants.

4.1 Model description

We consider a general equilibrium model with an endogenous measure of heterogeneous firms and a representative household. The economy is stationary and time is discrete. Firms produce a homogeneous good, maximizing the present value of after-tax profits. They operate decreasing returns-to-scale production technologies, denoted by $y = f(k, l, z)$, where y denotes output, k is the firm's capital stock, l is its labor input and z is Total Factor Productivity (TFP). The latter is firm-specific and follows a Markov process. Production also requires a fixed operational cost c_f, denominated in units of goods. Capital depreciates at a rate δ and we denote investment by $i = k - (1 - \delta) k_{-1}$, where k_{-1} denotes lagged capital. Capital becomes productive immediately in the period of investment. A firm further faces a tax bill, which we will detail below.

Incumbent firms face a cost of capital adjustment given by $\psi(k, k_{-1}) \geq 0$, which we will specify later. At the beginning of a period, a firm chooses whether to exit or to continue. At this point, the firm knows its lagged TFP level z_{-1}. If the firm continues, it learns its current productivity realization z and generates a before-tax cash flow given by $\pi^c = y - wn - i - c_f - \psi(k, k_{-1})$, where a superscript c denotes a continuing firm. If the firm exits, it avoids the fixed cost, sells its remaining capital, and terminates operations forever. It therefore generates a final, before-tax cash flow $\pi^x = -i - \psi(0, k_{-1}) = (1 - \delta) k_{-1} - \psi(0, k_{-1})$, where a superscript x denotes an exiting firm.

There is free entry of firms. After paying an entry cost, c_e (denominated in units of goods), an entrant draws its initial lagged value z_{-1} from a distribution. Thereafter, entrants behave as incumbents, i.e. they choose to either exit immediately or to start producing. We assume that entrants start with zero capital and are exempted from the

Table 2: Tax bills under the two expensing regimes.

	Continuing firms (T^c)	Exiting firms (T^x)
Gradual expensing:	$\tau\left(\pi^c + i - \delta k\right)$	$\tau\left(\pi^x - (1-\delta)\, k_{-1}\right) = -\tau\psi(0, k_{-1})$
Immediate expensing:	$\tau\pi^c$	$\tau\pi^x = \tau\left(1-\delta\right) k_{-1} - \tau\psi(0, k_{-1})$

capital adjustment cost.[7]

Let us now turn to the discussion of how firms are taxed. Taxable business income, calculated as revenues minus costs, is taxed at a rate τ. We assume that the costs which firms can deduct include labor and capital expenses, the fixed cost of production and the adjustment costs. We further assume that entry costs cannot be deducted, as we think of those primarily as costs associated with red tape and the development of a business plan, which are therefore not tax deductable. The deduction of capital expenses depends on the investment expensing regime.

Table 2 shows the tax bills for continuing firms (T^c) and exiting firms (T^x) under both regimes. Consider first the gradual expensing regime (top row), in which the deduction of capital takes the form of a depreciation allowance. This means that investment expenses are excluded from the calculation of taxable income. Instead, firms deduct the amount of capital that is lost in depreciation during the production process in a given period. For simplicity, we assume that the depreciation schedule assumed by the fiscal authority coincides with the speed of economic depreciation. That is, the deduction equals δk. Note that if the firm exits, it does not pay any taxes since the final sale of capital is a negative investment, which is excluded from taxable income under the gradual expensing regime. Instead, the firm receives a subsidy, based on the adjustment cost paid in the final period, as it can carry back this cost as a deduction

[7]Similarly, Hopenhayn and Rogerson (1993) exempt entrants from labor adjustment costs.

on previously paid taxes.[8]

In the immediate expensing regime (bottom row in Table 1), a continuing firm faces a tax bill that is proportional to its flow profit. Moreover, an exiting firm may now be confronted with a tax bill, as the government recaptures part of the tax deduction on investment, insofar the invested capital has not fully depreciated during the production process.[9]

Given all the above, firms optimize profits, taking prices and wages as given. Let r be the rate at which firms discount future profits. The firm value at the moment the exit decision is taken can be expressed recursively as:

$$V(z_{-1}, k_{-1}) = \max \left\{ \mathbb{E}\{\max_{k,l} \pi^c - T^c + \frac{1}{1+r} V(z,k)\}, \pi^x - T^x \right\}, \tag{1}$$

subject to the TFP process and the expressions for π^c, π^x, T and T^x given above, and where $\mathbb{E}$ is the conditional expectations operator. Given a capital level k_{-1}, there is now a cutoff value of productivity z^*_{-1} at which the firm is precisely indifferent between exiting and continuing. Firms with a level of productivity below this threshold choose to exit. This cutoff is increasing in the wage w, as higher wages reduce firm profits, pushing out the least productive firms.

Free entry implies that $c_e \geq \mathbb{E}_e V_e(z_{-1})$, where the expectation here is taken with respect to the distribution of initial productivity draws and $V_e(z_{-1})$ denotes the value of an entrant with a draw z_{-1} . We focus on equilibria with positive entry, i.e. the free-entry condition holds with equality. The right hand side of the condition, $\mathbb{E}_e V_e(z_{-1})$, is typically declining in the wage, as well as in the cutoff level. Hence, the free-entry condition defines a negative relation between the cutoff and the wage, as also noted by

[8]Realistically, a firm might also be subject to a capital gains tax when selling capital. This is not relevant in our model since the price of capital is constant.

[9]This is known as "depreciation recapture".

Melitz (2003).

Finally, the economy is populated by a a representative, price-taking, household. The flow utility of the household is given by $U(C, N) = \ln C - \nu N$, where C denotes aggregate consumption and N is aggregate labor supply. We further assume that the government runs a balanced budget and that all tax revenues are rebated to the household in a lump-sum way. Labor market clearing implies that labor demand, aggregated over all firms, equals N, whereas goods market clearing implies that $Y = C + I$, where Y is aggregate output, and I denotes the aggregate investments into capital, capital adjustment costs, fixed costs of operation, and entry costs.

