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ARTICLE

Fiscal stimulus and pension contributions: evidence from the TCJA

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Abstract
We evaluate the impact of the 2017 Tax Cuts & Jobs Act (TCJA) pension tax break on sponsor contributions to defined-benefit retirement plans. We exploit cross-sectional variation in ex-ante exposure to the tax break. We find that the tax break induced an extra $2.8 billion of sponsor contributions to medium- and large-scale plans in 2017. However, we find strong evidence of reversal, both in terms of sponsor contributions and plan funding ratios by 2018. Our contributions model indicates that this reversal is consistent with more binding financial constraints in 2018 relative to 2019. Our results suggest that the TCJA did not have a long-lasting impact on corporate defined-benefit pension funds.

Keywords: contributions; defined-benefit pension plans; Tax Cuts & Jobs Act

JEL Codes: H22; H25; H26; H32; J32

Governments around the world are embarking on unprecedented levels of fiscal stimulus in the wake of the COVID-19 shock and the ensuing global recession. Against this backdrop, a better understanding of the effects of *temporary* measures is warranted from both an academic and a policy perspective. In particular, there is evidence that these measures can result in both short-lived and permanent effects. The literature has focused on the impact of temporary stimulus on the household sector, either as a way to test the permanent income hypothesis (Johnson *et al.*, 2006) or to evaluate particular programmes (Mian and Sufi, 2012; Berger *et al.*, 2020) or to combine the two (Parker *et al.*, 2013). Mian and Sufi (2012) find only a temporary effect of temporary cash subsidies on household consumption of durable goods (cars). By contrast, Berger *et al.* (2020) show evidence of a permanent effect of temporary tax incentive for new homebuyers on home sales. Comparatively little work addresses temporary policies that target the corporate sector. House and Shapiro (2008) and Zwick and Mahon (2017) study the effects of temporarily accelerated tax depreciation on investment, but they do not investigate whether the initial positive response was subsequently reversed. This paper contributes to filling the gap by documenting an impact of temporary fiscal stimulus on corporate-sponsored pension plans.

We study the impact of the Tax Cuts & Jobs Act of 2017 (TCJA, also known as the 'Trump tax cuts') on sponsor contributions to corporate defined-benefit (DB) pension funds, as well as the response of the plans' funding ratios. The TCJA resulted in a temporary tax break on pension contributions. The Act permanently reduced the statutory federal corporate tax rate from 35 to 21 per cent, beginning in 2018. Under U.S. tax law, contributions to retirement plans made in a particular year can be deducted from previous year tax returns if they are made within a 'grace period' ending by the tax return due date including extensions (in practice, mid-September).[1] As a result, sponsor contributions

[1]See https://www..deloitte.com/content/dam/Deloitte/us/Documents/Tax/us-tax-considerations-for-accelerating-deductions-for-qualified-retirement-plans.pdf, 2018. 'Considerations for accelerating deductions for qualified retirement plans'.

made in both 2017 and 2018 could be deducted from 2017 income, thereby benefiting from a higher corporate tax rate. Concretely, a late-filing sponsor contributing $1bn to its DB pension plan before mid-September 2018 – rather than after the end of the grace period, for instance, in December 2018 – would have saved an extra $140m in 2017 taxes.

Because of widespread underfunding amongst corporate DB plans, whether the temporary TCJA tax break had a permanent effect on contributions – and thus narrowed plan deficits – is an especially relevant question. Despite an on-going shift towards defined contribution pension plans (e.g., 401(k)s), corporate DB plans accounted for about 15 per cent of U.S. pension assets in Q4 2018 (U.S. Financial Accounts). In the aggregate, DB plan assets fall short of liabilities, with plan funding ratios hovering around 80 per cent for the past decade.[2] We first address the temporary/permanent effect question through the lens of a contributions model that embeds constraints on sponsor access to external finance. The model is built on the premise that higher contributions today lower the costs of external finance tomorrow, by improving plan funding and thus the sponsor's balance sheet. The improvement in plan funding also reduces plan (insurance) expenses and boosts tomorrow's after-tax cash flows, further reducing the future costs of external finance. At the same time, higher contributions are a drag on today's after-tax cash flows, and thus also increase the current costs of external finance.

The model suggests that TCJA should induce an increase in 2017 contributions followed by a decline in 2018 (claim 1). Contributions in 2017 increase because, given lower expected corporate taxes tomorrow, an extra dollar put to work to reduce plan expenses has a bigger impact on tomorrow's cash flows and finance costs. Contributions in 2018 are different because, in addition to lower expected taxes tomorrow, sponsors also face lower taxes today. As the value of the contributions tax shield falls, the marginal cost of 2018 contributions rises. At the same time, higher 2017 contributions have already boosted plan funding. As a result, TCJA now makes tomorrow's external finance costs less sensitive to further plan improvements brought about by extra contributions today.

The model also indicates that whether the increase in 2017 contributions is large enough to offset the 2018 decline (permanent impact) or not (reversal) depends on the time profile of sponsor financial constraints (Claim 2). The more financially constrained a sponsor, the bigger the impact of changes in after-tax cash flows on external finance costs, and thus the larger the effect of changes in the corporate tax rate on the marginal cost and benefit of contributions. For a sponsor that expects to be more financially constrained in 2018 than in 2019, the increase in the marginal cost of 2018 contributions induced by TCJA could (in theory) cause a large enough drop in contributions to more than offset the rise in 2017 sponsor payments.

Our empirical results suggest that the contributions induced by the temporary tax break replaced contributions that would have been made in the near future anyway. A cross-sectional regression points to an above-average impact of our proxy for tax-based incentives on 2017 sponsor contributions (by 1/3 of a standard deviation). Regressing 2018 contributions on our measure of tax-based incentives returns a coefficient that is about 1/3 of a standard deviation below pre-TCJA average. Plan sponsors do respond to tax-based incentives for contributions. At the same time, they do not appear to be constrained – in setting pension plan strategies – by the amount of cash that have at hand.

In line with the result that the TCJA affected the time profile but not the overall level of sponsor contributions, we find no evidence of a long-lasting impact on plan funding ratios. Regressions of changes in funding ratios on tax-based incentives point to a relative increase of 2.5 percentage points for sponsors subject to such incentives in 2017, and a fully offsetting decrease in 2018.

Our identification strategy exploits cross-sectional differences in tax-based incentives for plan sponsoring firms, as in Gaertner *et al.* (2020) and Zwick and Mahon (2017). Sponsors have other, non-tax-based, time-varying incentives to shore up underfunded pension funds through higher contributions. For instance, industry newsletters often mention a sustained rise in the costs of insuring pension benefits through the Pension Benefit Guaranty Corporation (PBGC) (driven by deteriorating

[2]Funding ratio computed as in Klingler and Sundaseran (2019) using data from the US Financial Accounts (Table L.118.b).

funding ratios in a prolonged low interest rate environment) as a possible driver of higher sponsor contributions.[3] By using sponsor-level data, we exploit the fact that not all sponsoring firms would have been equally affected by the increase in tax-based incentives induced by the TCJA. For a sponsor's contribution decision to respond to tax-based incentives, two conditions need to be satisfied. First, the sponsor has to have a positive corporate income tax bill before deducting contributions (tax-paying sponsor). Second, plan funding has to be below the upper bound above which contributions stop being deductible (funding ratio below 150%). We say that a sponsor is exposed to tax-based incentives if it meets both these conditions, and split our sample into tax-exposed firms and non-tax-exposed firms. Non-exposed sponsors provide a counterfactual for outcome variables in the absence of the tax break.

One possible concern about our tax exposure measure is endogeneity to subsequent firm contribution decisions. The timing of tax-based incentives for retirement plan contributions, however, suggests that a sponsor is likely to take the pre-contribution tax bill as given when choosing how much to transfer to its pension plans. The 'grace period' for tax deductibility of contributions gives a sponsor the option to wait until the end of its fiscal year before deciding on its contributions, by which point there is no residual uncertainty about ex-contribution tax expenses. Empirical evidence suggests that sponsors are likely to prefer to exercise this option and to hold off on decisions regarding deductible expenses until income uncertainty is largely resolved.[4]

Our pension plan data come from yearly IRS 5500 filings of listed Compustat firms that sponsor medium- and large-scale DB retirement plans.[5] As an alternative source of pension data, we could have used yearly SEC 10-K filings. Unlike the IRS data, however, the SEC filings data are not well suited to assessing the impact of TCJA and its reversal. First, SEC filings report contributions made in a calendar rather than a fiscal year. Therefore, contributions made in the 2017 contributions grace period (deductible from 2017 returns, and thus subject to the TCJA tax break) would be counted as part of 2018 contributions, as the 2017 grace period falls in 2018. Because of this confounding effect, 2018 contributions measured with SEC filings would be too large. Second, SEC filings do not distinguish between mandatory and voluntary contributions, making it harder to assess whether changes in contributions were driven by changes in plan service cost or changes in tax-based incentives. Third, SEC filings do not contain information on plan funding, which is necessary to control for non-tax-based contribution incentives like the PBGC insurance premium. And fourth, SEC filings do not distinguish between domestic plans and plans pertaining to foreign subsidiaries. By contrast, the TCJA tax break applies only to contributions made to domestic plans.

Other researchers have also studied firms' response to the TCJA. In a paper closely related to ours, Gaertner *et al.* (2020) also consider the effect of TCJA on sponsor contributions. Our analysis differs from theirs in several ways. First, we investigate whether the initial positive response was subsequently reversed. Second, we explicitly model pension contribution incentives to discipline our empirical approach. Third, we use data from IRS 5500 filings rather than from SEC filings, so we can study both contributions made in fiscal years 2017 and 2018. By contrast, 2018 contributions in Gaertner *et al.* may be deductible from either 2017 or 2018 tax returns. As a result, we can document both the effects of expectations about the upcoming change in tax-based contribution incentives and its actual impact. Fourth, we broaden the analysis to funding ratios of the sponsored pension plans.

We are also not the first to use variation at the corporate micro-level to estimate the effect of corporate tax cut. Looking at gross profit and selling, general, and administrative expenses, Scholes *et al.* (1992) find a strong effect of the 1986 Tax Reform Act (TRA), which reduced the corporate tax rate from 46 per cent in 1986 to 34 per cent beginning in 1987, on income shifting. They suggest that corporation deferred revenues into 1987 and accelerated expenses into 1986. However, the

[3]See Pielichata (2017). March 30. See also Kozlowski (2018). March 19.

[4]Xu and Zwick (2018) show that most of CAPEX expenses are made in the last quarter, for tax-minimising purposes.

