THE RELATIONSHIP BETWEEN NON-DEBT AND DEBT TAX SHIELDS: AN EVIDENCE FROM THE TAX CUTS AND JOBS ACT

Keshav R. Bhattarai
University of Mississippi
kbhattarai@bus.olemiss.edu

Kathleen P. Fuller
University of Mississippi
kfuller@bus.olemiss.edu

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Abstract

We use the setting provided by the Tax Cuts and Jobs Act (TCJA) of 2017 to re-examine the relation between non-debt tax shield (NDTS) and firms' debt financing decisions. The TCJA brought significant changes to the corporate tax system, including reduced corporate tax rates and limited interest deductions and capital expensing, which reduced the tax benefits of debt. We hypothesize that firms with low marginal benefits of debt, especially those impacted by the interest deductibility limitation, will demonstrate a higher substitution effect between NDTS and debt financing. Employing a regression discontinuity design, we find that affected firms significantly reduce their reliance on debt financing when there is an increase in depreciation deduction, a proxy for NDTS. Furthermore, this effect is more pronounced for firms with lower effective tax rates.

Keywords: Capital Structure, Non-Debt Tax Shields, Debt Tax Shields, Tax Cuts and Jobs Act (TCJA), Interest Deductions, Regression Discontinuity Design

1. Introduction

Ever since Modigliani and Miller (1958), many studies have been conducted to identify the factors that impact a firm's capital structure. These studies have explored various factors including taxes, information asymmetry, financial distress costs, agency costs, and market strategies. One key factor shown to impact financing choices is taxes as the level of taxation impacts the interest tax shield companies receive in the United States (Graham, 2000; Heider and Ljungqvist, 2015). Another important tax-related consideration that can impact firms' financing choices is the non-debt tax shields (NDTS) such as depreciation deductions, investment tax credits, and research and development (R&D) credits. Since firms can substitute the tax benefits from the NDTS with the interest tax shield of debt (DeAngelo and Masulis, 1980), both play a vital role in a firm's financing decision.

Several studies have tested the tax hypothesis that there exists a substitution effect between debt tax-shields and NDTS, as proposed by DeAngelo and Masulis (1980), with mixed or occasionally inconclusive results. Some studies documented the evidence that supports the substitution effect between NDTS and debt (MacKie-Mason, 1990; Trezevant, 1992; Givoly et al., 1992; and Graham and Tucker, 2006), whereas others find inconclusive or no relation (Bardley et al., 1984; Dammon and Senbet, 1988; Titman and Wessels 1988; and Downs, 1993). However, the Tax Cuts and Jobs Act of 2017 (TCJA) provides a unique opportunity to reexamine DeAngelo and Masulis' predictions. The TCJA allowed firms to deduct 100 percent of qualified capital expenditure leading to a potential increase in the depreciation deductions of firms, thus reducing the value of the interest tax shields. Additionally, the TCJA limited interest deductibility for some firms. As a result, firms may place greater importance and value on NDTS relative to debt financing and the interest tax shield it provides. The recent tax reform allows us to examine the relationship more thoroughly between debt and NDTS, especially for firms with low marginal benefits of debt.

The TCJA made significant changes in the personal and corporate income tax systems. One of the most significant changes was the reduction of the statutory corporate income tax rate from 35 percent to 21 percent, which reduced the interest tax shield provided by debt for all firms. Moreover, the TCJA introduced new limits on the deductibility of interest. Interest deduction is now capped at 30 percent of earnings before net interest expenses, tax, depreciation, and amortization (EBITDA) and interest income, thus reducing the tax benefits of debt for those affected firms. Finally, the act introduced temporary capital expensing, which allows firms to fully deduct certain types of capital expenditure from their pre-tax income, effectively providing a bonus depreciation.[1] This provision should make debt less attractive for firms as their NDTS increase. As a result, debt has less value now, so firms, especially those affected by interest deduction rule, may utilize NDTS to make their financing decisions. These three changes of TCJA provide a unique opportunity to directly test the interplay between the tax advantages of NDTS and the firm's financing decisions.

Research by MacKie-Mason (1990) and Dhaliwal et al. (1992) suggests that the substitution effect is more relevant for firms facing a high probability of losing the tax benefits associated with their debt. This idea is supported by Trezevant (1992), who finds that firms with little or no tax payments (and thus a higher risk of losing the tax benefits of debt) tend to substitute NDTS with debt tax shields. With the new provision of interest deduction limitation, some firms automatically lose the deductibility of their tax shields, regardless of their effective

[1] The 100 percent bonus depreciation is set to drop by 20 percent at the end of 2022 until being completely phased out by 2027.

tax rate. Under the TCJA, even if a firm has sufficient taxable income to avoid tax exhaustion (where additional deductions do not lower taxable income), the 30 % limitation on interest deduction might prevent full utilization of interest deductions. Therefore, it can be expected that firms affected by this provision may rely on NDTS and substitute them for debt financing. Additionally, the temporary capital expensing provision may lead firms to increase their capital expenditures, which would further reduce the value of debt tax shields and increase the importance of NDTS. Overall, the TCJA provisions provide a unique setting to revisit the substitution effect between NDTS and debt tax shields, especially for firms with low marginal benefits of debt.

We focus on firms with low marginal benefits of debt that arise from low taxable profits and high deductible interest costs (Hanlon and Heitzman, 2022) to examine the relationship between NDTS and debt financing. Since the reduced corporate tax rate and interest deductibility limitations make the tax benefits of debt less attractive for these firms, we hypothesize that the substitution effect between NDTS and debt may be higher for these firms than the unaffected firms. In particular, we investigate how changes in depreciation deduction impact their capital structure in response to changes in the tax system.

Following Sanati (2023), we identify firms affected by limitation on interest deduction and conduct a regression discontinuity design (RDD) following the implementation of TCJA. RDD allows us to examine the substitution effects between depreciation deduction and debt tax shields for high-interest paying firms in a narrow bandwidth on both sides of the threshold and provide a causal impact of the changes in depreciation deduction on firms' debt financing resulting from the TCJA. We find that firms affected by the interest deduction limitation, compared to unaffected firms, reduce their debt financing when there is an increase in changes in depreciation deduction. Specifically, a one standard deviation increases in depreciation deduction results in a 11.05 percent reduction in firm leverage for the affected firms after the tax reform.

Further, we test whether firms with high depreciation deductions are reducing their debt financing after the TCJA. We observe that treated firms with low depreciation deductions choose not to adjust their debt financing after the enactment of TCJA, whereas firms with interest deductibility limitations and high depreciation deductions adjust their debt financing compared to the control group. Overall, these findings support DeAngelo and Masulis' (1980) hypothesis that firms substitute NDTS for debt financing.

We also explore the substitution effect (MacKie-Mason, 1990; Dhaliwal et al., 1992;and Trezevant,1992), by dividing our sample into two groups: firms with lower effective tax rates and firms with higher effective tax rates. We document that the substitution effect is applicable to firms with low effective tax rates; however, high tax-paying firms do not significantly alter their debt financing in response to increases in depreciation deductions. Overall, our analysis provides evidence consistent with MacKie-Mason (1990) and Trezevant (1992) that the substitution effect is particularly more relevant for firms that are near the tax exhaustion point or firms with a lower effective tax rate. However, treated firms with high effective tax rates may still have a stronger incentive to maintain their debt levels to preserve the tax benefits of debt.

We also conduct difference-in-differences (DID) analysis and confirm results estimated by the RDD mechanics are consistent. Additionally, we perform several robustness tests, including RDD estimates with different bandwidths and polynomial orders, as well as a falsification test using firms with 'low-interest' payments. All results are consistent across these various specifications.

Our study is related to Givoly et al. (1992) and Trezevant (1992. Givoly et al. (1992) find evidence of substitution effect between debt and NDTS following the Tax Reform of 1986. They also showed the influence of both corporate and personal taxes on firms' leverage ratios, indicating that taxes influence firms' financing choices. Trezevant (1992) examined the joint prediction of the substitution effect and tax exhaustion hypothesis utilizing the Economic Recovery Tax Act of 1981 (ERTA). He found support for the substitution effect and the tax exhaustion hypothesis, indicating that an increase in NDTS results in decrease in leverage.

Our paper is different from both papers in several ways. First our study focuses on the recent tax reform in the U.S. This reform not only changed the tax rate (unlike the Tax Reform of 1986) and altered capital expensing (similar to ETRA), but also introduced limitations to interest deductibility. Second, we account for the potential endogeneity issues by using RDD and difference-in-differences design surrounding TCJA and aim to provide causal inference on how changes in NDTS impact firms' financial leverage.

Our paper is also similar to Carrizosa, Gaerter, and Lynch (2023) and Sanati (2023). Carrizosa, Gaerter, and Lynch examine the impact of the limitation on interest deductions on the firm's leverage. By using a DID regression design, they found that firms affected by interest limitation decrease leverage after the TCJA. Sanati (2023) also utilized the same setting of TCJA to analyze the impact of tax benefits of debt firm's financing and real outcomes. By employing RDD around the average annual sales thresholds of above and below $25 million, Sanati documented that treated firms reduce the debt level, investment, and hiring. While these studies provided evidence that taxes affect capital structure, they did not consider the increased depreciation deduction after the TCJA's provision of bonus deprecation impact firms debt financing. By incorporating NDTS along with interest deductions, we show a richer and more comprehensive understanding of firms' financing choices.