Before we evaluate the model quantitatively, we derive a number of qualitative results which help to understand how tax reforms affect economic dynamism. We distinguish between "direct" and "indirect" effects. The direct effects capture the responses of firms to a change in taxation, holding fixed the equilibrium wage. The indirect effects are defined as the remaining effects which arise in general equilibrium and also involve the behavior of potential entrants.

4.2 Reduction in the tax rate

We present three qualitative results, which we prove in Appendix A. The first result concerns the effect of a change in taxes on incumbents:

Proposition 1. *Under immediate expensing and an exogenous wage, the decisions of incumbent firms are not affected by a change in the tax rate τ.*

Intuitively, under immediate expensing the tax rate affects net revenues and costs proportionally, the latter because of deductions. As a result, a change in the tax rate does not affect the firms' marginal decisions on employment and investment. It also does not affect the firms' exit decisions, as the continuation value and exit value are affected pro-

portionally by the tax as well. The tax skims off a proportion of firm values, but never turns a positive net value negative. A firm that is economically viable in the absence of taxation, will therefore continue to be viable when the tax is imposed, as long as the tax rate remains below one hundred percent. Proposition 1 therefore implies that, under immediate expensing, business dynamism, aggregate output, and productivity are not directly affected by a change in the tax rate.

Note that this irrelevance result regards the direct effect of a change in taxation, keeping constant the equilibrium wage. However, a decline in the tax rate does trigger a change in behavior via *indirect* effects, which is our second result:

Proposition 2. *Under immediate expensing, a permanent reduction in the tax rate increases the exit cutoff z^*_{-1} via an increase in the equilibrium wage.*

This result implies that selection becomes more stringent when the tax rate is reduced, as only firms with productivity levels above the cutoff survive. The result derives from the behavior of entrants. A decline in the tax rate pushes up firm values. The free-entry condition implies that the expected value of an entrant equals the entry cost, c_e. Therefore, an increase in values due to a tax cut must be offset by a decline in values due to an increase in the equilibrium wage. The latter also reduces the continuation values of incumbents, who then become more inclined to exit (i.e. the exit cutoff shifts up).

Intuitively, increased firm entry pushes up labor demand and hence wages, which makes the least productive firms terminate operations. As firms are hit by productivity shocks in every period, the exit rate increases persistently. Therefore, economic dynamism increases with a positive impact on aggregate TFP. Importantly, however, this increase in dynamism does not follow from the direct effect of the tax cut on incumbents, but rather from the ensuing general equilibrium effects.

An important assumption underlying the result is that the entry cost cannot be

deducted from taxes. Otherwise, a reduction in taxes would lift both the net-of-tax entrant values and the entry cost. We believe it is reasonable to assume that entry cost are not tax deductible (or at least not entirely), as we think of entry costs as mainly representing red tape costs and the effort involved in the development of a new business proposition. Our assumption is also consistent with the fact that many firms in the model immediately exit after paying the entry cost. These firms never make profits and hence do not get to declare taxes.

4.3 Immediate versus gradual expensing

Next, we consider how immediate and gradual expensing impact on economic dynamism. To this end, let us define the "expensing rate", denoted λ, as the present value of tax deductions, per unit of investment (including a deduction upon exit which applies under gradual expensing), see also Barro and Furman (2018). Under immediate expensing, this present value is trivially given by $\lambda = 1$.

Under gradual expensing, the moment when the firm exits may potentially matter. Consider a firm which exits j periods from the current period. The expensing rate for this firm is given by $\lambda(j) = \delta \sum_{t=0}^{t=j-1} \left(\frac{1-\delta}{1+r}\right)^t + \left(\frac{1-\delta}{1+r}\right)^j$. Without discounting ($r = 0$), the present value collapses to $\lambda(j) = 1$, i.e. it is the same as under immediate expensing, regardless of when the firm exits. We elaborate more on the expensing rate in the Appendix. This constitutes our third qualitative result:

Proposition 3. *Without discounting ($r = 0$), the decisions of incumbent firms under gradual and immediate expensing coincide.*

This result follows from the fact that, without discounting, the moment of exit has no effect on the expensing rate. Under both regimes the expensing rate is unity. With discounting ($r > 0$), however, the expensing rate is lower under gradual expensing. Re-

alistically, the latter case is the more relevant one, and we will evaluate it quantitatively in the next section.

4.4 The user cost of capital

We now consider the user cost of capital, allowing discounting for an arbitrary expense rate λ. For simplicity, we assume that the expensing rate is independent of the firm's moment of exit, and we abstract from adjustment costs. The first-order optimality condition for the capital investment decision can then be written as:[10]

$$\frac{\partial f(k,l,z)}{\partial k} = \frac{1-\lambda\tau}{1-\tau} - \frac{1-\delta}{1+r}.$$

The left-hand side is the marginal product of capital. The right-hand side is of often labeled the user cost of capital, i.e. the hypothetical rental value of a unit of capital. The equation shows that under a unit expensing rate ($\lambda = 1$), the tax rate τ is irrelevant for the user cost of capital and the user cost collapses to $\frac{\partial f(k,l,z)}{\partial k} = \frac{r+\delta}{1+r}$. This level corresponds to the undistorted choice. If in addition there is no discounting, the user cost is simply equal to the depreciation rate δ.

When $\lambda < 1$ (as is typically the case under gradual expensing, as discussed above) and $\tau > 0$, the user cost rises above its undistorted level, i.e. $\frac{\partial y}{\partial k} > \frac{r+\delta}{1+r}$. Intuitively, when firms cannot fully expense their capital investments, they are effectively taxed on their capital. As a result, they are less inclined to invest, which increases the marginal product of capital in equilibrium. In other words, expensing at a rate that is less than 100 percent creates a capital distortion which pushes firms to invest less. The magnitude of this distortion is increasing in the tax rate τ. That is, there is an interaction between the expensing rate and the tax rate.