[5]See Rauh (2006, 2008) for additional information on IRS 5500 filings.

aforementioned paper focuses on non-pension-related expenses. In contrast, our paper focuses on pension contribution which is not an expense that reduces book income.

Our results have implications for work on the incidence of corporate income taxes. In particular, ignoring 'uncertainty' effects on deferred compensation may lead to underestimating the incidence of corporate tax cuts on workers. To the best of our knowledge, the literature has concentrated on the current component of workers' compensation. It estimates that, on average, around 50 per cent of the corporate tax burden is passed on to workers through changes in wages (Arulampalam *et al.*, 2012; Serrato and Zidar, 2016; Fuest *et al.*, 2018). Current wages, however, are only one part of workers' compensation, with pensions (i.e., deferred wages) being another. Our model indicates that a temporary increase in tax-based incentives for contributions could in principle result in a permanent improvement in funding, depending on the time profile of financial constraints. The ensuing decrease in retirement income uncertainty would thus improve workers' welfare. That said, we find no evidence for this effect in the case of TCJA.

Methodologically, our paper belongs to a growing literature that uses diff-in-diff to study the effects of a popular form fiscal policy – tax breaks – at the corporate level. The application of our research design in the pension contributions context allows us to run a relatively clean experiment. U.S. tax laws allow pension contributions made up to 8.5 months after the end of the plan's year (usually the same as the sponsor's fiscal year) to be deducted from the previous fiscal year. This makes the pre-contribution corporate tax bill to be exogenous to the sponsor's contribution decision. By contrast, this may not be the case for other tax-deductible expenditures like capex. Capex choices have to be made in the course of the fiscal year, and might thus affect corporate income and the ensuing tax bill.

The rest of this paper is organised as follows. Section 1 provides an overview of the different incentives underpinning sponsor contribution choices, including the tax-based incentives directly affected by the TCJA tax break. Section 2 outlines a simple model that illustrates these incentives and guides the empirical analysis. Section 3 describes our data and explains how we constructed key variables. Results are given in Section 4, and Section 5 contains concluding remarks.

1. Contribution incentives and the TCJA

A DB pension plan is a promise of predictable retirement benefits from a plan sponsor (typically an employer) to participants (employees). Plans are funded by employer and employee contributions. In this section we review the main factors underpinning these transfers, and we discuss how the TCJA created tax-based incentives for sponsors to increase contributions.

Since corporate DB plans are subject to funding rules under U.S. law, the size of employer contributions depends on the funding status of the plan.[6] If a plan is overfunded, its sponsor has to contribute the present value of the expected yearly change in accrued benefits (normal or service cost), net of excess assets. Sponsors of overfunded plans have little incentive to contribute more than required, as the fiscal regime penalises them for drawing down plan assets net of liabilities.[7] Sponsors of underfunded plans, by contrast, are required by law to contribute more than the service cost. The Pension Protection Act of 2006 stipulates that plan funding should equal 100 per cent of the plan's liabilities. As a result, minimum required contributions (MRCs) are typically set according to rules which prescribe that sponsors contribute the service cost plus a fraction of the funding shortfall (shortfall amortisation charge). MRC schedules are intended to close funding deficits over a medium-term horizon. Sponsors of underfunded plans might also choose to improve funding status by making *voluntary* contributions in excess of MRCs. Firms subject to federal corporate income taxation (C-corporations) can deduct pension contributions from tax returns. As a result, there are tax-based

[6]The rules are set out in the Employee Retirement Income Security Act of 1974 (ERISA) and the Pension Protection Act of 2006 (PPA). See Manning and Napier (2014) for a concise discussion of funding and contribution rules. Firms are fined for under-contributing.

[7]Proceeds from taking excess plan assets and using them for other purposes (reversions) are subject to corporate income tax plus a 50 per cent excise tax.

incentives for sponsors to contribute more than minimum requirements. Section 404 of the Internal Revenue Code (IRC) specifies that contributions made in a particular year can be deducted from previous-year income under two conditions. First, the contribution has to be made on account of pension benefits accrued in the previous year. Second, the contribution has to be made by the employer's tax return due date, including extensions. Concretely, a firm whose fiscal year ends in December (called a calendar-year firm) has until mid-October of the current year to make contributions that are deductible from the previous-year tax return.[8] In practice, if the firm's 'plan year' (the 12-month period relevant for plan reporting) also ends in December, the firm would want to make contributions before mid-September. This is because contributions made after this date would not count towards satisfying minimum funding requirements under Section 430 of the IRC.[9] There are limits to deductibility: contributions are only allowed to be tax-deductible up to the point where a plan is 150 per cent funded.

The TCJA made plan contributions counted towards 2017 sponsor income more valuable than contributions counted towards 2018 income. The Act permanently reduced the statutory federal corporate tax rate from 35 to 21 per cent, beginning in 2018. As a result, sponsor contributions made by calendar-year firms within the grace period between January 2017 and mid-September 2018 could be deducted from 2017 income and thus reduce the corporate tax bill at the old, higher tax rate. By contrast, contributions made after mid-September were deducted at a lower rate. As an example, a late-filing sponsor contributing $1bn to its DB pension plan before mid-September 2018 – rather than after the end of the grace period (e.g., December 2018) – would have saved an extra $140m in 2017 taxes. In this sense, the TCJA included a temporary tax break on pension contributions.

Sponsors have other incentives to shore up underfunded pension plans, with rising benefit insurance premia being an oft-mentioned driver by industry commentary (Figure 1).[10] The retirement benefits of private sector workers are guaranteed (up to a limit) by the PBGC, a government agency established in the mid-1970s to protect plan beneficiaries in case of sponsor bankruptcy. In addition to a flat-rate premium which applies to all plans, there is a variable-rate premium which applies *only* to underfunded plans. Variable rate premia grow with plan deficit, so employers have incentives to make voluntary contributions in order to reduce insurance costs. Sufficiently overfunded firms are exempt from paying premia altogether.

Sponsors may also worry about the impact of unfunded pension liabilities on their cost of capital and valuations, particularly if bankruptcy risk is already a concern (Black, 1980). Since 2006, financial accounting standards require plan sponsors to 'flow through' pension fund deficits into their financial statements, meaning that employers must recognise a plan's funded status on their balance sheets (FAS 158). And credit rating agencies took pension liabilities into account even prior the change in reporting standards, when the funded status of plans was disclosed in financial statement footnotes (Clifton *et al.*, 2003; Mathur *et al.*, 2006; Campbell *et al.*, 2012). As a result, unfunded pension liabilities can have material effects on sponsor cost of capital and equity valuations.[11]

That said, there are opportunity costs to diverting firm resources to pension plans through contributions. In the presence of financing frictions, a reduction in internal financial resources may limit a sponsor's ability to finance investment projects. Indeed, Campbell *et al.* (2012) show that an increase in mandatory pension contributions – which reduces a firm's ability to rely on internal financing for investment projects – increases the cost of capital for firms facing greater constraints on external

[8]Calendar-year firms can either file tax returns by April 15 (on time) or apply for a 6-month extension and file until October 15 (late).

[9]All firms in our sample are calendar-year firms. Plan year and firm fiscal year match by both day and month for about 95 per cent of the firms in our sample in each year between 2014 and 2017. The share of exact matches is 99.8 per cent in 2018. Remaining firms have pension plan years that end a couple of months earlier than their fiscal year (e.g., if a firm's fiscal year ends in December, its plan year ends either in October or in November).

[10]See footnote 3.

[11]Ang *et al.* (2013) illustrate the point by referring to AT&T, whose funding status changed from $17 billion surplus in 2007 to a nearly $4 billion dollar deficit in 2008. This played a role in the decline of AT&T's equity price from 2007 to 2008.

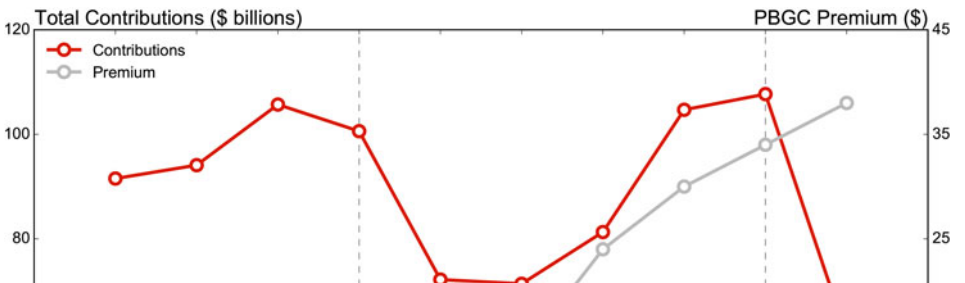

Figure 1. Aggregate contributions and the PBGC variable premium.

financing, a result consistent with earlier evidence of a negative relationship between contributions and firm investment (Rauh, 2006).

Sponsor contributions started rising before the TCJA (Figure 1), an increase which would likely have continued through 2017 even in the absence of tax-based incentives. Industry commentary tends to attribute this rebound to the sharp increase in the PBGC insurance premium.[12]

2. Conceptual framework

This section sketches a model of contributions. The framework is designed to formalise the tradeoffs faced by a sponsor in choosing contributions (see Section 1), and to derive testable predictions about the impact of the TCJA on optimal contributions. It embeds the idea that sponsors dislike plan funding deficits because they worsen the balance sheet, thereby increasing the costs of finance. As we focus on the TCJA impact on contributions, we do not model the sponsor's investment decision endogenously.[13] However, we do model the opportunity cost of diverting internal resources away from investment by letting investment returns affect the tradeoff that underpins optimal contributions.

The data only allow us to test the impact of TCJA on sponsor contributions deducted from 2017 and 2018 tax returns. Contributions counted towards 2019 tax returns are affected by the CARES Act, which gave DB sponsors the option to wait until January 2021 to make contributions deductible from 2019 returns. We thus assume there are three periods, $t = 0, 1, 2$. In periods $t = 0, 1$ (corresponding to 2017 and 2018), the management of a firm sponsoring a DB pension fund chooses plan contributions, c_t, to maximise the value of the firm. We capture the impact of the CARES Act of 2019 on contributions by assuming that sponsors did exercise the option to wait, and we let $c_2 = 0$.[14]

The pension plan funding status affects insurance costs, contribution requirements, and the costs of external finance. Plan funding depends positively on contributions and negatively on the service cost, s_t. The service cost is determined by previous decisions about wages and by factors outside of management's control (e.g., interest rates), and it is therefore exogenous to current contribution and

[12]Industry commentary has linked 2016 growth to both expectations of lower future corporate tax rates and to an upcoming increase in the PBGC variable premium (Pielichata, 2017; Kozlowski, 2018).