2. Hypothesis Development

2.1 Non-debt Tax Shields and Debt Financing

Corporate financing decisions are complex and can be influenced by various factors such as changes in the corporate and personal tax structure. Prior studies have suggested that taxes can significantly impact on a firm's financing decision (Graham, 2000; Graham and Tucker, 2006; Heider and Ljungqvist, 2015). One of the important tax-related considerations that can impact firms' leverage is the NDTS, that is the reduction in taxable income that a firm can achieve through deductions, such as depreciation expenses, investment tax credit, or research and development credit. This tax benefit can play an important role in a firm's overall tax strategy and impact its financing decisions.

Prior studies have found mixed results about whether NDTS are important determinants of a company's capital structure. DeAngelo and Masulis (1980) developed an optimal capital structure model that considers the effects of corporate and personal taxes, as well as NDTS. They argue that the value of tax benefits from debt financing depends on the presence of NDTS, and that there is a substitution effect between NDTS and leverage. Furthermore, they suggest that firms have different optimal leverage decisions depending on their industry, and that as the ratio of NDTS-to-expected-cash-flow increases, the leverage should decrease. Consequently, companies with large NDTS tend to have less debt in their capital structure.

Numerous studies have sought to test the substitution effect between NDTS and leverage proposed by DeAngelo and Masulis (1980). Bradley et al. (1984) provided one of the early empirical tests by analyzing the impact of NDTS, as measured by depreciation plus investment tax created, on firm leverage. They showed a direct relationship between firm leverage and the amount of NDTS, contradicting the substitution hypothesis. Bradley et al. suggest that firms with more depreciation deduction and investment tax credits are likely to have more assets in place and fewer growth options. These securable assets can lead to higher debt ratios.

Dammon and Senbet (1988) extended the DeAngelo and Masulis (1980) capital structure model by incorporating firm's investment decisions. Dammon and Senbet showed that changes in tax codes may affect not only a firm's leverage but also its investment decision. As a result, changes in corporate tax codes that enhance investment-related tax shields may not necessarily result in a decrease in leverage. Titman and Wessels (1988) do not find a substitution between NDTS and leverage and argue that firms with high fixed assets can leverage those assets as collateral to raise their debt level.

Furthermore, Downs (1993) analyzed the association between NDTS and found that firms with significant NDTS tend to have higher leverage ratios, contradicting the substitution hypothesis. Downs asserted that companies with substantial cash flow generated from depreciation could use their assets as collateral, which increases the debt capacity. As a result, these firms with larger debt capacity can obtain financing at lower interest rates, consequently giving advantage to firms to maintain more debt in their capital structure. Overall, these studies show that a number of factors, including asset collateralization and firm investment decisions, influence the relationship between NDTS and leverage.

In contrast, Kim and Sorensen (1986) found that tax saving from depreciation deduction is negatively related to tax savings from debt, supporting DeAngelo and Masulis' (1980) substitution hypothesis. Similarly, MacKie-Mason (1990) examines the impact of tax shields on the choice between debt and equity, focusing primarily on firms near "tax exhaustion," where the risk of losing the ability to deduct their debt shields is high. Using investment tax credits and tax loss carryforwards to proxy for NDTS, MacKie-Mason finds that firms near tax exhaustion substitute the tax benefits of debt when NDTS are high.

Trezevant (1992) uses the Economic Recovery Tax Act of 1981 to examine the substitution effect and the tax exhaustion hypothesis, a scenario in which a firm with negative or lower taxable income may not be able to fully utilize its available tax deductions. To estimate the impact of tax shields, Trezevant divides firms based on their effective tax rates: those with a higher likelihood of losing tax deductibility or paying little or no taxes and those with a lower risk of losing the tax shield advantage. After controlling for debt securability, he finds that firms more likely to be tax exhausted have a negative relationship between NDTS and leverage. Givoly et al. (1992) use the Tax Reform Act of 1986 to analyze the relationship between leverage and certain tax-related variables. They also observe a substitution effect between debt and NDTS and asserted that both corporate and personal tax rates impact leverage decisions of firms. Further, Graham and Tucker (2006) utilize tax shelter deduction as a measure of NDTS and show the negative effect of NDTS on debt policy for firms with large NDTS, supporting the substitution hypothesis proposed by DeAngelo and Masulis (1980).

2.2 Tax Cuts and Jobs Act (TCJA) 2017 and Debt Financing

The TCJA significantly changed the United States' tax code. One significant change was the statutory corporate tax rate reduction from 35 percent to 21 percent. This tax rate reduction dramatically decreased interest tax shields for any firms that had debt in their capital structure. Another significant change in the TCJA limited interest deductions for certain firms. Prior to the TCJA, any firm could fully deduct their interest expenses before paying taxes. However, post

TCJA under Section 163(j) of the Internal Revenue Code, the deductible business interest expenses for a given tax year cannot exceed the sum of 1) a firm's business interest income for the tax year, 2) 30% of the firm's adjusted taxable income (ATI) for the taxable year [2], and 3) the firm's floor plan financing interest expenses for the tax year[3]. If the interest amount exceeds the given limit, firms can carry forward to subsequent years indefinitely, but the limitation of interest deductibility still applies. For any year up to and including 2021, the adjusted taxable income is calculated as the earnings before interest, taxes, depreciation, and amortization (EBITDA). However, after 2021, the adjusted taxable income is calculated as the earnings before interest and taxes (EBIT), thus further limiting the interest deductibility.

De Mooij and Hebous (2018) examine limiting interest deductibility using data from foreign countries. They examine firm-level data from 60 countries to explore the effectiveness of limitation in interest deductibility and find that the rule limiting the deductibility of all debts leads to a reduction in debt level. However, rules specifically targeting internal debt or internal interest payment do not have any impact on external debt. Moreover, they observe that the interest deduction limitations rule has a stronger effect on the debt ratios of industries with a higher proportion of tangible assets.

Recent research by Hanlon and Heitzman (2022) document that firms that disclose Section 163(j) exposure have lower profitability and marginal benefits of tax. Moreover, these firms face greater financial constraints and are more likely to delist for distress. They show that

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[2] The interest deduction limitations of TCJA do not apply to firms that have annual average gross sales of $25 million or less in the previous three years. The sales threshold will be adjusted for inflation, such that the cutoff for sales is $26 million from 2019 through 2021 and $27 million for 2022.

[3] The floor plan financing interest expense refers to the interest paid on loans used to acquire motor vehicles for sales or lease. This rule specifically applies to motor vehicle, which are not included in our sample. Therefore, we use the first two conditions mentioned above to determine the interest deduction limit.

financially unconstrained firms adjust their debt level downward in response to the new provision while high leverage firms, which initially carry a higher financial risk, reacted least to the rule. Hanlon and Heitzman argue that this seems to contradict the intended policy goal of the new interest deductibility rule, which aims to focus on high financial risk.

Carrizosa, Gaerter, and Lynch (2023) utilize the setting provided by the TCJA to examine the effect of interest deduction limitation on firms leverage. By using the DID regression design, they document that firms affected by the rule reduce their leverage as compared to unaffected firms. Similarly, Sanati (2023) uses another aspect of law that makes an exception for firms with average annual average sales of less than $25 million. By employing RDD, Sanati finds that affected firms just over the cutoff experience a reduction in debt level compared to those just below the threshold. However, affected firms did not change their equity financing compared to the unaffected firms and these firms also reduce investment activities and hiring practices. Overall, these studies highlight the effect of limiting interest deductibility in firms' response. However, they do not explicitly examine how firms with high NDTS are reacting to the new rule.

This tradeoff between NDTS and interest tax shields becomes more pronounced after the TCJA as the act allowed for investment expensing, or bonus depreciation. Firms could expense 100 percent of a business assets value, effectively obtaining all depreciation when purchase, so long as the assets useful life is 20 years or less. Though this bonus depreciation is scheduled to decrease by 20 percent at the end of 2022 and gradually phased out by 2027, firms may have significantly greater NDTS if they increase their investment in depreciable assets.

The goal of this provision in the TCJA was to encourage domestic investment as the depreciation deductions immediately lowered the capital costs of investment. Prior studies documented the relationship between depreciation deduction and firms' investment decisions.

For instance, Summers (1987) argues that the present value of depreciation deduction and investment tax credit affects the cost of capital, which in turns impacts the investment decision of firms. Zwick and Mahon (2017) specifically looked at the effect of bonus depreciation and found a positive effect of bonus depreciation on investment. This positive effect was larger for small firms and cash-poor firms. They also showed that when a policy generates immediate cash flows, firms react more strongly to it; however, when the cash flows are not immediate, the policy does not have the same effect.

If firms increase their investment due to the tax incentives of bonus depreciation, it may lead to higher depreciation expenses for firms and these additional depreciation expenses could, in turn, reduce the tax benefits of financing investment with debt (Hanon and Heitzman, 2022). As a result, firms may tradeoff between NDTS and debt-related tax shields. Hanon and Heitzman argue that losing the tax benefits of debt may not be a concern if firms' main priority is to raise funding for an investment and these firms prefer to generate those funds through debt, especially if the debt is short-term.

The bonus depreciation can also significantly impact how firms decide to fund their operations. Firms may be incentivized to rely more heavily on NDTS, such as depreciation deductions, to reduce their taxable income, and thus, debt financing becomes less appealing as the benefits of interest deductions are diminished. We hypothesize that the tax savings from NDTS offset the loss from interest tax shields. In particular, we plan to investigate how companies with high levels of NDTS and low marginal benefits of debt will adjust their capital structure in response to changes in the tax system.