[10]Note that the marginal cost of capital investment is given by $1-\lambda\tau$ whereas the marginal benefit equals $(\frac{\partial f(k,l,z)}{\partial k} + \frac{1-\delta}{1+r})(1-\tau)$.

Finally, it is straightforward to verify that firm continuation values are decreasing in the user cost of capital (as they are in the user cost of labor, i.e. the wage), whereas exit values are unaffected. Therefore, the introduction of immediate expensing generally increases continuation values, by lowering the user cost of capital. Firms are thus discouraged from exiting, which reduces economic dynamism.

4.5 Taking stock

We have highlighted a number of lessons so far. First, under immediate expensing a cut in the tax rate has no direct effect on the decisions of incumbent firms. The economy at large is affected, but only through equilibrium effects, arising via increased entry. These effects push towards more dynamism.

Second, in the absence of discounting the behavior of firms is equivalent under immediate and gradual expensing. Moreover, firm values are unaffected, so no indirect equilibrium effects arise. Therefore, the introduction of immediate expensing would have no effect on dynamism or macroeconomic outcomes in general.

Third, when firms do discount the future, both direct and indirect effects arise when immediate expensing is introduced. The direct effects stem from an increase in the effective expensing rate, which removes distortion to the capital decision, reducing the user cost of capital to its efficient level. This reduction in costs encourages firms to invest more and exit less easily.

We have not considered explicitly the indirect effects that are triggered by the introduction of immediate expensing, but we anticipate two effects. First, firm values increase, which encourages entry, and triggers more dynamism, via increased labor demand which increases wages. Second, the increased investment pushes up the marginal product of labor, which also leads to more dynamism via increased labor demand and higher wages.

5 Quantitative evaluation

We now evaluate quantitatively the long-run effects of moving from a high-tax, gradual expensing regime to a low-tax, immediate expensing regime. In what follows, we first describe the model's parametrization. Within the calibrated model, we then implement the policy change and quantify the effects on both aggregate variables and characteristics of business dynamism.

For the purpose of the quantitative analysis, we extend our baseline model to include stochastic shocks to operational costs, as in e.g. Clementi and Palazzo (2016). Unlike in the baseline where the exit policy is determined by a threshold level of productivity (for a given capital stock), stochastic cost shocks result in all firms having a positive probability of survival. We assume that fixed operational costs are distributed logistically with mean μ_H and dispersion parameter σ_H.

5.1 Calibration

The model period is assumed to be one year and we set the discount rate to $r = 0.04$. The production function is defined as $y = z(k^{\alpha}l^{1-\alpha})^{\theta}$, with $\alpha = 0.35$ and the span of control parameter, θ, equal to 0.9. The former mimics the capital share in income, while the latter falls within the range of values documented by Basu and Fernald (1997). The depreciation rate of capital is set to be 8 percent. The remaining parameters are set such that the model matches a number of statistics in the data. While all model parameters typically influence the properties of the entire model, in what follows we highlight the key moment for each parameter.

The mean, autocorrelation and dispersion of the firm-specific TFP process are set such that the model matches average firm size, taken from the Business Dynamics Statistics (BDS), the autocorrelation and the dispersion of investment rates taken from

Table 3: Parameter values

parameter		value
r	discount rate	0.04
α	capital share	0.35
θ	span of control	0.90
δ	depreciation rate	0.08
ρ_z	autocorrelation of TFP shocks	0.38
σ_z	standard deviation of TFP shocks	0.19
μ_z	mean of TFP shocks	0.26
σ_H	dispersion of cost shocks	2.95
μ_H	mean of cost shocks	2.20
ζ_0	non-convex adjustment cost	0.001
ζ_1	convex adjustment cost	0.27
c_e	entry cost	1.55
υ	disutility of labor	0.01

Cooper and Haltiwanger (2006). The mean and dispersion of the stochastic operation costs are set in order to match the average exit rate of all firms and the ratio of average firm exit of one and five year old firms (both taken from the BDS). Finally, adjustment costs are assumed to take the form as in Cooper and Haltiwanger (2006), $\psi(k, k_{-1}) = \zeta_0(i)k_{-1} + \frac{\zeta_1}{2}(\frac{i}{k_{\{-1}})^2 k_{-1}$, where $\zeta_0(i) = \zeta_0$ whenever investment is non-zero and $\zeta_0(i) = 0$ otherwise. We set ζ_0 and ζ_1 to match the inaction rate and the average investment rate documented in Cooper and Haltiwanger (2006). Finally, we set the disutility of labor, ν, such that the wage rate is normalized to 1 and we set the entry cost, c_e, such that the mass of entrants is normalized to 1. All the calibrated parameters are shown in Table 3 and the model-predicted and actual target values are presented in Table 4.

5.2 Quantitative results

We now evaluate the quantitative effects of the tax reform. The baseline model assumes a tax rate of $\tau = 0.35$ and gradual expensing. Departing from this baseline, we consider three alternative policy scenarios: (i) a reduction in the tax rate to $\tau = 0.21$

Table 4: Targets: data and model

target	data	model
investment rate mean	0.12	0.10
investment rate standard deviation	0.34	0.39
investment autocorrelation	0.06	0.06
inaction rate	0.08	0.09
average exit rate	0.09	0.09
relative exit rate	2.2	2.3
average size	21	21

Note: the target values for the average, cross-sectional dispersion, autocorrelation of investment rates and the inaction rate are taken from Cooper and Haltiwanger (2006). Values for the targets on exit rates and average size are taken from the Business Dynamics Statistics.