[13]We work with a separable specification for the costs of external finance that is linear in cash flows. As a result, if we explicitly introduced an investment decision in the model, investment would not be affected by contributions.

[14]Because of the linear separable specification for the cost of finance, contributions at time t do not depend on expected contributions at time $t + 1$, so there is no loss of generality.

investment decisions. Letting z_t represent plan surplus – the difference between plan assets and plan liabilities – the law of motion of the funding status is

$$z_{t+1} = z_t + c_t - s_t + \omega_t, \tag{1}$$

where ω_t is a catch-all random variable capturing all uncertainty about pension assets and liabilities (e.g., uncertainty about investment returns). The sponsor does not observe ω_t before choosing contributions. The funding shock ω_t is i.i.d. over time, with bounded support $\omega_t \in [\underline{\omega}, \bar{\omega}]$.

If its pension plan is underfunded, the firm has to pay the variable PBGC insurance premium. The insurance premium, $q(z_t)$, is piece-wise linear:

$$q(z_t) \equiv \max[0, \ -\bar{q}z_t], \quad \bar{q} \in (0, 1), \tag{2}$$

with derivative $q'(z_t) = -\bar{q}$ if $z_t < 0$ and 0 otherwise. In addition, a sponsor with an underfunded pension plans must contribute more. Regulatory requirements mandate that contributions have to be at least as high as the service cost:

$$c_t \geqslant \max[s_t, s_t - z_t] \equiv \Psi(z_t), \tag{3}$$

so an underfunded sponsor with $z_t < 0$ has to contribute more that the service cost. The lower bound on contributions, $\Psi(z_t)$, is piece-wise linear with derivative equal to $\Psi'(z_t) = -1$ if $z_t < 0$ and 0 otherwise.

If a plan is underfunded, the sponsor suffers a loss. We think of the loss as a reduced form representation of the costs of obtaining external finance. Rather than modelling external finance costs endogenously, we follow Gomes (2001) and Whited (2006) and assume that when contributions are large relative to the sponsor's internal resources, the firm can only go ahead if it obtains external funds at a premium. External finance costs depend on plan funding and cash flows, x_t. In addition, the plan sponsor faces some uncertainty about the costs of finance. Concretely, we define external finance costs as

$$R(x_t, z_t) = r_0 - r_{x,t}x_t + r_z \frac{z_t^2}{2} 1_{z_t<0} \quad \text{if } x_t < 0 \tag{4}$$

and 0 otherwise, with r_0, $r_z > 0$ represents the minimum external finance costs that the sponsor can obtain external funds at. The linear term in (4) implies that a larger external finance need (a more negative x_t) makes external finance more expensive. The quadratic term denotes the underfunding penalty. Conditional on there being an external finance need, a larger plan funding shortfall (a more negative z_t) increases the cost of external finance. We thus let $R_x(x_t, z_t) = -r_{x,t}$ if $x_t < 0$ and 0 otherwise; and $R_z(x_t, z_t) = z_t < 0$ if x_t, $z_t < 0$, and 0 otherwise (see the Appendix A).

The external finance cost function parameter $r_{x,t}$ represents the sensitivity of external finance costs to changes in financing needs. We can thus interpret it as the shadow value of relaxing an external finance constraint, with a larger $r_{x,t}$ implying that the sponsor is more constrained. In Section 1 we argued that in the presence of financing frictions, a reduction in internal financial resources may limit a sponsor's ability to finance investment projects. In order to allow for this possibility we assume that $r_{x,t} = r(a_t)$, and we interpret the shock a_t as the productivity of investment/investment returns. A higher a_t realisation is associated with a higher $r_{x,t}$ realisation. The higher investment returns, the more valuable relaxing the external finance constraint (equivalently, the tighter the constraint). Formally, we assume that $r_{x,t}$ is i.i.d. and independent of ω_t, for all t, and that a_t is a mean-preserving shock, so the mean of $r_{x,t}$ is constant.[15]

[15]For example, $r_{x,t}$ could be a uniform random variable with support $[\underline{r} + a_t, \bar{r} + a_t]$.

The sponsor chooses contributions to maximise the value of the firm, which is equal to the present discounted value of expected cash flows. Cash flows are given by

$$x_t = y_t - (1 - \tau_t)(c_t + q(z_t)), \tag{5}$$

where y_t denotes the component of cash flows that does not depend on contributions. We take it as exogenous but dependent on the shock $y_t = f(a_t)$. The higher a_t, the larger y_t. τ_t is the corporate tax rate. Letting Λ^j denote the (constant) discount factor applied to cash flows received in period $t+j$, for some $\Lambda \in (0, 1)$, the firm's problem is thus given by

$$\max_{\{c_0, c_1\}} \quad \mathbb{E}_t\left[\sum_{j=0}^{2} \Lambda^j (x_{t+j} - R(x_{t+j}, z_{t+j}))\right], \tag{6}$$

subject to the law of motion of plan funding (1), the expression for the variable insurance premium (2), the regulatory requirement on contributions (3), the definition of external finance costs (4), the expression for cash flows (5), and $c_2 = 0$. A typical specification for the discount factor would take $\beta^j u'(C_{t+j})/u'(C_t)$ for $\beta \in (0, 1)$, where $u'(C_t)$ is the marginal utility of consumption of a representative household at date $t+1$. By assuming a constant discount factor we are implicitly assuming linear utility.

The first-order condition for contributions illustrates the intertemporal tradeoff faced by the sponsor:

$$\begin{aligned}(1 - R_x(x_t, z_t))(1 - \tau_t) =& \lambda_t + \mathbb{E}_t\{\Lambda[-(1 - \tau_{t+1})q'(z_{t+1})](1 - R_x(x_{t+1}, z_{t+1})) \\ & - \lambda_{t+1}\Psi'(z_{t+1}) - \Lambda R_z(x_{t+1}, z_{t+1})\}.\end{aligned} \tag{7}$$

Here, λ_t denotes the Lagrange multiplier on the period-t regulatory requirement on contributions (3). The left-hand side of this equation is the marginal cost of current contributions. Higher contributions today lower current cash flows (but less than one for one, thanks to the contributions tax shield) and possibly raise the cost of external finance, $-R_x(x_t, z_t) \geqslant 0$. The right-hand side represents the marginal benefit of contributing today. Higher current contributions relax the current regulatory constraint ($\lambda_t \geqslant 0$). They also increase next-period plan surplus. In turn, this raises next-period cash flows by lowering the PBGC premium ($-q'(z_{t+1}) \geqslant 0$), and reduces the need to rely on external finance and the corresponding costs. At the same time, a higher future surplus slackens the regulatory constraint by lowering the MRC ($-\lambda_{t+1}\Psi' \geqslant 0$). In addition, a higher future surplus reduces the costs of future external finance, $-\Lambda_{t+1}R_z(x_{t+1}, z_{t+1}) \geqslant 0$.

Modelling the impact of TCJA. We now derive a prediction for the impact of the TCJA on the time profile of contributions of underfunded sponsors. To that end, we introduce a distinction between the tax rate at which contributions can be deducted, τ_t^c, and the corporate tax rate, τ_t. As a result, the tax rate entering the left-hand side of the first-order condition (7) need not be the same as the tax rate entering the right-hand side. We assume that until period $t-1$, both tax rates are equal and constant at the level τ. In period t, it is announced that the corporate tax rate will decline from then on, $\tau_{t+j} = \tau(1 - \Delta)$for all $j \geqslant 0$, with $\Delta \in (0, 1)$. By contrast, the tax rate relevant for contributions stays at the old level in period t, before dropping down in all subsequent period, $\tau_t^c = \tau$and $\tau_{t+j}^c = \tau(1 - \Delta)$ for all $j \geqslant 1$.

TCJA causes a steepening in the time profile of underfunded sponsor contributions, with c_t increasing and c_{t+1} decreasing. Consider an underfunded sponsor that expects to continue to be underfunded in the immediate aftermath of the TCJA. The firm's pension plan is underfunded in t, $t+1$, and $t+2$. As a result, the firm contributes more than the minimum requirement, $\lambda_{t+j} = 0$ for $j = 0, 1, 2$. The firm relies on external finance, $x_{t+j} < 0$ for $j = 0, 1, 2$.[16] A higher Δ increases the marginal benefit of

[16]Underfunded sponsors that contribute more than the minimum requirement account for about 76 per cent of firms in our sample in 2014–2018. All firms in our sample are listed firms that can be expected to rely on external finance.

contributing today (see (7)). Intuitively, given lower expected corporate taxes tomorrow ($t+1$), an extra dollar put to work to reduce plan expenses (by lowering PBGC payments) has a bigger impact on tomorrow's cash flows and finance costs. As a result, current contributions, c_t, increase in Δ.

Future contributions, c_{t+1}, are different because in addition to lower expected taxes tomorrow, sponsors also face lower taxes today. As Δ rises and the value of the contributions tax shield falls, the marginal cost of c_{t+1} rises. Higher Δ raises both the marginal costs and the marginal benefit of future contributions, c_{t+1}. At the same time, higher c_t contributions have already boosted plan fundingz_{t+1}, in turn decreasing the expected funding gap, $E_{t+1}[z_{t+2}]$. And the smaller the funding gap, the less responsive the costs of external finance to further funding improvements brought about by additional $t+1$ contributions. As a result, the TCJA has an indirect negative effect on the marginal benefit of contributions, which dampens the direct (positive) effect. The marginal cost channel then dominates and c_{t+1} falls. We formalise in the claim below.

Claim 1. The TCJA causes an underfunded sponsor with a need for external finance to increase $t+1$ contributions and to decrease $t+1$ contributions.