3. Data and Empirical Strategy

3.1 Empirical strategy

To analyze the relationship between depreciation deduction and leverage and determine whether tax savings from depreciation deduction can offset tax loss from debt tax savings, we employ an RDD similar to Sanati (2023). As mentioned previously, the TCJA introduced the limitation on interest deductions. Under Section 163(j) of the Internal Revenue Code, firms are subject to this rule if their interest expenses exceed the sum of 30 percent of EBIDTA and interest income. As a result, firms with low interest expenses remain unaffected by the new tax code. Further, the TCJA created a clear discontinuity at $25 million threshold for 3-years average annual sales. Firms with annual average sales exceeding $25 million are affected by the interest deductibility limitations, whereas firms below this threshold face no restriction on interest deductions. Thus, we restrict our sample to high interest paying firms with three-year average annual sales falling within a narrow bandwidth around the $25 million threshold.

Following Sanati (2023), we use a local polynomial regression to estimate the heterogenous causal effects of interest deduction limitation on firms' leverage in response to changes in depreciation deduction. We utilize the log of sales as the running variable since sales are measured in millions of dollars. We estimate the following regression specification to capture the impact of changes in deprecation deduction on debt financing.

$$\Delta Debt\ Ratio_i = \alpha + \beta\ Treat_i + \gamma\ Treat_i \times \Delta DepD_i + \sum_{m=1}^{2} \phi_m^b (s_i - \bar{s})^m + \sum_{n=1}^{2} \phi_n^b\ Treat_i \times (s_i - \bar{s})^n + \sum_{p=1}^{2} \phi_p^c\ Treat_i \times \Delta DepD_i \times (s_i - \bar{s})^p + \eta \Delta X_i + \epsilon_i \qquad (1)$$

In equation (1) i indexes firms. The dependent variable is change in the two-year average debt ratio ($\Delta Debt\ Ratio_i$) measured from before to after the enactment of TCJA; that is, $\Delta Debt\ Ratio_i = Debt\ Ratio_{i,\frac{2018+2019}{2}} - Debt\ Ratio_{i,\frac{2016+2017}{2}}$. Following Trezevant (1992) and Sanati (2023), we define the change in depreciation deduction ($\Delta DepD_i$) as the average change after the TCJA minus the average change before the TCJA, that is, $\Delta DepD = \left(\frac{DepD_{2018}+DepD_{2019}}{2}\right) - \left(\frac{DepD_{2016}+DepD_{2017}}{2}\right)$. We utilize a two-year average change for debt and depreciation as Trezevant argues that firms may response to the investment incentives provided by the new tax rule over several years, depending upon economic environment, such as interest rates and anticipation about potential tax changes.

Treat is an indicator variable that takes the value of 1 for firms with average sales more than $25 million that are affected by limitation in interest deductibility, and zero otherwise. The variable ($s_i - \bar{s}$) is the distance from the sales threshold, where s_i is the log of annual average of three-year sales and $\bar{s}$ is logarithm of sales threshold (25). The coefficient of interest in equation (1) is the interaction term between $Treat_i$ and $\Delta DepD_i$.

To ensure the accuracy of our analysis, we have taken several measures to control for various factors (ΔX_i) that could impact our results. Specifically, we have accounted for firm size, profitability, tangibility, market-to-book ratio, research and development expenditure, net operating loss carry forward, and investment tax credit. Previous literature found that a firm's size and tangibility are positively related to leverage (Heider and Ljungqvist, 2015; and Titman and Wessels,1988). Since firms with substantial tangible assets can use these assets as collateral to borrow at the lower cost of capital, it encourages firms to acquire more debt; thus, high tangibility should have a positive impact on firms' leverage. Finally, to control for the correlation within firms, we cluster standard errors at the firm level[4].

Equation (1) uses second-order polynomial and coverage error-rate (CER) optimal bandwidths, as provided by Calonico, Cattaneo, and Titiunik (2014)[5]. Our identification strategy relies on creating a sudden change in the tax benefits of debt. Firms could not have predicted this change because the exception rule did not exist in previous reform proposal, and there were no discussions about repealing and replacing the tax law during the post-reform years (Sanati, 2023). Thus, our estimates are unlikely to be biased by expectations about the deductibility of interest limitation.

3.2 Data

We gather annual firm-level data from Compustat from 2014 to 2019[6] for all publicly traded firms that are incorporated in the U.S. Following Heider and Ljungqvist (2015), we drop firms in regulated utility (SIC 4900-4999; 377 observations), financial firms (SIC 6000-6799; 1,809 observations), public sector entities (SIC 9000-9999; 30 observations). We also drop firms in agriculture (SIC 0100-0999; 26 observations) industries since that are exempt from Section 163(j) limitation on interest deductions, as well as motor vehicle dealers (SIC 5511-5521 and 5551-5599; 0 observations) to eliminate the effect of floor plan financing on Section 163(j) limitation. We exclude firms with unavailable total assets, negative equity[7], and missing values

[4] All results remain similar when we cluster standard errors at the SIC level.

[5] We used different bandwidths as well as used the mean squared error (MSE) for optimal bandwidths as provided by Imbens and Kalyanaraman (2012). Results are qualitatively similar and reported in the robustness section.

[6] Since our outcome variable, change in leverage, and key independent variable, change in depreciation deduction, are calculated as the average change after the TCJA minus the average change before the TCJA, our sample includes the period from 2016 to 2019. However, the discontinuity threshold is based on a three-year average of sales, so we require firm-level data since 2014.

[7] If we include all observations, the results remain quantitatively similar. Since the analysis focuses on high-interest-paying firms, some firms have an excessively high debt ratio, and including those firms impacts the coefficient

of three-year average sales. Finally, we exclude firms with interest expenses is less than the sum of 30 percent of EBITDA and interest income (0.30 × EBITDA + interest income[8]). All the firm-level financial variables are winsorized at the top 1 percent and the bottom 1 percent to reduce the effects of outliers.

As mentioned before, we use the CER optimal bandwidth around the sales threshold in our baseline model to obtain accurate and valid casual estimates of the treatment effect. We compute the covariate-adjusted CER optimal bandwidth[9] and find a value of 1.345. The CER optimal bandwidth of 1.345 provides a sample of firms with a three-year average sales range spanning from $6.64 million to $92.67 million.

[Insert Table 1 here]

Table 1 reports the summary statistics for firm-level variables used in this analysis. Panel A reports the firm-level variables of treated and control groups. As expected, the treated firms have higher average sales compared to the control group, whereas all other firm characteristics variable are similar between those groups. Notably, both the treated and control groups show a negative average ROA over the sample period. It is essential to consider that firms may have an option to forward disallowed interest indefinitely under the new tax rule, suggesting that the negative profitability does not entirely eliminate the tax benefits of debt (Sanati, 2023).

4. Validity of the Regression Discontinuity Design (RDD)

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magnitude but not the direction of the results. To deal with these outliers, we remove firms with negative equity or total debt greater than 1.

[8] If any observations have missing interest income, we assign a value of zero. However, the results remain consistent even if we exclude these observations.

[9] We use the '*rdbwselect*' function from Stata to compute the CER optimal bandwidth. In our robustness test, we also compute covariate-adjusted CER optimal bandwidth, and all results are consistent with the baseline model.

The key identification assumption in an RDD is the continuity assumption, which states that the outcome of firms below and above the threshold would be similar without the treatment. To test the local continuity assumption, we conduct two tests; first we examine whether firms are manipulating the assignment variable near the cutoff, and second, we examine the discontinuity in pre-tax reform firm characteristics. To test whether manipulation is occurring at the cutoff, we examine the distribution of running variable after the TCJA for high-interest firms.

[Insert Figure 1 Here]

Figure 1 reports the distribution of log of three-year average sales around the cutoff after the TCJA enactment. The figure shows there is not a bunching of running variables at either side of the sales threshold. The evidence does not support the notion of firms manipulating their sales to qualify for exemption from the limitation on interest deductions. Furthermore, since the rule of interest deduction limitation was not part of the earlier proposal (U.S. House, 2016), it is unlikely that firms were aware of the gross receipt test for interest deduction limitation well before the final bill's approval (Sanati, 2023). Moreover, whether firms are affected or not depends on their annual average gross receipts (sales) over the past three years, thus making it more difficult for firms to manipulate the assignment variable even if they were aware of the interest deductibility threshold before the passing of TCJA.

Next, to investigate whether there is a discontinuity at the sales cutoff threshold (log of average sales of $3.219), we conduct manipulation test as introduced by McCrary (2008). We utilize the procedures outlined by Cattaneo, Jansson, and Ma (2020), which involve local polynomial density estimators. The results of this analysis are presented in Figure 2. The solid line represents the fitted density, with the shaded region indicating a 95% confidence interval. The T-statistic for the discontinuity in the density at the cutoff point is 1.1754, with a p-value of

0.2398. Therefore, the results show that there is no statistically significant evidence of manipulation in the running variable (log of average sales) around the cutoff point (3.219). This means that our results provide no evidence of manipulation by firms in their reported sales.

[Insert Figure 2 here]

In order to further validate the local continuity assumption, we plot pre-TCJA firm-level variables using the "*rdplot*" function in Stata and examine whether firms just above and below the cutoff points are similar in all respects. Figure 3 displays the RDD plots for firm-level variables, such as firm size, depreciation deduction, market-to-book ratio, debt ratio, profitability, tangibility, investment tax credit, and research & development expenditure. These plots sort observations into distinct non-overlapping bins based on the log of average sales over the sample period. In each graph, the circles represent bin averages and solid lines display second-order polynomial fits on either side of the sales cutoff. All of these plots appear to exhibit similarity on both sides of the cutoff points.