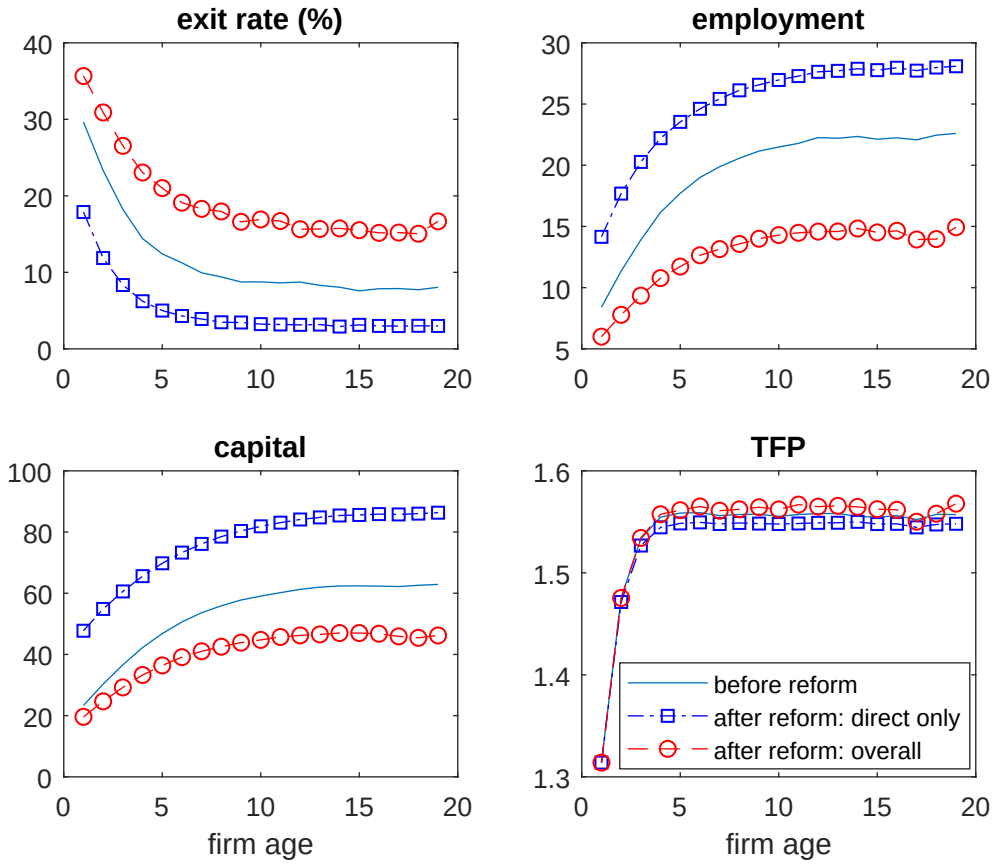
(with continued gradual expensing), (ii) the introduction of immediate expensing (while holding the tax rate fixed at $\tau = 0.35$), and (iii) a combined reduction in the tax rate to $\tau = 0.21$ and the introduction of immediate expensing. While the last scenario most closely resembles the reform recently implemented in the U.S., the first two allow us to understand how the two different parts of the reform contribute to the overall outcomes. In all cases, we evaluate the long-run effects of the tax reform, comparing the stationary equilibrium of the economy before the tax reform to the stationary equilibrium after the reform.

Let us start by focusing on the effects of reducing taxes alone, reform (i). Figure 3 shows the average effects of the reduction in the tax rate alone, by firm age. The figure separates direct (partial equilibrium) effects, holding fixed firm entry and the wage rate, from overall effects, which take into account that the entry rate and in turn the labor market adjust to the policy changes.

Following a reduction in taxes, holding wages fixed, the exit rate falls for all firm ages (upper left panel). Moreover, incumbent firms expand both in terms of employment (upper right panel) and in terms of capital accumulation (lower left panel). Weaker firm selection then leads to a slight drop in average firm TFP (lower right panel).

These direct effects might seem surprising from the perspective of Proposition 1.

Figure 3: Effects of tax reform: reduction in tax rate only



Note: the figure shows, by firm age, average exit rates (top left), average firm size (top right), average capital (bottom left) and average TFP (bottom right). The lines represent the baseline model ("before reform"), the direct (partial equilibrium) effects ("after reform: direct only") and the overall (general equilibrium) effects ("after reform: overall"). The policy change considered is a tax reduction from $\tau = 0.35$ to $\tau = 0.21$, while maintaining gradual expensing.

Note however that this proposition applies to an economy with immediate expensing, whereas the experiment underlying Figure 1 assumes gradual expensing. Appendix B confirms that under immediate expensing employment, capital and the exit rate are, as expected, not directly affected by a cut in the tax rate. Therefore, the direct effects observed in Figure 3 rely crucially on the presence of a gradual expensing regime. The cut in the tax rate simultaneously increases net-of-tax revenues and net-of-tax costs. Under immediate expensing, these effects balance out and firms do not directly change their behavior. However, under gradual expensing the increase in net revenues exceeds

the increase in net costs in percentage terms. In response, more firms stay in operation, and firms increase employment as well as capital investment.