Proof. See the Appendix A. □

The overall impact of the TCJA on sponsor contributions depends on the time profile of the sponsor's financial constraint. If a sponsor is more financially constrained in period $t+1$ than it expects to be in period $t+2$, then $t+1$ contributions decrease by more than t contributions increase (reversal). To see why this is the case, consider the first-order conditions for $t+1$ contributions:

$$(1-\tau(1-\Delta))(1+r_{x,t+1}) = \Lambda(1+\mathbb{E}\%_{t+1}[r_{x,t+2}])(1-\tau(1-\Delta))\bar{q} - \Lambda\mathbb{E}_{t+1}[z_{t+2}]. \tag{8}$$

The marginal cost of contributions (the left-hand side of (8)) increases in Δ. As the corporate tax rate decreases, the negative impact of higher contributions on current after-tax cash flows x_t rises. And the more constrained the sponsor, the larger the negative impact on current free cash flows, $x_t - R(x_t, z_t)$. The marginal benefit of contributions (the right-hand side of (8)) has two terms. The first one increases in Δ, because a lower corporate tax rate raises the positive impact of lower PBGC payments on after-tax cash flows. Like the marginal cost, this term is also larger for a more constrained sponsor, because an increase in after-tax cash flows x_{t+1} has a larger impact on future free cash flows, $x_{t+1} - R(x_{t+1}, z_{t+1})$. The second term, $-\Lambda R_z = \Lambda E_{t+1}[z_{t+2}]$, depends on the corporate tax rate only through plan funding, z_{t+2}. By (1), z_{t+2} is linear in the sum of past contributions, $c_t + c_{t+1}$. Using (1) and (8) we thus obtain:

$$\frac{d(c_t + c_{t+1})}{d\Delta} = \frac{-(1+r_{x,t+1})\tau + \Lambda(1+\mathbb{E}\%_{t+1}[r_{x,t+2}])\tau\bar{q}}{\Lambda},$$

which is negative (reversal) if the sensitivity of the marginal cost of contributions with respect to Δ, $(1+r_{x,t+1})\tau$, is larger than the sensitivity of the marginal benefit, $\Lambda(1+\mathbb{E}_{t+1}[r_{x,t+2}])\tau\bar{q}$.[17] As both the marginal cost and marginal benefit of contributions are more sensitive to the corporate tax rate when the sponsor is more constrained, but the former accrues earlier than the latter, reversal happens when $r_{x,t+1}$ is sufficiently large relative to $E_{t+1}[r_{x,t+2}]$.

Claim 2. *If* $1 + r_{x,t+1} > \Lambda\bar{q}(1+\mathbb{E}_{t+1}r_{x,t+2})$, then the positive impact of TCJA on sponsor contributions in period t is more than fully reversed in period $t+1$, so the overall impact of the TCJA on sponsor contributions is negative. Otherwise, the overall impact is positive.

Proof. See the Appendix A. □

[17]This result will continue to hold even if the underfunding penalty is not quadratic, as long as $R_z < 0$ so the denominator is positive.

We next turn to taking the predictions formalised in claims 1 and 2 to the data.

3. Data and construction of variables

Our plan-sponsor level data come from Schedules SB and H of the electronic IRS 5500 filings from the Department of Labor. All employers sponsoring funds with more than 100 employees must file Schedules SB and H of the IRS 5500 Form on an annual basis.[18,19] We match the plans with Compustat employers to obtain sponsor-level information.

An alternative source of pension data for Compustat firms is annual 10-K forms filed with the SEC. Unlike IRS data, SEC filings data do not include MRCs, making it harder to disentangle the voluntary component of contributions from the mandatory. In addition, pension variables obtained from SEC filings (contributions, plan assets, and liabilities) do not distinguish between domestic plans and plans pertaining to foreign subsidiaries. By contrast, the TCJA tax break only applies to contributions made to domestic plans. Similarly, the PBGC premium only applies to funding shortfalls of domestic plans.

3.1 The sample

Our sample starts in 2014 to avoid possible confounding effects from the Transportation Bill of June 2012 (Moving Ahead for Progress in the 21st Century, or MAP-21). MAP-21 allowed single-employer plans to discount liabilities using a rolling average of yields over the previous 25 years instead of over the previous 2. With interest rates at historical lows, the change amounted to an increase in the discount factor, which boosted plan funding ratios and lowered contribution incentives.[20] The sample ends in 2018 to avoid confounding effects from the Coronavirus Aid, Relief and Economic Security (CARES) Act of March 2020. As part of a broader effort to mitigate the COVID-19 shock, CARES afforded DB plan sponsors the option to defer 2020 contributions (deductible from 2019 returns) until January 2021.

To ensure that all sponsors have an equal amount of time to respond to the TCJA tax break, we restrict the sample to plans sponsored by firms whose fiscal year ends in December.[21] About 79 per cent of sponsors (585 firms) in our matched sample are calendar year firms. We end up with a sample of 4,105 plan-year observations and 2,506 firm-year observations (some employers have multiple plans) that were matched to Compustat.[22] According to the financial accounts of the United States, the assets held by our sample plans in 2017 represent about 30 per cent of total private DB plan assets as of 2017 Q4 (single- and multi-employer). They account for 43 per cent of the total assets held by all single-employer pension plans that filed the IRS Form 5500. We turn to the construction of variables and the corresponding summary statistics next.

3.2 Outcome variables

We study the impact of the TCJA tax break on voluntary sponsor contributions, total sponsor contributions, and plan funding.

[18]See Rauh (2006, 2008) for additional information on IRS filings.

[19]Plans with less 100 participants must file Schedule SF. This form includes very limited information on funding ratio, number of participants, and investment income. Compustat firms, which are listed companies, usually don't sponsor such small plans.

[20]van Binsbergen and Brandt (2016) calculate that reported liabilities fell to half of their market value in 2012.

[21]Although the tax reform principles were unveiled on 26 April 2017, President Donald Trump signed the legislation approving the TCJA into law on 22 December 2017.

[22]The number of firms filing IRS 5500 is decreasing over time, consistent with an on-going shift away from DB plans in the U.S. private sector.

3.2.1 Contributions

As discussed in Section 1, tax-based incentives affect only the *voluntary* component of sponsor contributions. We compute voluntary contributions by a particular sponsor to a particular plan by subtracting mandatory contributions from total contributions.[23] We define the mandatory component of pension contributions as the sum of MRCs (both legacy and current) and of special contributions made to avoid restrictions on the timing of benefits payment for underfunded plans.[24] As a firm may sponsor multiple plans, we aggregate over all the plans sponsored by the same firm to obtain sponsor-level contributions (Voluntary Contributions and Total Contributions, respectively).[25]

As larger firms naturally tend to contribute more (e.g., because they have higher service costs), we scale both our contribution variables – voluntary and total – by sponsor size, captured by sponsor assets at the beginning of the current year (Assets (book)). Normalising by firm assets is standard in papers studying either pension contributions from the sponsor's perspective (e.g., Rauh, 2006) or the impact of tax-based incentives on other firm choices, such as capital expenditures (e.g., Zwick and Mahon, 2017; Xu and Zwick, 2018).[26]

Voluntary contributions represent 0.02 per cent of sponsor assets at the mean and 0.002 per cent of assets at the median (Table 1). Total pension contributions are 0.31 per cent of assets at the mean and 0.05 per cent at the median. Both total and voluntary contributions grew in 2016 and in 2017. They declined sharply in 2018 (Figure 2, left panel).

3.2.2 Funding ratios

To assess whether the TCJA tax break had an impact on plan funding, we consider the change in funding ratios between 2016 and 2017. We chose this period because contributions made up until the end of the contribution 'grace period' (in theory, mid-October 2018; in practice, mid-September 2018), are counted towards 2017 contributions for financial reporting purposes and thus flow into 2017 assets and funding. We compute the funding ratio for a particular plan-sponsoring firm in any given year (Funding Ratio) in a few steps. First, for each plan sponsored by a particular firm, we sum of reported plan assets (Assets) and sponsor contributions (Total Contributions) net of credit balances (Credit Balances).[27] Reported plan assets are measured at year-end market value, and they *do not* include contributions. Second, we aggregate the resulting plan-level asset measure over all the plans sponsored by the firm, and we thus obtain the funding ratio numerator. To get the denominator, we sum plan-level liabilities (Liabilities) over all the plans sported by the firm. Liabilities are the present discounted value of future pension benefits accumulated to year-end. MAP-21 allows sponsors to discount plan liabilities using an average of market rates on corporate bonds over the past 25 years.[28] Plans in our sample are 107.6 per cent funded at the mean and 104.4 per cent funded at the median, with a standard deviation of 16 per cent.

3.3 Explanatory variables

3.3.1 Tax-based incentives

For the TCJA tax break to affect voluntary contributions, two conditions need to be satisfied. First, the firm has to have a positive corporate income tax bill before deducting contributions (tax-paying

[23]Contribution figures reported on Schedule SB as year t contributions take into account transfers made by the sponsor up to the point of filing year-t tax returns, and thus include any transfers made within the 'grace period' for contributions in year $t+1$.

[24]The PPA imposes benefit restrictions that constrain sponsors of underfunded plans from improving or accelerating the payment of benefits. For example, plans are not allowed to pay lump sum benefits if they are less than 60 per cent funded.

[25]See Tables 9 and 10 for more details on the construction of variables.

[26]Other normalisations are appropriate when thinking about contributions from a plan's perspective (e.g., contributions as a share of plan assets or as a share of service cost).

[27]Credit balances arise when an employer chooses to credit current voluntary contributions towards satisfying future minimum funding requirements and the ensuing minimum required contributions.

[28]With interest rates at historical lows, these regulatory discount rates are higher than the discount rates used in the Financial Accounts of United States, which are based on AAA-rated corporate bond rates (Stefanescu and Vidangos, 2014). As a result, average funding ratios in our sample are higher than funding ratios derived from the flow of funds (Figure 2, centre panel). Financial Accounts data point to average funding of 85.5 per cent between 2014 Q1 and 2018 Q4.

Table 1. Summary statistics

(a) Cross-section variation	Mean	Std. dev.	10th	50th	90th	*N*
Voluntary contributions (%)	0.02	0.046	0.00	0.002	0.06	2,417
Total contributions (%)	0.31	0.66	0.00	0.050	0.86	2,417
Funding ratio (%)	107.58	16.02	92.33	104.42	126.31	2,457
PBGC premium (%)	0.004	0.02	0.00	0.00	0.005	2,417
Return on investment (%)	5.06	6.88	−1.16	6.18	14.43	2,390
Discount rate (%)	6.07	0.31	5.67	6.08	6.48	2,459
Altman's *Z*-score	2.42	4.85	0.60	1.86	3.64	1,001
CAPEX (%)	4.26	3.78	0.21	3.35	8.94	2,161
Payout (%)	3.97	4.83	0.05	2.32	9.77	2,118
Cash flows (%)	8.63	6.84	1.19	8.13	16.30	2,063
Tobin's *Q*	1.21	2.66	0.50	0.72	1.72	1,023
DB plans share	1.15	1.11	0.16	0.84	2.35	2,363

(b) Time variation Year	(1) Plans	(2) Firms	(3) TE	(4) NTE	(5) PBGC
2014	900	557	431	126	14
2015	848	521	406	115	24
2016	823	504	383	121	30
2017	782	482	381	101	34
2018	752	442	298	144	38

Notes: Panel (a) presents plan-level and sponsor-level summary statistics for our sample. There are 4,105 plan-year observations and 2,506 firm-year observations during the period 2014–18 (some firms sponsor multiple plans). All plans in the sample are middle- and large-scale plans covering more than 100 employees. Plan-level data are from IRS 5500 filings. Sponsor-level data are from Compustat. Voluntary and Total contributions, PBGC premium, CAPEX, Payout, and Cash flows are scaled by beginning-of-year sponsor balance sheet assets. Voluntary contributions, Total contributions, and PBGC premium are winsorised at the top 1% level. Funding ratio, Cash flows, Tobin's *Q*, Altman's *Z*, CAPEX, Payout, Return on investment, Discount rate, and DB pension plans significance are winsorised at the top and bottom 1% level. Panel (b) shows time variation in DB pension plans significance, Tax exposure, and PBGC premium. Columns (1) and (2) show the number of retirement plans and sponsoring firms in each sample year. Columns (3) and (4) break the sample down by tax-exposure. Column (5) shows the Pension Benefit Guarantee Corporation variable premium rates. Rates are quoted per $1,000 of unfunded vested benefits for single-employer plans.