[Insert Figure 3 here]

Moreover, to examine the pre-reform firm level characteristics, we estimate the following equation by using each firm-level variable as the outcome variable to check whether these variables are continuous at the cutoff.

$$\Delta Y_i = \alpha + \beta\, Treat_i + \sum_{m=1}^{2} \phi_m^b\, (s_i - \bar{s})^m + \sum_{n=1}^{2} \phi_p^c\, Treat_i \times (s_i - \bar{s})^n + \epsilon_i \qquad (2)$$

The results are reported in Table 2. Notably, the treatment variable (*Treat*$_i$) is insignificant for each of these variables. This suggests that all variables are continuous at the cutoff, implying that the cutoff is arbitrary. Furthermore, firms exhibit comparable underlying characteristics and leverage ratios on both sides of the cutoff before the enactment of the TCJA.

[Insert Table 2 here]

5. Empirical Results

5.1.1 Interest tax deduction, changes in depreciation deduction, and firm leverage

Table 3 presents the results using RDD analysis to estimate equation (1) and examine how the changes in depreciation deduction affect firm leverage for firms with low marginal benefits of debt following the enactment of TCJA. Panel A reports the results for the full sample. We utilize two measures of leverage as the dependent variable: the long-term debt ratio (Columns 1 and 2) and the total debt ratio, which includes both short-term and long-term components of debt (Columns 3 and 4). As mentioned previously, we use the covariate adjusted CER optimal bandwidth of 1.345 and compare firms just below and above the sales threshold. Columns (1) and (3) report RDD estimates without control variables, while Columns (2) and (4) present the RDD estimates with relevant firm characteristics for the full sample.

[Insert Table 3 here]

The RDD estimates in Column 1 indicate a negative and significant interaction term of changes in depreciation deductions and treatment variables. This result suggests that treated firms reduce their long-term debt ratio when there are increases in the depreciation deductions after the TCJA enactment. The results in column 2 present the RDD estimates with firm characteristics, and the coefficient of the interaction term between treated firms and changes in depreciation deductions is negative and statistically significant at the 1 percent level. This suggests that including the covariates in the RDD model does not significantly change the estimates. Moreover, when we include both short-term and long-term components of debt in column 3 and 4, the RDD estimate for the interaction terms is negative and significant at the 5 percent level. The interaction term $\Delta DepD \times Treat$ consistently shows a significant negative effect on both measure of debt ratio across all specifications. These results suggest that firms affected by interest deduction limitation are substituting their debt financing with NDTS. Overall, these results support the substitution hypothesis proposed by DeAngelo and Masulis (1980. In particular, the findings indicate that treated firms experiencing a one standard deviation increase in depreciation deductions following the tax reform decreased their long-term debt ratio by 11.05 percentage points.

Next, to explore the substitution effect identified by MacKie-Mason (1990) and Trezevant (1992) – the significant substitution effect between debt and non-debt tax shields for firms with a high chance of losing the ability to deduct their tax shields – we divide the sample into low and high tax bracket groups based on their effective tax rates. We categorize firms as low taxpayers if their effective tax rate is at or below the 50th percentile, and as high taxpayers if their effective tax rate is above the 50th percentile[10]. Using these subsamples, we estimate equation (1) again and report the results in Panel B of Table 1.

Columns 1 and 2 of Panel B report the RDD estimates for firms with low effective tax rates. The coefficient of the interaction term $\Delta DepD \times Treat$ shows a statistically significant negative effect on both measures of the debt ratio. This indicates that low tax-paying firms

[10] As previously mentioned, the sample firms, on average, are unprofitable, and the effective tax rate is also lower for these firms, averaging around 3 percent, with the 75th percentile being about 0.02 percent. In the un-tabulated results, we classify high taxpayer firms if their effective tax rate is in the top quartile, and the remaining firms as low taxpayers. The DID estimates yield similar results. Additionally, we categorize firms as low taxpayer firms based on their pre-TCJA effective tax status and find quantitatively similar results.

experiencing an increase in depreciation deductions reduce their debt ratios. These findings align with the results documented by MacKie-Mason (1990) and Trezevant (1992).In contrast, the results for firms with high effective tax rates (Columns 3 and 4) do not indicate a significant substitution effect. The coefficients of the interaction term are positive and not statistically significant, suggesting that high tax-paying firms do not significantly alter their debt in response to increases in depreciation deductions. Overall, our analysis provides evidence consistent with MacKie-Mason (1990) and Trezevant (1992) that firms more likely to lose their ability to deduct their tax shields demonstrate a significant substitution effect.

5.1.2 Interest tax deduction, high vs low depreciation deduction, and firm leverage

Next, we conduct a test to determine whether firms with high and low depreciation deductions are decreasing their debt financing after the TCJA. To perform this analysis, we sort the sample firms based on their depreciation deductions and create a dummy variable, High-DepD, which takes the value of 1 if firms fall into the top quartile, and 0 otherwise. Similarly, we generate another indicator variable, Low-DepD, which takes the value of 1 for firms in the lowest quartile of depreciation deduction and 0 otherwise. We then estimate equation (1) using RDD with the CER optimal bandwidth of 1.345, and the results are presented in Table 4.

[Insert Table 4 here]

Columns 1, 2, and 3 (4, 5, and 6) present the results for firms with high (low) depreciation deductions. The dependent variable is the change in the long-term debt ratio. The coefficient of the interaction term, *High-DepD×Treat*, is statistically significant and negative for the full sample (Column 1) and low taxpayer groups (Column 2), with coefficients of -0.376 and -0.475, respectively. This suggests that firms with high depreciation deductions are reducing their debt financing following the TCJA, further supporting the substitution hypothesis. The interaction term is again not significant for the high taxpayer group. The RDD estimates from columns 4, 5, and 6 show an insignificant interaction coefficient. This indicates that firms with low depreciation deductions are not reducing their debt financing after the TCJA.

5.2 Robustness Section

5.2.1 Robustness of the RDD: Alternative optimal bandwidth and polynomial orders

In this section, we re-estimate equation (1) using RDD with various optimal bandwidth and polynomial orders to further validate our main findings, as suggested by Roberts and Whited (2013), and report our findings in Table 5.

[Insert Table 5 here]

We use the mean squared error (MSE) optimal bandwidth in Column (1), a random bandwidth of 2.0 in Column (2), and covariates adjusted bandwidth of 1.009 in Column (3). The RDD estimates of the interaction terms in all three columns are negative and statistically significant. The results indicate that using either a higher or smaller bandwidth does not change the main results that NTDS are substituted for interest tax deductions. Moreover, Columns (4) and (5) report the RDD estimates using the first-order and third-order polynomial terms, respectively, and the coefficients again are negative and highly significant. These results provide evidence that the main findings are robust when using different optimal bandwidths and polynomial orders.

5.2.2 Interest tax deduction, non-debt tax shield, and firm leverage

In this section, we examine the substitution effect between non-debt and debt financing using additional measures of NDTS. Specifically, we use the sum of depreciation deductions and investment tax credits divided by total assets. We employ a covariate-adjusted CER with an optional bandwidth of 1.299 and estimate Equation 1 and present the results in Table 6.

[Insert Table 6 here]

Columns 1, 2, and 3 report results for the long-term debt ratio, while columns 4, 5, and 6 report estimates for the total debt ratio. The interaction term between NDTS and the treatment variable (*Treat*) is negative and significant for the full sample and the subsample of low-tax payer firms, across both measures of debt ratio. However, firms with higher effective tax rate show no relationship between non-debt tax shield and debt financing. These results further support our main findings, indicating that firms affected by interest deduction limitations reduce their reliance on debt financing when non-debt tax shields increase.

5.2.3 Falsification Test

In this section, we investigate whether firms unaffected by the interest deduction limitation exhibit a significant relationship between NDTS and debt financing. This analysis serves as a validation of our RDD model, allowing us to assess whether the observed relationship between non-debt tax shields and debt financing is indeed driven by the interest deduction limitation, rather than other underlying factors. In this analysis, we focus on firms with interest expenses less than or equal to interest income plus 30 percent of EBITDA, referred to as "low-interest" firms. These firms are not subject to Section 163(j) limitation on interest deduction. We construct an indicator variable "pseudo-treat" that takes the value of 1 if 3-year average sales is exceed the $25 million sales threshold, and zero otherwise. We then estimate the equation (1) using this pseudo-treatment indicator and report RDD estimates in Table 7.

[Insert Table 7 here]

Table 7 reports the RDD estimates using a bandwidth of 1.345 around the sales cutoff of \$25 million (log of 25), which is the optimal bandwidth used in our baseline analyses[11]. Columns 1 and 2 presents estimates for the full sample (and Columns 3 through 6 present the estimates for the subsample analyses: low effective tax rate (Columns 3 and 4) and high effective tax rate (Columns 5 and 6). Notably, the interaction term between the pseudo-treatment indicator and depreciation deductions (*Pseudo-Treat* × *DepD*) yields insignificant coefficients across all columns. These findings indicate that no discernible treatment effect is present in this sample. This suggests that the relationship between non-debt tax shields and debt financing does not exhibit a significant discontinuity around the \$25 million threshold.