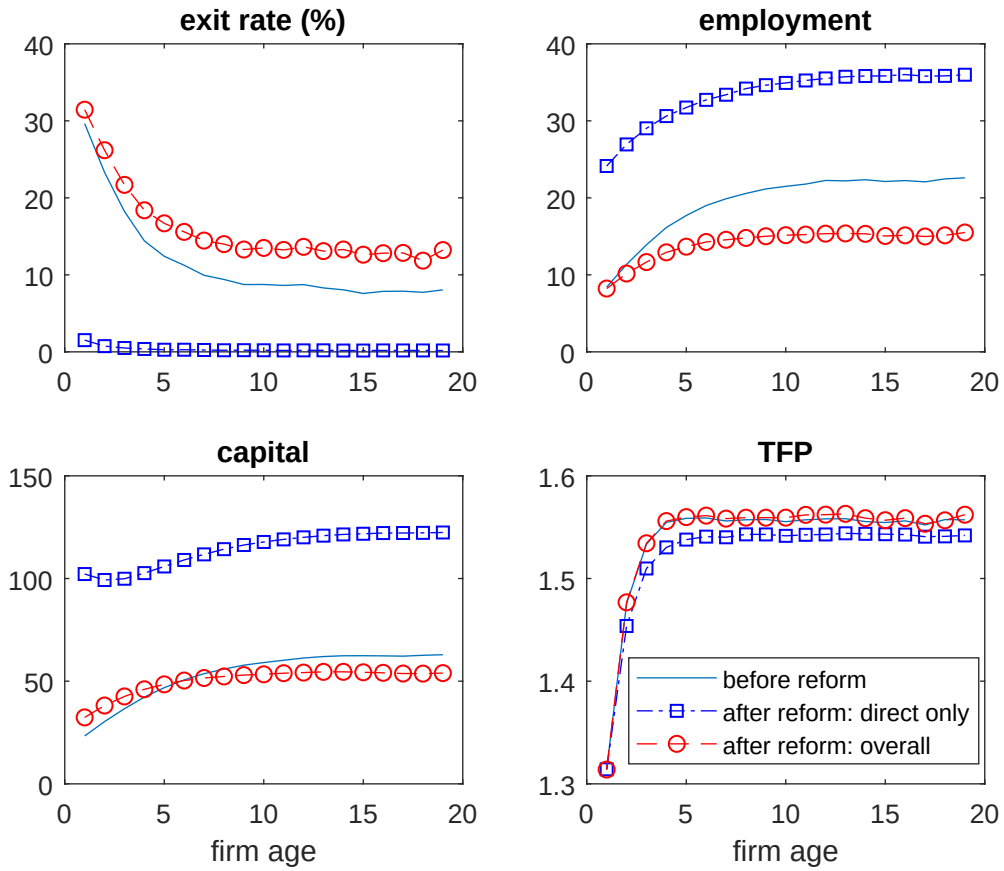
Consider now the overall effects of a cut in the tax rate, also shown in Figure 3. In equilibrium, the more favorable tax environment encourages firm entry. Together with more firm entry comes higher labor demand, which pushes wages above their initial values. The increase in the wage discourages firms from hiring, and average size declines. Also, these effects strengthen firm selection as only relatively productive firms can afford to operate on the more competitive labor market. Therefore, the overall outcomes of lower taxes include a *higher* exit rate, *lower* average firm size and average capital accumulation and somewhat *higher* average TFP, by firm age.

In other words, the overall impact of the decline in the tax rate is thus to *increase* business dynamism, as measured by the rates at which firms enter and exit the economy. This increase in dynamism crucially relies on indirect (general equilibrium) effects operating through firm entry and the labor market.

Next, consider the effects of changing from gradual to immediate expensing, holding fixed the tax rate at 35 percent. The direct and indirect effects are shown in Figure 4. Consider first the direct effects. The change in expensing regime directly lowers the user cost of capital, as explained in the previous section. In response, firms invest more in capital. This increases the marginal product of labor, and therefore firms also increase employment. Finally, the lower user cost of capital allows more firms to stay in operation, reducing the exit rate dramatically.

While the direct effects bring about a strong reduction in the exit rate and an expansion of employment and capital accumulation, the general equilibrium forces more than offset these effects. The lower user cost of capital increases firm values, encouraging entry and pushing up wages, which spurs firm exit. The overall impact of moving to immediate expensing is similar to that of lowering the tax rate. In particular, the move