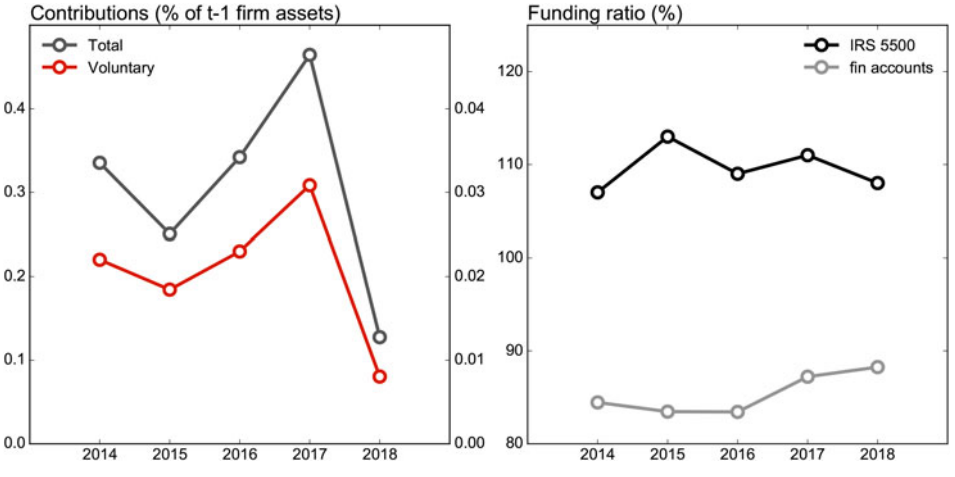

Figure 2. Aggregate contributions and funding.

sponsor).[29] Second, the funding ratio has to be below the 150 per cent bound above which contributions stop being deductible (funding ratio below 150%), for at least one of the sponsored plans.

We say that a sponsor is *exposed* to tax-based incentives – including the TCJA tax break – if it meets both these conditions. We define the tax exposure of sponsor *s* at time *t* (Tax Exposure) as a

[29]Gaertner *et al.* (2018) also employ this condition to assess the impact of TCJA. Zwick and Mahon (2017) use it to assess the impact of tax-based incentives on firm investment.

dummy variable which is equal to 1 if Gross Tax >0 and if Funding Ratio <150% for at least one plan i of sponsor s. Here, Gross Tax denotes the Federal corporate tax bill of sponsor s before deducting pension contributions. Since we do not observe Gross Tax, we obtain it by adding back the contribution deduction to the corporate tax bill from Compustat. Concretely, Gross Tax = Net Tax + $\tau \times$sum of Total Contributions over sponsored plans, where Net Tax is the Federal corporate income tax expense from Compustat and τ is the statutory corporate income tax rate.

By using Tax Exposure as a proxy for sponsor exposure to the TCJA tax break, we assume that the gross corporate tax bill (Gross Tax) is exogenous to the sponsor's contribution decision. This assumption is justified by the timing of tax-based incentives for retirement plan contributions, which suggests that a sponsor is likely to take the pre-contribution tax bill as given when choosing how much to (voluntarily) transfer to its pension plans. To account for any possible endogeneity and as a robustness check, we will rerun the analysis by relaxing the definition of tax exposure of sponsor s at time t (Tax Exposure) as a dummy variable which is equal to 1 *only* if Funding Ratio <150% for at least one plan i of sponsor s.

Tax-based incentives for sponsors to contribute could be captured by other proxies. These include estimates of corporate marginal tax rates (Graham, 1996a, 1996b) and measures of tax exposure based on sponsor tax credits such as net operating loss carryforwards and investment tax credits.[30] According to the latter set of proxies, a firm is *not* exposed to tax-based incentives if its accumulated tax credits are large enough to cause it not to report any taxable income. Our tax-based incentives measure is positively correlated with marginal corporate tax rates, and negatively correlated a set of dummies capturing *lack* of exposure due to tax credits (see Table 2).

There are disadvantages to using corporate marginal tax rate estimates or exposure measures based on accumulated tax credits in order to capture the impact of the TCJA tax break on sponsor contributions. First, marginal tax rates may not be the relevant tax rates for sponsor contribution decisions. There is evidence that firms may prefer to use simple heuristics such as statutory and effective tax rates to evaluate incremental decisions, rather than harder-to-estimate marginal tax rates (Graham *et al.*, 2017). This suggests that our tax-exposure measure, which is based on the statutory tax rate, is a more suitable proxy than the marginal tax rate for capturing the impact of tax-based incentives on sponsor contributions. Second, the tax credit dummies might incorrectly classify some sponsors as not exposed to the TCJA tax break. This is because the exposure measures based on accumulated tax credits reported in Compustat include tax credits accrued to foreign subsidiaries, as well as domestic subsidiaries which are unconsolidated for tax purposes (Corporate Taxes and Defined Benefit Pension Plans, 1988). By contrast, pension contributions are deducted from corporate income net of income from such subsidiaries, so sponsors may be subject to tax-based incentives even if the no-exposure dummies are equal to 1.

3.4 Controls for other contribution incentives

As we argued in Section 1, contribution incentives are affected by insurance premia. As PBGC insurance premia depend on plan funding, we include funding ratios as a control in our regressions. We also add controls for sponsor bankruptcy risk – because pension deficits flow through to sponsor balance sheets – and for the opportunity cost of diverting internal financial resources to shoring up pension benefits.

To control for sponsor bankruptcy risk, we use the Altman's Z-score, a weighted average of standard business ratios (working capital, operating earnings, sales, and retained earnings). To account for the opportunity cost of diverting internal financial resources to funding pension benefits, we use sponsor cash flows excluding contributions (Cash Flows), capital expenditures (CAPEX), earnings distribution to investors (Payout), and Tobin's Q (i.e., the market-to-book ratio of firm assets).

[30]Net operating losses arise when taxable corporate income falls short of applicable deductions. They can be carried forward, meaning that losses occurred in a particular year can be used to abate taxable corporate income in subsequent years. In this sense, past net operating losses result in current tax credits.

Table 2. Tax exposure and other proxies for tax-based incentives

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Marginal tax rate before interest	1.77***						
	(6.41)						
Marginal tax rate after interest		0.62**					
		(3.14)					
Net operating loss			−0.061				
			(−1.50)				
Net operating loss dummy 1				−0.989***			
				(−9.02)			
Net operating loss dummy 2					−0.62***		
					(−7.64)		
Net operating loss dummy 3						−0.62***	
						(−7.62)	
Investment tax credit							−8.51
							(−0.67)
Observations	2,256	2,405	1,391	2,506	2,506	2,506	1,929
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents pooled probit regression estimates of the impact of different proxies for tax-based incentives to make pension contributions on the probability that a sponsor is tax exposed. The dependent variable is Tax exposure, a dummy variable = 1 if (i) a firm has a positive ex-contributions tax bill and (ii) the firm sponsors at least one plan with funding ratio below 150%. Marginal tax rate before interest is a simulated corporate marginal tax rate based on income before interest expense has been deducted. Marginal tax rate after interest is a simulated corporate marginal tax rate based on income after interest expense has been deducted. See https://faculty.fuqua.duke.edu/~jgraham/read.html for more details. Net operating loss (NOL) and Investment tax credit are scaled by beginning-of-year sponsor balance sheet assets. NOL dummy 1 is a dummy variable which is = 1 if a sponsor has a positive carryforward balance and it pays no current U.S. income tax. NOL dummy 2 is a dummy variable which is = 1 if a sponsor has a positive carryforward balance and it reports no pre-tax income. NOL dummy 3 is a dummy variable which is = 1 if a sponsor does not report any pre-tax income. *Z*-statistics obtained using robust standard errors are in parentheses.

3.5 Other controls

We control for plan performance by including investment returns (Return on Investment) and liability discount rates (Discount Rate). Both these variables vary at the sponsor level. The data come from Schedules H and SB of the IRS filings, respectively. Return on Investment is a weighted average of returns over sponsored plans, with weights proportional to plan assets. Plan returns are calculated as investment income divided by beginning-of-year investable assets (measured ex-contributions). Discount rates are the interest rates used to compute the present discount value of the pension liability of a particular plan. Discount rates for U.S. corporate DB plans are regulated and decoupled from expected plan returns. Under MAP-21, funds discount using an average corporate bond yield over the past 25 years, with a corridor around this average.[31] The discount rate at the sponsor level is computed as the weighted average of discount rates across all sponsored plans, with weights proportional to plan liabilities. Discount rates are 6.07 and 6.08 per cent at the mean and median, respectively. By contrast, the average yield of a 30-year Treasury bond was 2.95 per cent over our sample period.

Finally, we include a proxy of the relative importance of DB plans for a particular sponsor, the idea being that the larger the relative importance of DB plans in a firm's pension benefits, the more likely the sponsor to shore up those plans (e.g., in order to retain current employees). We proxy the relative importance with the ratio of the total number of participants in DB plans to the current number of employees of the firm (DB Plans Share). The 'significance' measure is 1.15 and 0.84, at the mean and the median, respectively.