5.2.4 Alternative Setup: Difference-in-Differences

Sanati (2023) argues that the allocation of treatment and control groups in this study is non-random and depends on the firm's average sales. As a result, the preferred empirical methodology for identifying and analyzing the treatment effect is the RDD. In this section, we also employ the difference-in-differences (DID) framework to confirm that the primary results are not influenced by the RDD mechanics. We estimate the following DID model to measure the substitution effect between depreciation deduction and debt financing:

$$\Delta Lev_{i,t} = \beta_0 + \beta_1 Treat_i + \beta_2 Post_t + \beta_3 Treat_i * Post_t + \beta_4 \Delta DepD_{i,t} + \beta_5 Treat_{i,t} * \Delta DepD_{i,t} + \beta_6 Post_t * \Delta DepD_{i,t} + \beta_7 Treat_{i,t} * Post_t * \Delta DepD_{i,t} + X_{i,t-1} + \mu_{ind} + \epsilon_{i,t} \quad (3)$$

[11] The optimal bandwidth for this sample is 0.330, which creates a low sample size (17) around the sales cutoff, so we do not present the results here. However, when you run the regression with MSE bandwidth of 1.812 used in baseline analysis and some randomly chosen bandwidth, all results are consistent.

where i indexes firms and t indexes fiscal year. The dependent variable (ΔLev) in equation (3) is the annual change in the leverage ($Lev_t - Lev_{t-1}$)[12], instead of average change from before to after TCJA. All other variables are as previously defined. The variable $\Delta DepD$ is the one-year change in the depreciation deduction ($DepD_t - DepD_{t-1}$), where depreciation deduction is measured as total depreciation and amortization over total assets. We are primarily interested in examining how the changes in depreciation deduction ($\Delta DepD$) interacts with *Treat,* the indicator for affected firms and *Post*, a binary variable that equals 1 for fiscal years starting in 2018 and later and 0 otherwise. *X* includes firm size, profitability, tangibility, market-to-book ratio, investment tax credit, and net operating loss carry forward to ensure we control for other factors that impact changes in leverage. Finally, to mitigate the impact of industry-specific regulations and characteristics on these firms or within the variation in firm level, we use industry-year fixed effects or firm fixed effects and cluster standard errors at the firm level. Table 8 presents the findings of this analysis.

[Insert Table 8 here]

Columns (1) and (2) report the estimates of the DID analysis for the full sample. Columns (3) and (4) present results for firms with low effective tax rates, and Columns (5) and (6) show results for firms with high effective tax rates. Columns (1), (3), and (5) present results using firm fixed effects, while Columns (2), (4), and (6) report results using industry-year fixed effects. For the full sample, the regression coefficient in Column (1) indicates that the interaction terms among changes in depreciation deductions, the treatment variable, and the post-treatment period are negative but statistically insignificant. However, Column (2) shows that the interaction term

[12] Leverage is calculated as long-term debt (DLTT) divided by total assets (AT). For brevity, we only present the results for the long-term debt ratio; however, the results are quantitatively similar when using the total debt ratio.

is negative and significant at the 10 percent level. These results provide some evidence of a substitution effect between non-debt tax shields and debt financing for treated firms. However, when we select our sample around the sales cutoff (3-year average sales of less than 50 million) in Columns 7 and 8, the coefficient of the interaction term becomes negative and highly significant in both specifications.[13]

The results in Column (3) and (4) demonstrate that the interaction term is negative and statistically significant at the 1 percent levels, respectively. This suggests that firms with lower effective tax rates are substituting debt tax shields with depreciation deductions. In particular, treated firms experience a 2.90 percent reduction in firm leverage with a one standard deviation increase in the change in depreciation deduction. However, the regression estimates from columns (4) and (5) indicate that high taxpayers are not using depreciation deductions to offset losses from the debt tax shields. These results again support the findings documented in MacKie-Mason (1990) and Trezevant (1992). Overall, Table 8 results confirm that regression coefficients derived from the DID model are consistent with the results obtained from the baseline RDD analysis.

6. Conclusions

The TCJA was one of the most significant changes to firms' taxes since the Tax Reform Act of 1986 and was intended to reduce the tax burden on businesses to encourage investment. In addition to reducing tax rates, and thus reducing the interest tax shield of debt, the TCJA also reduced firms eligible for the interest tax shield. Thus, the TCJA provided a novel experiment to

[13] This selection is random and is made to ensure that the treated and control firm groups are similar in size. However, if we alternatively select samples based on a 3-year average sales of less than 100 million or 40 million, the results remain similar.

see if firms substituted NDTS for lost interest tax shield (the substitution hypothesis proposed by DeAngelo and Masulis,1980). We find that indeed affected by the interest deduction provision significantly reduced their debt financing in response to increases in NDTS. Furthermore, we find that firms with a higher risk of losing the deductibility of tax shields substitute their debt-related tax shields with changes in depreciation deductions following the TCJA, supporting the findings of MacKie-Mason (1990) and Trezevant (1992). Additionally, we observe that firms affected by the interest deductibility limitation and those with high depreciation deductions adjust their debt financing more effectively, whereas firms with low depreciation deductions choose not to adjust their debt financing after the TCJA's enactment. We show that the TCJA's provisions, particularly the limitation on interest deductibility and the introduction of temporary capital expenses, have significantly influenced firms' financing decisions. Overall, our findings further establish that taxes and changes in tax policy play a fundamental role in shaping corporate financial policies.

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Figure 1: Sample distribution around the assignment cutoff

The figure illustrates the distribution of the sample firms around the assignment cutoff points. The figure allows us to observe any potential discontinuities around the cutoff point of log(25)= 3.219.

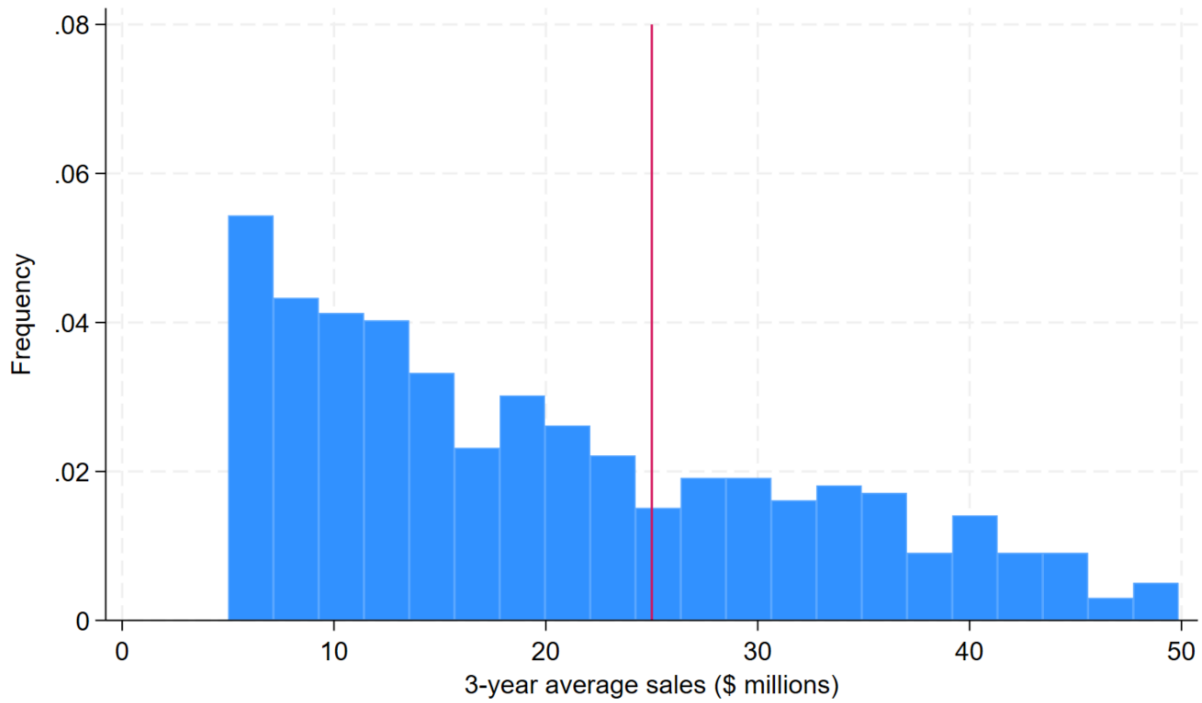

Figure 2: McCrary's Test of Discontinuity

The graph shows the results of the density test of McCrary (2008) in the baseline sample. The text utilizes the RD Manipulation test using local polynomial density estimation.