Figure 4: Effects of tax reform: immediate expensing only

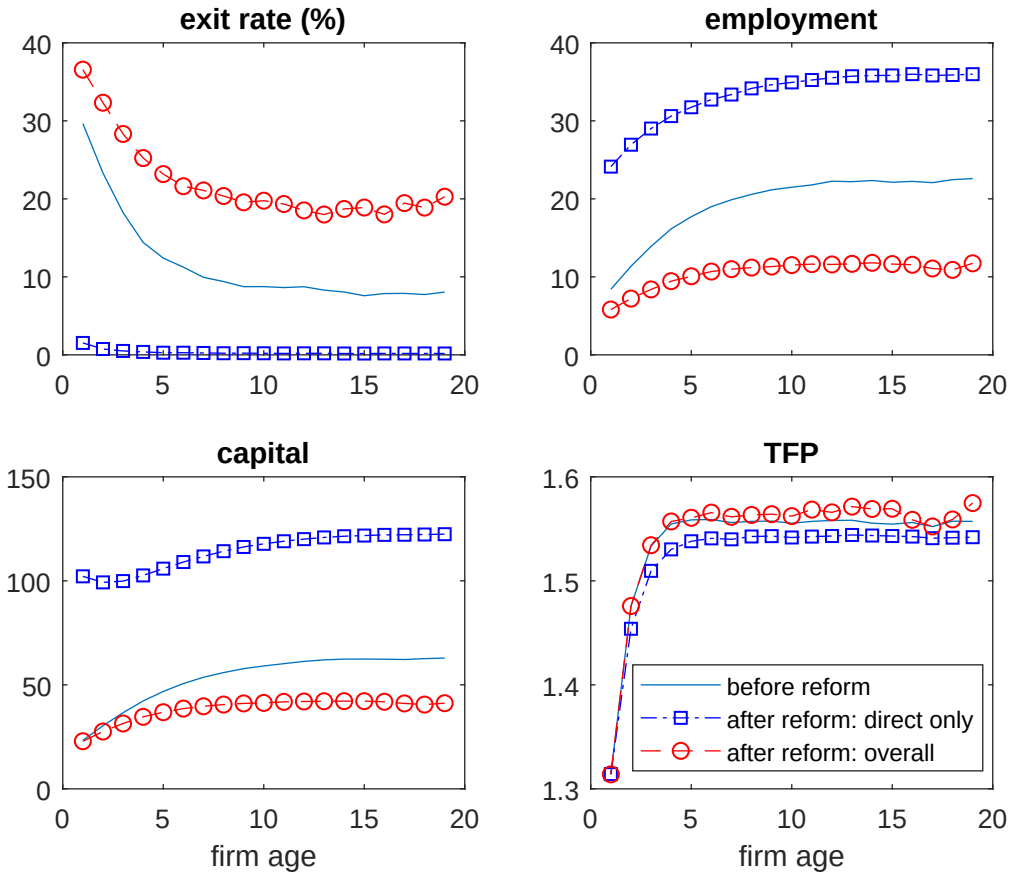


Note: the figure shows, by firm age, average exit rates (top left), average firm size (top right), average capital (bottom left) and average TFP (bottom right). The lines represent the baseline model ("before reform"), the direct (partial equilibrium) effects ("after reform: direct only") and the overall (general equilibrium) effects ("after reform: overall"). The policy change considered is a move from gradual to immediate expensing, while maintaining a tax rate of $\tau = 0.35$.

to immediate expensing leads to an increase in dynamism.

Finally, Figure 5 shows the impact of the combined policy reform with both a reduction in taxes and a move to immediate expensing. Once again, while the direct effects of these policy changes bring about a strong decrease in the exit rates, resulting in a rise in firm sizes and capital accumulation, these outcomes are overturned in general equilibrium. By contrast, the overall effects of the policy reform is a strong increase in exit rates, a decrease in firm size and capital accumulation and a slight increase in average firm productivity by age.

Figure 5: Effets of tax reform: lower taxes and immediate expensing



Note: the figure shows, by firm age, average exit rates (top left), average firm size (top right), average capital (bottom left) and average TFP (bottom right). The lines represent the baseline model ("before reform"), the direct (partial equilibrium) effects ("after reform: direct only") and the overall (general equilibrium) effects ("after reform: overall"). The policy change considered is a tax reduction from $\tau = 0.35$ to $\tau = 0.21$, and a move from gradual to immediate expensing.

The long-run macroeconomic impact of the changes in taxation is shown Table 5, which reports the values of several macroeconomic variables, relative to their values before the tax reform. The top row of the table shows the effects of the overall reform, i.e. a simultaneous cut in the tax rate and a change to immediate expensing.

The tax reform generates large long-run macroeconomic effects: aggregate output and the aggregate capital stock increase by more than forty percent, whereas labor supply rises by a fifth. Consumption and wages increase by sixteen percent. These

gains are brought about by an expansion along the extensive margin, whereby the number of firms is almost five times as high as in the baseline model. At the same time, individual firms are much smaller (by about fifty percent) and invest about a third as much into capital as before the reform.

The increased economic activity is reflected in greater firm churn: the startup rate after the reform is almost twice as high as before. Because of more stringent firm selection, average TFP increases by about two percent.[11] Recall that in the data, the startup rate fell by about fifty percent, since the 1970s. Thus, according to the model, the tax reform would reverse this decline.

Rows (ii) and (iii) of Table 5 show the effects of individual policy changes. It is apparent that while both policy changes have relatively similar effects on aggregate variables, the reduction in taxes has does more to increase business dynamism. In particular, lower taxes raise the entry rate by almost eighty percent. This increased firm churn then raises average TFP by one percent. While moving to immediate expensing (and holding the tax rate unchanged from the baseline scenario) also increases the entry rate, it does so by less.

Finally, Table 6 shows the size and age distributions in the data, the baseline model and in the model are overall affected by the reform. Our previous results already showed that average firm size falls considerably. This is confirmed by the top panel of Table 6, which depicts the size distributions. The entire distribution shifts towards small businesses with only just over two percent of all firms having more than fifty employees.

Similarly, the bottom panel of Table 6 shows the age distributions in the data, baseline model and the model following the reform. As shown previously, the model predicts an increase in the exit rate across all firm age groups. This is reflected in a

[11] Since we consider stationary economies, the startup rate equals the exit rate.

Table 5: Results: aggregate effects of tax reform, relative to baseline.

Y	N	K	C	W	n_{avg}	i_{rate}	m_{total}	tfp_{avg}	e_{rate}
(i) tax reduction and immediate expensing									
1.42	1.22	1.56	1.16	1.16	0.55	0.36	4.97	1.02	1.95
(ii) tax reduction only									
1.24	1.13	1.24	1.09	1.09	0.68	0.55	3.56	1.01	1.78
(iii) immediate expensing only									
1.25	1.12	1.45	1.12	1.12	0.69	0.48	2.20	1.00	1.39

Note: Aggregate output (Y), employment (N), capital (K), consumption (C), the wage (W), average size (n_{avg}), average investment rate (i_{rate}), total number of firms (m_{total}), average firm TFP (tfp_{avg}) and the entry rate (e_{rate}). All variables are expressed relative to the baseline calibration ($\tau = 0.35$, gradual expense rate). Lower tax rate: $\tau = 0.21$.

strong shift towards young businesses. The share of young firms (less than 6 years old) increases from 48 percent to 80 percent. Only about 3 percent of all business make it past the age of 15 years.

Finally, we report the budgetary effects of the tax reform in the model. Considering first only the direct effects of the tax reform, we find that the cut in the tax rate reduces total tax revenues from 16 percent of GDP to 8 percent. The introduction of immediate expensing, in isolation, reduces tax revenues to 7 percent. Taken jointly, the effect of the tax reform is to reduce tax revenues from 16 percent to only 5 percent of GDP.