4. The effect of TCJA on pension plans

4.1 Identification strategy

Our empirical strategy exploits cross-sectional variation in sponsor exposure to tax-based incentives to assess the impact of the TCJA tax break. We use non-tax-exposed sponsors as a control group to assess

[31]The corridor was ±20% in 2014, ±25% in 2015, and ±30% since 2016. See Novick *et al.* (2012). 'Corporate Pension Funding Update'. *Blackrock White Papers.*

the counterfactual level of voluntary and total pension contributions in the absence of the tax break for the tax-exposed firm.[32] This allows us to estimate of the marginal impact of the TCJA tax break on contributions and funding. The identification strategy depends on the assumption that tax-exposed (treatment) and non-tax-exposed control firms do not differ across dimensions other than tax-based incentives that may affect voluntary contributions during the sample period.

Exposure to tax-based incentives is not random in our sample. Table 3 reports the correlation of our measure of tax-exposure with other variables that are likely to affect pension contribution patterns: plan funding (Funding Ratio), profitability metrics (Return on Investment and Discount Rates), PBGC premia, proxies for sponsor bankruptcy risk (Altman's Z), and the opportunity cost of internal resources (Cash Flows, CAPEX, Payout, Tobin's Q). Tax-exposed firms have more underfunded pension plans, higher PBGC variable premium, higher payout, and higher pre-contributions cash flows, which all push for higher contributions. At the same time, tax-exposed sponsors have higher pension liability discount rates, which would tend to reduce sponsor incentives to contribute. The tax-exposed also display lower CAPEX, which could be associated with relatively lower contributions if resulting from more binding constraints on external finance. On balance, it is not obvious that the significant correlates in Table 3 will bias our estimates in a specific direction. To account for all possible biases, we include the observable correlates as controls in our empirical specifications.

4.2 The TCJA tax break and contributions

The conceptual framework outlined in Section 2 indicates that TCJA should have has a positive impact on 2017 contributions. By contrast, it should have had a negative impact on 2018 contributions (claim 1). Therefore we should expect 2017 contributions from tax exposed firms to be higher than those of non-tax-exposed firms. We should expect the opposite for 2018 contributions. The model also suggests that whether the drop in 2018 contributions is large enough to offset the 2017 increase depends on the time profile of sponsor financial constraints (claim 2). Empirically, we can gauge whether this was the case or not by comparing the 2017 (differential) response of tax-exposed firms to tax-based incentives to their 2018 response.

A graphical analysis suggests that the TCJA tax break had a positive impact on 2017 contributions and a negative impact on 2018 contributions, as expected. We split the sample into two groups according to tax-based incentives, proxied by our tax exposure measure. The first group includes firms that have pre-pension contribution tax-based incentives (i.e., Tax Exposure =1) and the second group includes firms that have no pre-pension contribution tax-based incentives (i.e., Tax Exposure =0). The left panel of Figure 3 plots average yearly voluntary pension contributions from 2014 through 2018, for both tax-exposed and non-tax-exposed firms. The difference between voluntary contributions from tax-exposed and non-tax-exposed sponsors was relatively stable prior to the TCJA tax break (2014–2016). In 2017, contributions from tax-exposed sponsors increased by 0.008 per cent of sponsor assets. By contrast, contributions from non-tax-exposed sponsors increased by 0.0024 per cent. In 2018, pension contributions from tax-exposed firms decreased significantly relative to those of non-tax-exposed firms. Given the more permanent nature of changes in other time-varying contribution incentives (such as increases in the PBGC variable premium), it is difficult to argue that this increase/decrease pattern can be accounted for by something other than TCJA and the ensuing temporary tax break.

Regression analysis confirms the findings of the graphical analysis on impact. We estimate the following cross-sectional specification:

$$\frac{\text{Voluntary Contributions}_{s,t}}{\text{Assets (book)}_{s,t-1}} = \alpha_t + \beta_t \text{Tax Exposure}_{s,t} + \delta_t Z_{s,t} + \varepsilon_{s,t}, \quad \text{for } t = 2014, \ldots, 2018. \quad (9)$$

[32]Given the firm's other incentives to shore up underfunded pension plans, it would be difficult to estimate counterfactual outcomes using aggregate data.

Table 3. Tax exposure and plan- and sponsor-level characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Funding ratio	−0.63***									
	(−3.61)									
PBGC premium		917.42**								
		(2.90)								
Investment return			0.80							
			(1.94)							
Discount rate				0.30***						
				(3.47)						
DB plans significance					−0.04					
					(−1.42)					
CAPEX						−1.47*				
						(−2.39)				
Tobin's *Q*							0.001			
							(0.08)			
Non-pension cash-flows								2.82***		
								(6.09)		
Altman's *Z*-score									−0.005	
									(−0.63)	
Payout										3.80***
										(5.27)
Observations	2,457	2,417	2,390	2,459	2,363	2,158	993	2,063	1,011	2,118
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents pooled probit regression estimates of the impact of different plan-level (rows (1)–(4)) and sponsor-level characteristics (rows (5)–(9)) on the probability that a sponsor is tax exposed. The dependent variable is Tax exposure, a dummy variable equal to 1 if (i) a firm has a positive ex-contributions tax bill and (ii) the firm sponsors at least one plan with funding ratio below 150%. *Z*-statistics obtained using robust standard errors are in parentheses.

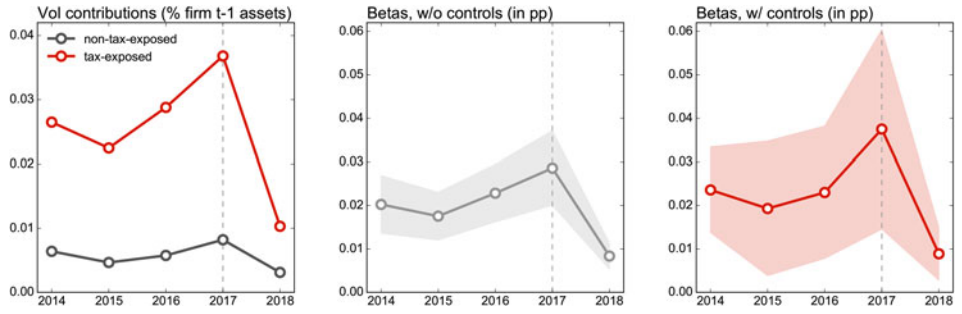

Figure 3. Voluntary contributions and the TCJA.

Here, Tax Exposure is our measure of tax-based incentives and Z is a vector of controls which includes the observable correlates of tax-based incentives. The β_t coefficients are the coefficients of interest, as they capture the impact of tax deductibility of contributions on contributions in each of our sample years. We plot them on the right panel of Figure 3. A priori, we would expect the impact of tax-based incentives in 2017 to be above pre-TCJA average, $\beta_{2017} > \sum_{t=2014}^{2016} \hat{\beta}_t/3$, and the impact of tax-based incentives in 2018 to be below, $\beta_{2018} < \sum_{t=2014}^{2016} \hat{\beta}_t/3$.

Tax-based incentives had a larger impact on contributions in 2017 than in the 3 years pre-TCJA. The 2017 estimate of the tax exposure coefficient, $\hat{\beta}_{2017}$, is positive and significant (Table 4, columns (1) and (2)). This result is robust to including controls for the observable correlates of our tax exposure measure (column (2)), assuaging concerns about identification. According to our preferred specification (with controls, column (2)), voluntary contributions from tax-exposed sponsors were 0.037 percentage points larger than their counterpart from non-tax-exposed firms. By contrast, the average impact of tax-based incentives on voluntary contributions prior to the TCJA, $\sum_{t=2014}^{2016} \hat{\beta}_t/3$, was around 0.022 percentage points, making the 2017 impact about one-third of a standard deviation higher than the pre-TCJA average.

The impact of tax-based incentives on 2018 contributions was below pre-TCJA average, with a large enough deviation to fully offset the above-average 2017 effect (reversal). The 2018 estimates of the tax exposure coefficient, $\hat{\beta}_{2018}$, are at the minimum level over our five-year sample period (Table 4, columns (1) and (2)), implying that tax-based incentives to contribute were at their weakest right after the end of the tax break. In our preferred specification (with controls, column (2)), the impact of tax-based incentives in 2018 amounted to 0.008 percentage points. At around one-third of a standard deviation lower than pre-TCJA average, this decline fully offset the 2017 increase. We interpret this as evidence that tax-exposed firms shifted planned future contributions from 2018 to 2017. Through the lens of our model, the fact that 2018 tax-based incentives completely reversed the effects of 2017 incentives on contributions is consistent with sponsor financial constraints being relatively more binding than future expected constraints (claim 2).

These results are robust to changing the definition of tax exposure to a dummy variable equal to 1 if only the firm sponsors at least one plan with funding ratio below 150 per cent (Tables 5 and 6). These results are also robust to including sector fixed effects. Estimates with sector fixed effects are qualitatively similar to estimates without (Table 7). The second column of Table 7 changes the dependent variable to total pension contributions. We continue to find a positive impact of the TCJA tax break in 2017, followed by a reversal in 2018.

In dollar values, our estimates imply a $2.8bn to $5.0bn increase in voluntary contributions to medium- and large-scale plans associated with the tax break, depending on whether or not the specification includes controls (the impact is larger with controls). Our estimates report the TCJA impact in percentage points, so we multiply by tax exposed sponsor assets to obtain a dollar figure. Accordingly, the tax break impact on voluntary contributions in dollars in sample is given by

Table 4. Pension contributions, tax-based incentives, and the TCJA

	2014		2015		2016		2017		2018	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Tax exp.	0.020***	0.024***	0.018***	0.019*	0.023***	0.023**	0.029***	0.037**	0.008***	0.008**
	(6.00)	(4.75)	(6.26)	(2.47)	(6.77)	(3.00)	(6.59)	(3.23)	(5.45)	(2.89)
Obs.	530	150	503	140	483	128	471	142	430	134
R^2	0.04	0.25	0.05	0.11	0.04	0.15	0.04	0.13	0.04	0.08
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: This table presents regression estimates of the response of voluntary pension contributions to fiscal incentives in each year between 2014 and 2018. The dependent variable is voluntary pension contributions deducted from 2014 tax returns in columns (1) and (2); from 2015 returns in columns (3) and (4); from 2016 returns in columns (5) and (6); from 2017 returns in columns (7) and (8); and from 2018 returns in columns (9) and (10). Tax exposure is a dummy variable equal to 1 if (i) a firm has a positive ex-contributions tax bill and (ii) the firm sponsors at least one plan with funding ratio below 150%. The TCJA reduced the federal corporate tax rate from 35% to 21% beginning in 2018. As a result, contributions counted towards the 2017 corporate tax return could be deducted at 35%, while contributions counted towards 2018 returns at 21%. Columns (2), (4), (5), (6), and (8) include the following plan-level controls: Funding ratio, PBGC premium, Return on investment, Discount rate. They also include the following sponsor-level controls: Altman's *Z*-score, Cash flows, CAPEX, Tobin's *Q*, Payout, and DB plans share. *t*-statistics obtained using robust standard errors are in parentheses.