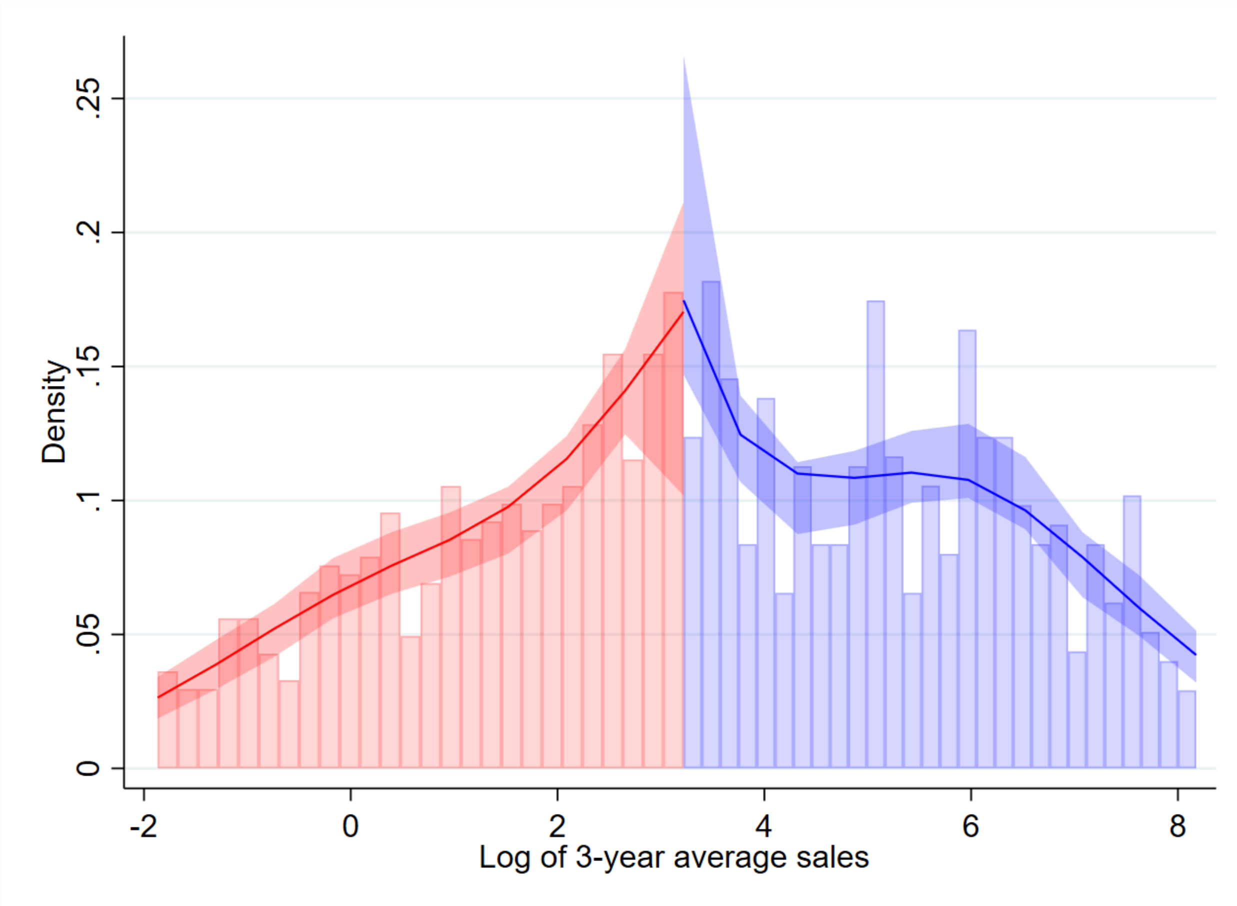

Figure 3: Discontinuity in pre-TCJA firm characteristics

The graph illustrates regression discontinuity plots representing pre-TCJA firm characteristics within the baseline sample. Data points are grouped into distinct, non-overlapping categories based on the logarithm of average annual sales (shown on the horizontal axis) during the sample period. Each circle denotes the average value of the corresponding bin, while solid lines represent the second-order polynomial fit on both sides of the cutoff.

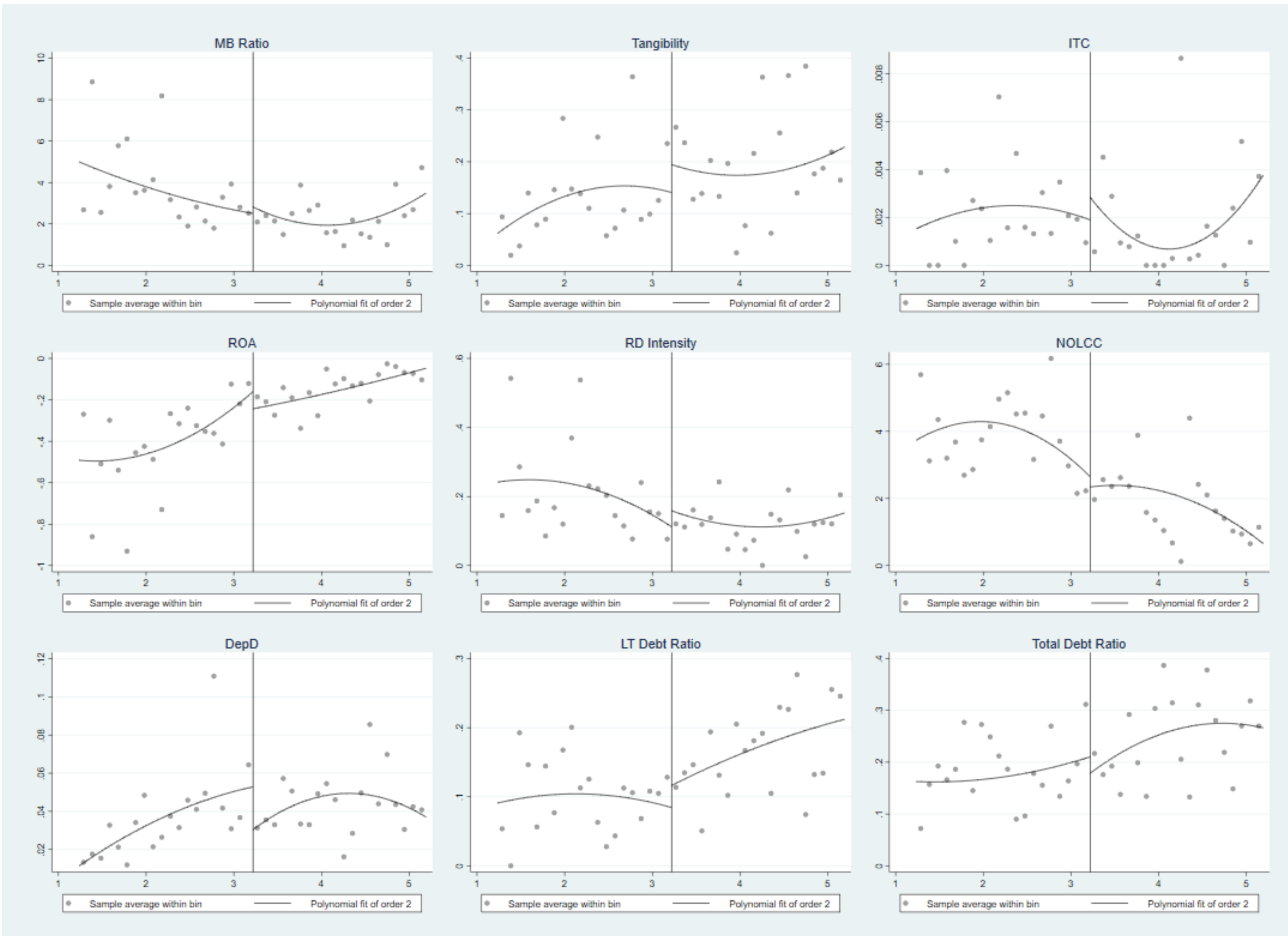

Table 1: Summary statistics

The table presents summary statistics for key variables used in this study. The sample consists of U.S. firms that are non-financing and non-utility, with three-year average annual sales ranging from $6.94 million to $87.68 million. The lower and upper bounds are determined using CER optimal bandwidth. The sample covers available data from fiscal years 2016 through 2019. The top panel shows the summary statistics of firm characteristics, while the bottom panel displays the outcome variables, which represent the change from the period prior to the period after TCJA. To address outliers, all firm-level variables are winsorized at the 1st and 99th percentiles. For detailed variable definitions and information on their construction, please refer to Appendix 1.

Bandwidth around log(25)	1.345 (Left sides)				1.345 (Right sides)			
Range of Avg. Sales	[6.64, 24.984]				[25.295, 92.672]			
Variables	N	Mean	Std. Dev.	Median	N	Mean	Std. Dev.	Median
	Control				Treated			
LTD Ratio	281	0.122	0.185	0.039	248	0.174	0.200	0.108
Total Debt Ratio	281	0.205	0.211	0.147	248	0.267	0.239	0.222
3-year avg. sales ($ mil.)	281	14.495	5.267	13.650	248	49.438	19.845	42.493
Size	281	3.549	1.266	3.276	248	4.371	1.061	4.341
ETR	281	0.022	0.217	0.000	248	-0.009	0.317	0.000
ROA	281	-0.362	0.336	-0.295	248	-0.226	0.252	-0.150
MB Ratio	281	2.770	2.381	2.083	248	2.291	1.769	1.665
Tangibility	281	0.155	0.189	0.080	248	0.181	0.225	0.098
DepD	281	0.041	0.042	0.031	248	0.041	0.042	0.028
RD Intensity	281	0.189	0.213	0.130	248	0.139	0.196	0.053
ITC	281	0.002	0.006	0.000	248	0.002	0.006	0.000
NOLCC	281	4.162	4.127	2.766	248	2.640	3.001	1.707

Outcome Variables	Control				Treated			
	N	Mean	Std. Dev.	Median	N	Mean	Std. Dev.	Median
ΔLTD Ratio	73	0.061	0.156	0.021	63	0.027	0.199	0.020
ΔTotal Debt Ratio	73	0.053	0.188	0.016	63	0.054	0.200	0.054
ΔDepD	73	-0.004	0.029	0.001	63	0.0002	0.022	0.000
ΔSize	73	0.119	0.643	0.051	63	0.066	0.542	0.040
ΔROA	73	-0.004	0.367	-0.024	63	0.020	0.286	0.005
ΔMB Ratio	73	-0.572	1.787	-0.353	63	-0.359	1.939	-0.063
ΔTangibility	73	0.029	0.088	0.019	63	0.018	0.080	0.011
ΔRD Intensity	73	-0.009	0.111	0.000	63	-0.022	0.133	0.000
ΔNOLCC	73	0.818	4.705	0.244	63	0.381	1.819	0.200