Taking into account the general equilibrium effects, we find that the overall effect of the tax reform is to *increase* tax revenues to 22 percent of GDP. Remarkably, the equilibrium effects thus more than offset the direct effects. As more firms enter the economy and the distribution of firms shifts towards younger and smaller businesses with higher profit rates, the tax base increases which in turn raises tax revenues. However, it is important to note that here we only compute long-run effects. An increase

Table 6: Size and age distributions

	size distribution				
	<50	50-99	100-249	250-500	>500
data	95.8	2.3	1.2	0.4	0.3
model: baseline	93.6	5.0	1.2	0.1	0.1
model: after reform	97.8	1.8	0.3	0.1	0.0

	age distribution				
	<1	1-5	6-10	11-15	>15
data	9.8	29.4	18.4	12.9	29.5
model: baseline	13.8	34.3	17.9	11.6	22.3
model: after reform	28.7	51.0	13.2	4.5	2.6

Note: the table shows firm size and age distributions. All data are taken from the Business Dynamics Statistics.

in long-run tax receipts might be offset by a decrease along the transition path. In particular, part of the increase in tax revenues is due to the fact that the economy has a substantially higher capital stock in the long run. Along the transition path, firms invest more in capital, and therefore claim larger tax deductions. Thus, the higher long-run tax receipts are likely associated with lower tax receipts in the short run.

6 Some caveats

Before concluding this article, we highlight five issues which warrant caution when projecting the model results onto the real-world U.S. economy and the effects of the TCJA in particular. We believe that these issues can be a fruitful starting point for future research.

First, our model results apply to the long run and heavily rely on indirect equilibrium effects via increased entry. Setting aside the question of the exact transition path of the economy, it might simply take a substantial amount of time before the long-run effects of the reform fully manifest themselves. This is important given that the TCJA is currently subject to a number of sunset clauses, as described in Section 2.

Second, we have assumed that the tax reform is financed via an increase in lump-sum taxes. We have thus sidestepped any distortionary effects that might arise from changes in other distortionary taxes, which realistically might be required to balance the long-run government budget.

Third, we have focused on the effects of the business tax rate and investment expensing regime, leaving out many other specific features of the U.S. tax system and its reform. For example, we have ignored the fact that individual income taxes were also reduced under the TCJA. Via changes in household labor supply and equilibrium effects, this change might also affect business dynamism.[12] Also, immediate expensing was already partially applied in the U.S. in the years leading up to the TCJA, as mentioned in Section 2.

Fourth, our model abstracts from an entrepreneurial choice margin and entrepreneurial utility. Neira and Singhania (2017) argue that a cut in corporate taxes can reduce the startup rate via the entrepreneurial choice channel. Hurst and Pugsley (2011) argue that for many entrepreneurs, starting a firm is a lifestyle choice. When entrepreneurs enjoy a fixed utility benefit from running a firm, a cut in the corporate tax rates might create direct effects even under immediate expensing.

Finally, we have abstracted from financial market imperfections. The cut in tax rates and the introduction of immediate expensing might alleviate the impact of such frictions, creating additional effects.

[12]The effects would heavily depend on assumptions regarding labor supply elasticities. If substitution effects dominate income effects, a cut in the individual tax rate will increase labor supply, reducing wages. The direct effect of the decline in wages would be to reduce dynamism. On the other hand, the equilibrium effects would likely work to increase dynamism.

7 Concluding remarks

The quantitative firm dynamics model indicates that a reform of firm taxation, as in the TCJA, can trigger a dramatic boost in business dynamism and of economic activity in general. The increase in dynamism is driven by the indirect effects associated with the cut in the tax rates. Intuitively, the tax cut increases firm values, which encourages firm entry. This in turn increases wages, which pushes out more firms that are hit by adverse productivity shocks. Together, these effects imply an increase in business dynamism. The magnitude of this increase is large, and in fact large enough to offset the decline in startup rates observed in the U.S. of the last few decades.

A quantitatively important component of the reform is the cut in the tax rate on firm profits. Firm entry, and the resulting endogenous number of businesses, is the key channel through which tax cuts can affect the aggregate economy in our model. Specifically, because the costs of starting up a business are incurred before the firm is formally established, they are not tax deductible. A cut in the tax rate raises post-entry values, but leaves the entry cost unaffected, triggering an increase in firm entry, boosting dynamism and aggregate output. Our results show that this effect, which is absent in representative-agent models, can have quantitatively very large implications for the effects of tax policies. This contrasts analyses in representative-agent models in which changes in corporate tax rates tend to have relatively small effects, see e.g. Barro and Furman (2018). This feature of the model also potentially has important implications for the literature on optimal taxation, which often abstracts from firm heterogeneity.

Appendix

A Proofs

This part of the Appendix provides proofs for the three propositions in the main text.

Proof of proposition 1. Under immediate expensing, the exit value can be expressed as $V^x = (1-\tau)\,\widetilde{V}^x$, where $\widetilde{V}^x \equiv (1-\delta)\,k_{-1} - \psi(0, k_{-1})$ is the exit value without the tax ($\tau = 0$). Note also that after-tax profits of a continuing firm are proportional to $1-\tau$. It follows that the firm value is linear and homogeneous in $1-\tau$, i.e. it can be written as $V = (1-\tau)\,\widetilde{V}$, where $\widetilde{V}$ is the firm value without the tax, but with the same wage. The choices for k, l and z^* which maximize $\widetilde{V}$ therefore also maximize V. Hence, the firms' decisions are not affected by a change in the tax rate, given a fixed wage.

Proof of proposition 2. We can write the free entry condition as: $c_e = (1-\tau)\,\mathbb{E}\widetilde{V}(w)$, where $\widetilde{V}(w)$ is again the value of an entrant without a tax, but now expressed explicitly as a function of the wage w. $\widetilde{V}(w)$ is decreasing in w, since profits and continuation values are decreasing in w. It follows from the free-entry condition that a decline in τ must be offset by a decrease in $\widetilde{V}(w)$, and hence an increase in w. The latter reduces continuation values but does not affect exit values. Therefore, the exit cutoff z^* must increase following a decline in τ.