Table 5. Tax exposure and plan- and sponsor-level characteristics: robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Funding ratio	−1.67***									
	(−8.34)									
PBGC premium		7,293.38***								
		(3.48)								
Investment return			0.77							
			(1.58)							
Discount rate				0.03						
				(0.29)						
DB plans significance					0.01					
					(0.19)					
CAPEX						1.29				
						(1.22)				
Tobin's *Q*							−0.01			
							(−0.70)			
Non-pension cash-flows								1.91***		
								(3.55)		
Altman's *Z*-score									−0.007	
									(−0.87)	
Payout										0.72
										(1.00)
Observations	2,457	2,417	2,390	2,459	2,363	2,158	993	2,063	1,011	2,118
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents pooled probit regression estimates of the impact of different plan-level (rows (1)–(4)) and sponsor-level characteristics (rows (5)–(9)) on the probability that a sponsor is tax exposed. The dependent variable is Tax exposure, a dummy variable equal to 1 if the firm sponsors at least one plan with funding ratio below 150%. *Z*-statistics obtained using robust standard errors are in parentheses.

Table 6. Contributions, tax-based incentives, and the TCJA: robustness

	2014		2015		2016		2017		2018	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Tax exp.	0.021***	0.029***	0.020***	0.023***	0.026***	0.025**	0.034***	0.040***	0.010***	0.011***
	(5.46)	(4.93)	(11.71)	(4.97)	(9.61)	(3.21)	(11.07)	(3.33)	(9.53)	(3.98)
Obs.	530	150	503	140	483	128	471	142	430	134
R^2	0.02	0.24	0.04	0.10	0.03	0.14	0.03	0.12	0.04	0.07
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: This table presents regression estimates of the response of voluntary pension contributions to fiscal incentives in each year between 2014 and 2018. The dependent variable is voluntary pension contributions deducted from 2014 tax returns in columns (1) and (2); from 2015 returns in columns (3) and (4); from 2016 returns in columns (5) and (6); from 2017 returns in columns (7) and (8); and from 2018 returns in columns (9) and (10). Tax exposure is a dummy variable equal to 1 if the firm sponsors at least one plan with funding ratio below 150%. The TCJA reduced the federal corporate tax rate from 35% to 21% beginning in 2018. As a result, contributions counted towards the 2017 corporate tax return could be deducted at 35%, while contributions counted towards 2018 returns at 21%. Columns (2), (4), (5), (6), and (8) include the following plan-level controls: Funding ratio, PBGC premium, Return on investment, Discount rate. They also include the following sponsor-level controls: Altman's *Z*-score, Cash flows, CAPEX, Tobin's *Q*, Payout, and DB plans share. *t*-statistics obtained using robust standard errors are in parentheses.

Table 7. Contributions, tax-based incentives, and the TCJA: robustness

	2014		2015		2016		2017		2018	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Tax exp.	0.025***	0.34***	0.025***	0.22**	0.026*	0.30**	0.048**	0.53***	0.010**	0.15**
	(3.72)	(4.76)	(3.88)	(2.47)	(2.71)	(2.95)	(2.79)	(3.39)	(2.94)	(3.21)
Obs.	150	150	140	140	128	128	142	141	134	135
R^2	0.31	0.33	0.20	0.16	0.27	0.21	0.20	0.16	0.13	0.09
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	No	Yes	No	Yes	No	Yes	No	No	No

Notes: This table presents regression estimates of the response of pension contributions to fiscal incentives in each year between 2014 and 2018. The dependent variable is *voluntary* pension contributions deducted from 2014 returns in column (1); from 2015 returns in column (3); from 2016 returns in column (5); from 2017 returns in column (7); and from 2018 returns in column (9). The dependent variable is *total* pension contributions deducted from 2014 returns in column (2); from 2015 returns in column (4); from 2016 returns in column (6); from 2017 returns in column (8); and from 2018 returns in column (10). Tax exposure is a dummy variable equal to 1 if (i) a firm has a positive ex-contributions tax bill and (ii) the firm sponsors at least one plan with funding ratio below 150%. The TCJA reduced the federal corporate tax rate from 35% to 21% beginning in 2018. As a result, contributions counted towards the 2017 corporate tax return could be deducted at 35%, while contributions counted towards 2018 returns at 21%. All columns include the following plan-level controls: Funding ratio, PBGC premium, Investment return, Discount rate. They also include the following sponsor-level controls: Altman's Z-score, Cash flows, CAPEX, Tobin's *Q*, and DB plans share. *t*-statistics obtained using robust standard errors are in parentheses.

$\left(\hat{\beta}_{2017} - \sum_{t=2014}^{2016} \hat{\beta}_t/3\right) A_{2016}/100$, where $A_{2016} = \sum_{s=1}^{381} A_{s,2016}$ represents the total assets of the 381 tax-exposed sponsors in our sample at the end of 2016 (beginning of 2017). We obtain a \$1.3bn increase in voluntary contributions for the specification without controls and a \$2.3bn increase for the specification with controls. By assumption, the TCJA had no impact on contributions from the non-tax-exposed. Assuming that our sample is representative of the broader population of firms submitting Schedule SB of the IRS 5500 filings – some of which are not listed, and therefore do not appear in Compustat – we extrapolate to estimate the TCJA impact on the voluntary contributions of *all* sponsors of middle- and large-scale plans. To that end, we multiply the in-sample estimates by the ratio of total voluntary contributions by Schedule SB filers to total voluntary contributions by sponsors in our sample, which is equal to \$6.7bn/\$3.1bn. To compute the tax break impact on total contributions for firms in sample, we repeat the same steps using the estimates in Table 7 instead. This returns a \$15.3bn increase in voluntary contribution for the specification without controls and a \$37bn increase for the specification with controls. Total contributions by firms in our sample amount to \$50bn, while total contributions by Schedule SB filers are equal to \$107.7bn. This implies a \$33bn to \$79.7bn increase in total contributions to medium- and large-scale plans associated with the tax break.

4.3 The TCJA tax break and funding ratios

In this section, we study other effects of the TCJA tax break on firms and their DB retirement plans. We examine whether or not the tax break had an impact on funding ratios. We find that our results on contributions carry over to plan funding ratios.

Our estimates suggest that the TCJA tax break had a short-lived impact on plan funding. While the TCJA increased 2017 funding ratios, by 2018 they were already back where they would have been in the absence of the intervention. We estimate the following specification:

$$\Delta\text{Funding Ratio}_{s,t,t-1} = \alpha_t + \beta_t \text{Tax Exposure}_{s,t} + \delta_t Z_{s,t} + \varepsilon_{s,t}, \quad \text{for } t = 2017,\ 2018. \tag{10}$$

Here, Funding Ratio is defined as in Section 3.2.2 and Z_t is a vector of controls which includes pre-TCJA plan funding status (Funding Ratio in 2016), the actual investment return on plan assets and the change in discount rates between t and $t-1$. Results are reported in columns (1)–(4) of Table 8. Tax-exposed firms experienced an increase of 2.5–3.4 percentage points in the funding status of their corporate pension plans between 2016 and 2017 (relative to non-tax-exposed firms), depending on whether or not the specification includes controls. Firms that were tax exposed in both 2017

Table 8. Funding ratios and the TCJA

	ΔFR 16–17		ΔFR 17–18		ΔFR 16–18	
	(1)	(2)	(3)	(4)	(5)	(6)
Tax exposure in 2017	3.37***	2.49**	−1.11	−2.00*	1.47	−0.22
	(4.53)	(3.28)	(−1.19)	(−2.29)	(1.31)	(−0.20)
Observations	457	425	307	284	311	248
R^2	0.02	0.06	0.00	0.17	0.16	0.12
Controls	No	Yes	No	Yes	No	Yes

Notes: This table presents regression estimates of the response of pension contributions to fiscal incentives in each year between 2014 and 2018. The dependent variable is *voluntary* pension contributions deducted from 2014 returns in column (1); from 2015 returns in column (3); from 2016 returns in column (5); from 2017 returns in column (7); and from 2018 returns in column (9). The dependent variable is *total* pension contributions deducted from 2014 returns in column (2); from 2015 returns in column (4); from 2016 returns in column (6); from 2017 returns in column (8); and from 2018 returns in column (10). Tax Exposure is a dummy variable equal to 1 if (i) a firm has a positive ex-contributions tax bill and (ii) the firm sponsors at least one plan with funding ratio below 150%. The TCJA reduced the federal corporate tax rate from 35% to 21% beginning in 2018. As a result, contributions counted towards the 2017 corporate tax return could be deducted at 35%, while contributions counted towards 2018 returns at 21%. All columns include the following plan-level controls: Funding ratio, PBGC premium, Investment return, Discount rate. They also include the following sponsor-level controls: Altman's *Z*-score, Cash flows, CAPEX, Tobin's *Q*, and DB plans share. *t*-statistics obtained using robust standard errors are in parentheses.

and 2018 saw a relative decrease of 2 percentage points in the funding status of their corporate pension plans between 2017 and 2018. Columns (5) and (6) report the results of estimating a variant of (10) which considers the change in funding ratios between end-2016 and end-2018, again focusing on firms that were tax exposed in both 2017 and 2018. The coefficient of 2017 Tax Exposure is not significant, confirming that the temporary increase tax incentives for contributions associated with the TCJA had no long-lasting impact on funding ratios.

5. Conclusion

This paper contributes to the literature studying the effects of temporary fiscal stimulus on the corporate sector by documenting that sponsor contributions to retirement plans respond to tax-based incentives. We first develop a simple model to derive conditions under which temporary changes in tax-based incentives may result in permanent changes in contributions and plan funding. We then take these predictions to the data using the TCJA.

We use TCJA as a source of exogenous variation in tax-based incentives for contributions. The TCJA permanently lowered the federal corporate tax rate from 35 to 21 per cent beginning in 2018. In turn, this resulted in a temporary incentive for sponsors to raise contributions reported in 2017, as they could then be deducted from federal income tax bills at the older, higher tax rate. We identify firm response to the TCJA contributions tax break by exploiting cross-sectional variation in sponsors' exposure to tax-based incentives.

Our results support the conclusion that the policy change induced an intertemporal substitution of higher contributions today for lower contributions tomorrow, and therefore it did not permanently improve the funding status of U.S. private sector DB plans. We find that contributions and funding ratios increased – relative to what their levels would have been in the absence of the tax break – in 2017, the tax break year. That said, 2018 contributions and funding ratios fell relative to counterfactual levels. On balance, pension plan funding ended up where it would have been in the absence of the tax break by 2018.