Table 2: Discontinuity in pre-TCJA firm characteristics

The table presents an RDD estimate to test the discontinuity assumptions of RDD. Firm level variables are used as outcome variables, and the RDD model (Equation 2) is run for the period before the enactment of TCJA. Appendix A provides definitions for the variable used. Standard errors are calculated allowing for clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

Pre-TCJA Characteristics	Coefficient	Standard error	Observations	R-squared	Optimal bandwidth
Size	-0.046	(0.370)	259	0.185	1.376
DepD	-0.019	(0.018)	214	0.029	1.133
NDTS	-0.018	(0.017)	240	0.023	1.254
ROA	-0.009	(0.083)	220	0.098	1.147
MB Ratio	-1.211	(0.760)	250	0.054	1.318
RD Exp.	0.008	(0.066)	231	0.086	1.21
Tangibility	0.073	(0.089)	228	0.019	1.203
ITC	0.002	(0.002)	224	0.019	1.180
NOLCC	0.752	(0.975)	233	0.107	1.215
LT Debt Ratio	-0.041	(0.052)	220	0.043	1.153
Total Debt Ratio	-0.068	(0.084)	312	0.033	1.724

Table 3: Impact of changes in depreciation deduction on firm debt financing

The table presents the results of an RDD analysis to analyze the impact of changes in depreciation deduction on the firm's debt financing. The dependent variable change in long-term debt ratio in Columns 1 and 2, debt ratio in Columns 3 and 4, and short-term debt ratio in Columns 5 and 6. The outcome variable is calculated as change in firm leverage before to after the TCJA, that is, $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$ .The coefficients are presented with robust standard errors in parentheses, and standard errors are calculated allowing for clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

Panel A: RDD estimates for full sample

VARIABLES	Full Sample			
	ΔLTD Ratio		ΔTotal Debt Ratio	
	(1)	(2)	(3)	(4)
ΔDepD*Treat	-12.137***	-11.054***	-9.861**	-8.452**
	(3.419)	(3.454)	(3.853)	(4.070)
Treated	0.026	0.026	0.100	0.106
	(0.059)	(0.058)	(0.076)	(0.073)
ΔDepD	2.618**	1.509	4.644**	3.481
	(1.305)	(1.776)	(2.144)	(2.892)
ΔSize		-0.027		0.003
		(0.033)		(0.053)
ΔROA		-0.030		-0.057
		(0.063)		(0.083)
ΔTangibility		0.167		0.343
		(0.181)		(0.367)
ΔMB Ratio		0.004		0.012
		(0.012)		(0.015)
ΔR&D Intensity		-0.106		-0.092
		(0.148)		(0.166)
ΔITC		1.389		2.996
		(6.557)		(6.178)
ΔNOLCC		-0.002		-0.003
		(0.004)		(0.006)
Constant	-0.014	-0.013	-0.045	-0.041
	(0.028)	(0.029)	(0.039)	(0.041)
Polynomial terms	Yes	Yes	Yes	Yes
Optimal bandwidth	1.345			
No. of firms	136	136	136	136
R-squared	0.158	0.177	0.095	0.134
Cluster by firms	Yes	Yes	Yes	Yes

Table 3 (continued)
Panel B: RDD estimates for sub-sample

VARIABLES	Low Tax Payer		High Tax Payer	
	ΔLTD Ratio	ΔTotal Debt Ratio	ΔLTD Ratio	ΔTotal Debt Ratio
	(5)	(6)	(7)	(8)
ΔDepD*Treat	-10.985**	-8.852*	3.605	9.193
	(4.213)	(5.285)	(10.156)	(10.631)
Treated	0.018	0.109	0.111	0.086
	(0.072)	(0.093)	(0.192)	(0.173)
ΔDepD	-0.397	2.406	1.585	-0.717
	(2.146)	(3.992)	(4.796)	(4.441)
ΔSize	-0.031	-0.001	0.054	0.140**
	(0.040)	(0.071)	(0.051)	(0.053)
ΔROA	-0.071	-0.079	-0.005	-0.036
	(0.079)	(0.102)	(0.230)	(0.248)
ΔTangibility	-0.060	0.086	0.643**	0.969***
	(0.230)	(0.517)	(0.245)	(0.214)
ΔMB Ratio	0.001	0.010	0.011	0.035
	(0.014)	(0.018)	(0.027)	(0.025)
ΔR&D Intensity	-0.127	-0.078	-0.142	-0.185
	(0.165)	(0.191)	(0.326)	(0.329)
ΔITC	2.307	4.168	-3.613	-6.639
	(7.326)	(6.833)	(13.493)	(11.916)
ΔNOLCC	-0.005	-0.006	0.022	0.026
	(0.005)	(0.007)	(0.014)	(0.017)
Constant	-0.011	-0.047	-0.042	0.028
	(0.039)	(0.054)	(0.100)	(0.075)
Polynomial terms	Yes	Yes	Yes	Yes
Optimal bandwidth		1.345		
No. of firms	102	102	34	34
R-squared	0.214	0.133	0.504	0.700
Cluster by firms	Yes	Yes	Yes	Yes

Table 4: How do firms with high vs low depreciation deduction use debt financing?

The table presents the findings of an RDD analysis to explore the impact of high vs low depreciation deduction on the firms' debt financing. The dependent variable is change in long-term debt ratio, which is calculated as change in firm leverage before to after the TCJA, that is, $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$ .The coefficients are presented with robust standard errors in parentheses, and standard errors are calculated allowing for clustering at the SIC level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

	High DepD			Low DepD		
	Full Sample	Low TaxPayer	High TaxPayer	Full Sample	Low TaxPayer	High TaxPayer
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
High-DepD*Treat	-0.376***	-0.475***	-0.318			
	(0.143)	(0.162)	(0.401)			
High-DepD	0.122*	0.161**	0.333			
	(0.064)	(0.072)	(0.245)			
Low-DepD*Treated				-0.040	0.304	-0.075
				(0.242)	(0.374)	(1.812)
Low-DepD				0.071	0.059	-0.135
				(0.081)	(0.085)	(1.279)
Treated	0.115	0.128	0.079	0.042	0.023	0.146
	(0.075)	(0.087)	(0.228)	(0.072)	(0.084)	(0.166)
ΔSize	-0.042	-0.068	0.074	-0.025	-0.014	0.092
	(0.032)	(0.044)	(0.046)	(0.033)	(0.050)	(0.057)
ΔROA	-0.012	-0.022	0.141	-0.000	-0.020	0.156
	(0.060)	(0.065)	(0.171)	(0.056)	(0.061)	(0.212)
ΔTangibility	0.344**	0.262	0.670***	0.354*	0.281	0.609*
	(0.147)	(0.214)	(0.173)	(0.208)	(0.315)	(0.316)
ΔMB Ratio	0.006	0.004	0.014	0.003	0.002	0.019
	(0.013)	(0.014)	(0.020)	(0.010)	(0.010)	(0.024)
ΔR&D Intensity	-0.072	-0.084	-0.087	-0.093	-0.137	0.415
	(0.153)	(0.172)	(0.295)	(0.156)	(0.167)	(0.293)
ΔITC	1.733	2.605	-12.003	3.157	5.071	1.648
	(6.446)	(6.963)	(16.496)	(6.436)	(6.600)	(15.886)
ΔNOLCC	0.001	-0.002	0.014	0.001	0.001	0.016
	(0.004)	(0.004)	(0.015)	(0.003)	(0.003)	(0.015)
Constant	-0.030	-0.019	-0.033	-0.026	-0.013	0.058
	(0.035)	(0.044)	(0.105)	(0.032)	(0.036)	(0.100)
Polynomial terms	Yes	Yes	Yes	Yes	Yes	Yes
Optimal bandwidth				1.345		
No. of firms	136	102	34	136	102	34
R-squared	0.130	0.157	0.595	0.143	0.164	0.505
Cluster by firms	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: Robustness: Various optimal bandwidths and alternative order of polynomials

The table displays the results of an RDD estimate with different optimal bandwidth and alternative order of polynomials. The variable of interest is change in long-term debt ratio, which is calculated as change in firm leverage before to after the TCJA, that is, $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$ .coefficients are presented with robust standard errors in parentheses, and standard errors are calculated allowing for clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