The expensing rate. Consider a unit of investment made by a firm, j periods before it exits. The present value of tax deductions obtained from this investment unit is given by:

$$\lambda(j) = \delta + \frac{\delta(1-\delta)}{1+r} + \frac{\delta(1-\delta)^2}{(1+r)^2} + ... + \frac{\delta(1-\delta)^{j-1}}{(1+r)^{j-1}} + \frac{(1-\delta)^j}{(1+r)^j}.$$

This equation directly leads to the expression for $\lambda(j)$ given in the main text. The final term is the deduction obtained in the final period, when the firm exits. In this period,

the firm does not produce but generates a before-tax cash flow $\pi^x = (1-\delta)\, k_{-1} - \psi(0, k_{-1})$. In the final period, the firm can deduct $(1-\delta)\, k_{-1}$ when computing its taxable income, since this income stream was not generated from the firm's production activities, but rather from previous purchases of capital.

Without discounting ($r = 0$) the expensing rate becomes:

$$\lambda(j) = \delta \sum_{t=0}^{t=j-1} (1-\delta)^t + (1-\delta)^j = \delta \frac{1-(1-\delta)^j}{\delta} + (1-\delta)^j = 1,$$

where the second equality follows from the properties of a geometric series.

Proof of proposition 3. We can express the sum all tax payments of a firm over its lifetime, under gradual expensing, as:

$$\sum_{t=0}^{s-1} T_t^c + T_t^x = \sum_{t=0}^{s-1} \tau \pi_t^c + \tau(1-\lambda(s-t)) i_t + \tau \pi_j^x,$$

where $s \geq 0$ is the date at which the firm exits and $\lambda(j)$ is the expensing rate as defined in the main text. Since without discounting the expensing rate is unity, the present value of tax payments under gradual expensing then becomes:

$$\sum_{u=t}^{t+s-1} T_u^c + T_j^x = \sum_{u=t}^{t+j-1} \tau \pi_u^c + \tau \pi_j^x.$$

Without discounting, this corresponds precisely to the present value of tax payments under immediate expensing.

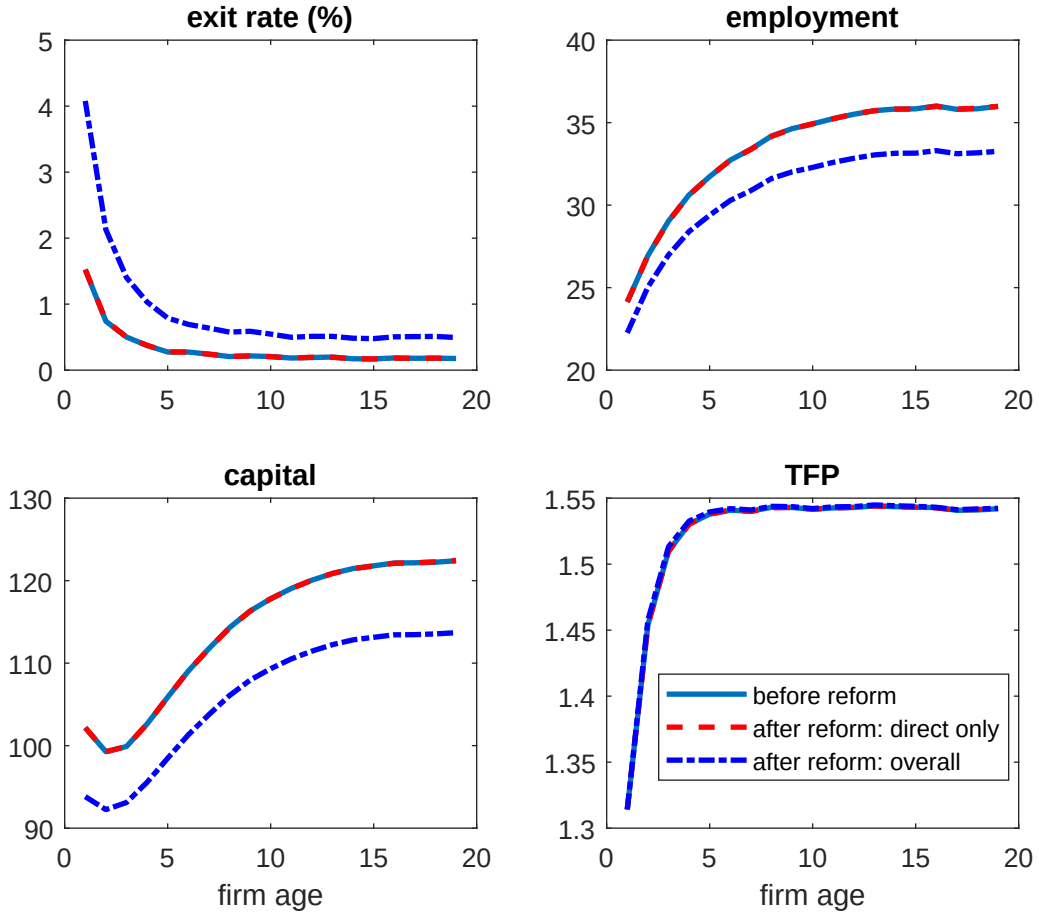
B Tax cuts under immediate expensing

This section shows that as predicted by our Proposition 1 and 2, changing taxes in the model under immediate expensing impacts the economy only through indirect (general

equilibrium effects). This can be seen from Figure B which uses the baseline calibration except that it considers immediate expensing already before the reform. The policy change then reflects only a decrease in the tax rate.[13] Clearly, there are no direct effects of the tax decrease and the policy has an impact on the economy only through indirect channels operating via firm entry and the labor market.

[13]We have not re-calibrated the model to match the targets in this case.

Figure 6: Effects of tax reform: lower taxes under immediate expensing



Note: the figure shows, by firm age, average exit rates (top left), average firm size (top right), average capital (bottom left) and average TFP (bottom right). The lines represent the baseline model ("before reform"), the direct (partial equilibrium) effects ("after reform: direct only") and the overall (general equilibrium) effects ("after reform: overall"). The policy change considered is a tax reduction from $\tau = 0.35$to $\tau = 0.21$, while maintaining *immediate* expensing.

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