Our results have implications for work on the incidence of corporate income taxes. In particular, ignoring 'uncertainty' effects on deferred compensation may lead to underestimating the incidence of corporate tax cuts on workers. Estimates of the share of the corporate tax burden passed on to workers focus on wages. Wages, however, are only one part of workers' compensation, with pensions being another. Our model indicates that a temporary increase in tax-based incentives for contributions could in principle result in a permanent improvement in funding, depending on the time profile of financial constraints. The ensuing decrease in retirement income uncertainty would thus improve workers' welfare. That said, we find no evidence for this effect in the case of TCJA.

Table 9. Variable definitions (plan-sponsor level)

Variable	Definition
Total contributions (plan)	Total sponsor contributions reported on tax return
Required contributions I	Contributions allocated towards unpaid MRC from prior years
Required contributions II	Contributions allocated towards MRC for the current year
Special contributions	Contributions made to avoid restrictions on benefits
Mandatory contributions	Required contributions (I + II) + Special contributions
Voluntary contributions (plan)	Total: mandatory contributions
Credit balances	Funding standard carryover balance + Pre-funding balance
Assets	Market value of plan assets at year end. Contributions not included
Safe assets	Sum of investment grade bonds, insurance contract and cash
Safe assets share (plan)	Safe assets/assets
Liabilities	Present value of plan benefits accumulated to year end
Return on investment (plan)	Investment income/(L1. assets – Total contributions)
Discount rate (plan)	Interest rate used to compute liabilities
Vested benefits	The share of liabilities that employees will receive regardless of their continued participation in the sponsor's pension plan
Participants	Number of plan participants
PBGC premium (plan)	Variable-rate benefits insurance premium = max[0, *R*(Vested Benefits-Assets)/1, 000], where *R* is variable-rate premium set by the PBGC according to the schedule in column (5) of Table 1

Table 10. Variable definitions (sponsor-level)

Variable	Definition
Aggregates of plan-level variables (IRS 5500 Filings)	
Voluntary contributions	Sum of voluntary contributions (plan) over sponsored plans
Total contributions	Sum of total contributions (plan) over sponsored plans
Funding ratio	Sum of (Assets + Total contributions – Credit balances) over sponsored plans/Sum of liabilities over sponsored plans
Return on investment	Assets-weighted average of Return on investment (plan), over sponsored plans
Discount rate	Liabilities-weighted average of Discount rates (plan), over sponsored plans
PBGC premium	Sum of PBGC premium (plan) over sponsored plans (Compustat)
Other sponsor-level variables	
Net Tax	Federal corporate income tax expense
Gross tax	Net Tax + τ × sum of Total contributions over sponsored plans. τ = 35% until 2017, 21% after
Tax exposure	A dummy variable =1 if Gross Tax >0 and Funding ratio <150% for at least one firm pension plan
Net income	Net income
Depreciation	Depreciation and amortisation
Pensions expense	The sum of the service cost and an interest cost (the change in the present discounted value of the pension obligations arising from the approach of the time when these obligations come due) minus an assumed return on pension plan assets (see Bergstresser *et al*., 2006)
Cash flows	Net income + Depreciation + Pensions expense + sum of total contributions over sponsored plans
CAPEX	Capital expenditures
Altman's *Z*	(3.3 × EBIT + Sales + 1.4 × Retained Earnings + 1.2 × Net Working Capital)/Operating Assets + Market Value of Equity/Total Liabilities
Tobin's *Q*	(Assets (book) + Equity (market) – Common Equity (book) – Deferred taxes)/Assets (book)
Employees	Current number of employees
DB plans share	Sum of Participants over sponsored plans/Employees
Payout	Purchase of Common and Preferred Stock + Dividends for Common Stock + Dividends for Preferred Stock

A corporate tax change could also affect workers' welfare through changes in expected pension benefits (which would be reflected in plan service costs and mandatory as opposed to voluntary contributions) rather than changes in uncertainty about those benefits. There is evidence that the TCJA corporate tax cut affected the current component of workers' compensation, with firms with greater

expected tax savings from the TCJA more likely to announce bonus payments to workers (Hanlon *et al.*, 2019). Whether similar findings also apply to deferred compensation is a question we leave to future research.

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Appendix A

Proof of claim 1

Conjecture that there exists an underfunded sponsor that must rely on external finance, $z_t < 0$ and $x_t < 0$ for $t = 0, 1, 2$. As a result, $R_x = r_{x,t}$ and $R_z = -z_t > 0$. Since the sponsor is underfunded, it must contribute more than the minimum requirement in each of these three periods, so $\lambda_t = 0$ for $t = 0, 1, 2$. Moreover, the sponsor pays a positive PBGC insurance premium, $q(z_t) = -\bar{q}z_t > 0$ for $t = 0, 1, 2$. The first-order condition for period-0 contributions (7) and the law of motion for plan surplus (1) then imply:

$$\begin{aligned}(1 + r_{x,0})(1 - \tau) =& \Lambda(1 - \tau(1 - \Delta))\bar{q}\mathbb{E}_0[(1 + r_{x,1})] \\ &- \Lambda r_z(z_0 + c_0 - s_0 + \mathbb{E}\%_0[\omega_0]).\end{aligned}$$

The left-hand side of this equation is the marginal cost of time-0 contributions, which does not depend on Δ. The right-hand side is the marginal benefit. The marginal benefit is decreasing in c_0 and increasing in Δ. As a result, contributions are increasing in Δ, $dc_0/d\Delta = ((1 + \mathbb{E}_0[r_1^x])\tau\bar{q})/(r_z\mathbb{E}_0[r_1^x]) > 0$. Because of the linear nature of the model and the separability of the finance costs function, $dc_0/d\Delta$ is equal to the partial derivative of the marginal benefit of contributions with respect to Δ.

Moving one period forward, we have:

$$\begin{aligned}(1 + r_{x,1})(1 - \tau(1 - \Delta)) =& \Lambda(1 - \tau(1 - \Delta))\bar{q}\mathbb{E}_1[1 + r_{x,2}] \\ &- \Lambda r_z(z_1(\Delta) + c_1 - s_1 + \mathbb{E}_1[\omega_1]),\end{aligned}$$

which emphasises that period 1 plan funding depends on Δ. Using the law of motion of plan surplus (1) to substitute out $z_1(\Delta)$, we have

$$\begin{aligned}(1 + r_{x,1})(1 - \tau(1 - \Delta)) =& \Lambda(1 - \tau(1 - \Delta))\bar{q}\mathbb{E}_1[1 + r_{x,2}] \\ &- \Lambda r_z(z_0 + c_0(\Delta) - s_0 + \omega_t + c_1 - s_1 + \mathbb{E}_1[\omega_1]).\end{aligned}$$

The left-hand side of this equation is the marginal cost of time-1 contributions, which is increasing in Δ. The right-hand side is the marginal benefit. The marginal benefit is decreasing in c_1. Δ affects the marginal benefit through two channels: directly, because of the PBGC premium term, and indirectly because plan funding is an increasing function of Δ. Letting μ_{r_x} denote the (constant) mean of the distribution of $r_{x,0}$, we can write:

$$\begin{aligned}\frac{dc_1}{d\Delta} =& \frac{\tau}{\Lambda r_z\mathbb{E}_1[r_{x,2}]}((\mathbb{E}_1[r_{x,2}] - r_{x,1}) - (1 + \mathbb{E}_1[r_{x,2}])(1 - \Lambda\bar{q})) \\ &- \frac{(1 + \mathbb{E}_0[r_{x,1}])\tau\bar{q}}{r_z\mathbb{E}_t[r_{x,1}\%]} \\ =& -\frac{1}{\Lambda}\frac{\tau}{\mu_{r_x}r_z}(1 + r_{x,1}) < 0.\end{aligned}$$

This is because $dc_0/d\Delta$ is equal to the partial derivative of the marginal benefit of contributions with respect to Δ, which is constant over time. As a result, the higher marginal cost dominates.

There remains to verify the conjecture above. Using the FOC for contributions (7) and the law of motion for plan surplus (1) we obtain that

$$z_1 = \omega_0 - \mathbb{E}_0[\omega_0] + \frac{(1+\mathbb{E}_0[r_{x,1}])(1-\tau(1-\Delta))\bar{q}}{r_z \mathbb{E}_0[r_{x,1}]} - \frac{1-\tau}{\Lambda r_z \mathbb{E}_0[r_{x,1}]}(1+r_{x,1}),$$

and

$$z_2 = \omega_1 - \mathbb{E}_1[\omega_1] + \frac{(1+\mathbb{E}_1[r_{x,2}])(1-\tau(1-\Delta))\bar{q}}{r_z \mathbb{E}_1[r_{x,2}]} - \frac{1-\tau(1-\Delta)}{\Lambda r_z \mathbb{E}_1[r_{x,2}]}(1+r_{x,1}).$$

These expressions show that the plan is underfunded when the funding shock is sufficiently below its mean and the sensitivity of external finance costs to cash flows is sufficiently above its mean. Let μ_ω denote the constant mean of the funding shock distribution. Provided that:

$$\frac{(1+\mu_{r_x})(1-\tau(1-\Delta))\bar{q}}{r_z \mu_{r_x}} - \frac{1-\tau(1-\Delta)}{r_z \mu_{r_x}}(1+\bar{r}) > 0, \tag{A.1}$$

there exists some $r_{x,1}$, $r_{x,2}$ that are sufficiently above their mean to ensure that z_1, $z_2 < 0$.

There remains to be verified that the sponsor is relying on external finance in all three periods, $x_t < 0$ for $t = 0, 1, 2$. By the definition of cash flows, (5), $x_t$decreases in contributions c_t for all $t = 0, 1, 2$. Since contributions in turn increase in the (contemporaneous) service cost for all $t = 0, 1, 2$, we can always find a level of s_t such that $x_t < 0$. This concludes the proof.

Proof of claim 2

By the proof of claim 1, the total response of contributions to the TCJA is given by

$$\frac{dc_0}{d\Delta} + \frac{dc_1}{d\Delta} = \frac{\tau}{\Lambda r_z \mathbb{E}_1[r_2^x]}((\mathbb{E}_1[r_2^x] - r_1^x) - (1+\mathbb{E}_1[r_2^x])(1-\Lambda\bar{q})) < 0 \quad \text{iff} \quad \frac{1+r_1^x}{1+\mathbb{E}_1[r_2^x]} > \Lambda\bar{q}.$$

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