	ΔLTD Ratio				
VARIABLES	(1)	(2)	(3)	(4)	(5)
ΔDepD*Treat	-9.644***	-6.378**	-11.137**	-6.635**	-11.054***
	(2.973)	(3.178)	(4.381)	(2.650)	(3.454)
Treated	0.003	-0.009	-0.052	-0.004	0.026
	(0.054)	(0.055)	(0.077)	(0.049)	(0.058)
ΔDepD	2.272	1.547	1.917	0.777	1.509
	(1.415)	(1.402)	(2.115)	(1.278)	(1.776)
ΔSize	-0.004	0.004	-0.031	-0.019	-0.027
	(0.030)	(0.030)	(0.036)	(0.034)	(0.033)
ΔROA	-0.016	-0.026	-0.050	-0.044	-0.030
	(0.052)	(0.048)	(0.063)	(0.060)	(0.063)
ΔTangibility	0.212	0.260*	0.159	0.215	0.167
	(0.150)	(0.149)	(0.188)	(0.176)	(0.181)
ΔMB Ratio	0.006	0.006	0.011	0.017	0.004
	(0.011)	(0.007)	(0.017)	(0.017)	(0.012)
ΔR&D Intensity	-0.128	-0.161	-0.030	-0.039	-0.106
	(0.128)	(0.136)	(0.158)	(0.155)	(0.148)
ΔITC	2.383	0.696	2.010	2.158	1.389
	(6.550)	(6.830)	(6.025)	(6.290)	(6.557)
ΔNOLCC	-0.001	-0.000	-0.002	-0.002	-0.002
	(0.003)	(0.003)	(0.007)	(0.007)	(0.004)
Constant	0.005	-0.000	-0.032	0.030	-0.013
	(0.029)	(0.030)	(0.046)	(0.027)	(0.029)
Polynomial order	2	2	2	1	3
Optimal bandwidth	1.812	2.000	1.009	1.009	1.345
No. of firms	168	192	110	110	136
R-squared	0.190	0.156	0.202	0.161	0.177
Cluster by firms	Yes	Yes	Yes	Yes	Yes

Table 6: Impact of changes in NDTS on firm debt financing

The table presents the results of an RDD analysis to analyze the impact of changes in non-debt tax shield on the firm's debt financing. The dependent variable change in long-term debt ratio in Columns 1, 2, and 3 and total debt ratio in Columns 4, 5, and 6. The outcome variable is calculated as change in firm leverage before to after the TCJA, that is, $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$ .The coefficients are presented with robust standard errors in parentheses, and standard errors are calculated allowing for clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

	ΔLTDRatio			ΔTotal Debt Ratio		
	Full Sample	Low TaxPayer	High TaxPayer	Full Sample	Low TaxPayer	High TaxPayer
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
ΔNDTS*Treat	-13.985***	-14.517***	3.414	-11.907***	-13.294**	11.802
	(3.745)	(4.418)	(8.544)	(3.999)	(5.179)	(9.091)
Treated	-0.039	-0.068	0.100	0.028	0.001	0.071
	(0.064)	(0.076)	(0.172)	(0.074)	(0.092)	(0.153)
ΔNDTS	1.395	-0.311	1.974	2.974	2.156	-1.217
	(1.964)	(2.442)	(4.966)	(3.080)	(4.406)	(4.760)
ΔSize	-0.011	-0.012	0.050	0.020	0.023	0.152**
	(0.031)	(0.038)	(0.049)	(0.050)	(0.067)	(0.056)
ΔROA	-0.072	-0.108	-0.043	-0.114	-0.135	-0.021
	(0.052)	(0.070)	(0.241)	(0.072)	(0.095)	(0.261)
ΔTangibility	0.208	0.021	0.606**	0.397	0.192	0.965***
	(0.181)	(0.242)	(0.233)	(0.356)	(0.513)	(0.202)
ΔMB Ratio	0.016	0.014	0.010	0.027*	0.027	0.038
	(0.013)	(0.016)	(0.028)	(0.015)	(0.019)	(0.026)
ΔR&D Intensity	-0.045	-0.054	-0.277	-0.008	0.020	-0.391
	(0.151)	(0.177)	(0.315)	(0.166)	(0.204)	(0.313)
ΔNOLCC	-0.004	-0.007	0.022	-0.007	-0.009	0.031*
	(0.004)	(0.005)	(0.015)	(0.005)	(0.006)	(0.018)
Constant	0.004	0.008	-0.062	-0.015	-0.021	0.010
	(0.033)	(0.043)	(0.098)	(0.045)	(0.061)	(0.074)
Polynomial terms	Yes	Yes	Yes	Yes	Yes	Yes
Optimal bandwidth	1.299					
No. of firms	132	99	33	132	99	33
R-squared	0.236	0.279	0.506	0.205	0.209	0.694
Cluster by SIC	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Robustness: Falsification Test

The table presents the results of an RDD analysis to analyze the impact of changes in non-debt tax shield on the firm's debt financing. The dependent variable change in long-term debt ratio in Columns 1, 2, and 3 and total debt ratio in Columns 4, 5, and 6. The outcome variable is calculated as change in firm leverage before to after the TCJA, that is, $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$ .The coefficients are presented with robust standard errors in parentheses, and standard errors are calculated allowing for clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

VARIABLES	Full Sample		Low Tax Payer		High Tax Payer	
	ΔLTD Ratio	ΔTotal Debt Ratio	ΔLTD Ratio	ΔTotal Debt Ratio	ΔLTD Ratio	ΔTotal Debt Ratio
	(1)	(2)	(3)	(4)	(5)	(6)
ΔDepD*Pseudo-Treat	-1.058	1.542	-16.069	-14.220	-5.782	4.554
	(4.909)	(5.255)	(13.637)	(14.714)	(9.045)	(10.510)
Pseudo-Treated	0.013	-0.008	-0.042	-0.041	0.057	0.019
	(0.040)	(0.047)	(0.064)	(0.075)	(0.043)	(0.055)
ΔDepD	1.693	0.232	18.670	17.999	4.051	-5.550
	(4.780)	(5.023)	(14.226)	(15.412)	(5.282)	(7.046)
ΔSize	0.041	0.019	-0.023	-0.055	0.109***	0.087**
	(0.031)	(0.034)	(0.049)	(0.051)	(0.033)	(0.034)
ΔROA	0.035	0.079	0.158	0.251*	0.084	0.092
	(0.109)	(0.132)	(0.147)	(0.147)	(0.306)	(0.277)
ΔTangibility	0.599***	0.686***	1.053***	1.227***	0.369	0.538
	(0.197)	(0.231)	(0.375)	(0.422)	(0.266)	(0.336)
ΔMB Ratio	-0.004	-0.011	-0.010	-0.010	-0.015	-0.039**
	(0.008)	(0.010)	(0.015)	(0.017)	(0.018)	(0.015)
ΔR&D Intensity	-2.592	-2.879*	-1.652	-1.936*	-2.262	0.955
	(1.576)	(1.709)	(1.073)	(1.104)	(2.161)	(2.785)
ΔITC	3.895	2.502	-4.994	-4.697	11.447**	11.477*
	(3.661)	(4.208)	(5.334)	(5.743)	(4.576)	(6.272)
ΔNOLCC	-0.027	-0.027	0.228**	0.277**	-0.030	0.023
	(0.027)	(0.030)	(0.106)	(0.118)	(0.039)	(0.047)
Constant	-0.021	-0.002	0.018	0.029	-0.047	-0.009
	(0.021)	(0.024)	(0.044)	(0.054)	(0.030)	(0.037)
Polynomial terms	Yes	Yes	Yes	Yes	Yes	Yes
Optimal bandwidth			1.345			
No. of firms	71	71	33	33	38	38
R-squared	0.449	0.480	0.809	0.837	0.674	0.706
Cluster by firms	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Difference-in-Differences estimates.

The table presents the results of a DID estimate to examine the impact of changes in depreciation deduction on the firms' debt financing. The dependent variable is change in long-term debt ratio, which is defined as $LTD\ Ratio_t - LTD\ Ratio_{t-1}$. The coefficients are shown along with robust standard errors in parentheses, and standard errors are calculated by clustering at the firm level. *** represents 1% significance level, ** represents 5% significance level, and * represents 10% significance level, respectively.

	Dependent variable: ΔLTD Ratio							
	Full Sample		Low TaxPayer		High TaxPayer		Selected Sample	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔDepD*Treated*Post	-1.094	-1.414*	-2.901***	-2.726***	0.723	1.049	-4.080***	-2.717***
	(0.862)	(0.829)	(1.053)	(0.888)	(1.658)	(2.568)	(1.277)	(1.026)
ΔDepD*Treated	-0.546	0.130	0.602	0.157	-1.563	-1.938	2.417***	2.144**
	(0.670)	(0.515)	(0.691)	(0.513)	(1.519)	(2.462)	(0.869)	(0.840)
ΔDepD*Post	-0.036	0.135	-0.432	-0.185	0.544	0.619	0.005	0.126
	(0.417)	(0.384)	(0.459)	(0.405)	(1.039)	(1.094)	(0.417)	(0.399)
Treated*Post	0.005	0.024	-0.005	0.013	-0.024	0.021	0.008	0.047
	(0.013)	(0.021)	(0.019)	(0.026)	(0.032)	(0.058)	(0.032)	(0.034)
Treated	0.018	-0.018	0.007	-0.026	0.063	0.056	0.032	-0.017
	(0.024)	(0.014)	(0.029)	(0.018)	(0.048)	(0.041)	(0.029)	(0.020)
Post	0.030**	0.359***	0.028**	0.374***	0.067**	-0.293***	0.037***	0.373***
	(0.012)	(0.014)	(0.014)	(0.023)	(0.033)	(0.098)	(0.014)	(0.019)
ΔDepD	0.179	0.154	0.152	0.277	0.025	0.049	0.167	0.197
	(0.334)	(0.301)	(0.372)	(0.314)	(1.021)	(0.941)	(0.335)	(0.313)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,662	1,662	1,165	1,165	497	497	1,004	1,004
R-squared	0.044	0.069	0.059	0.086	0.073	0.151	0.047	0.246
Firm FE	Yes	No	Yes	No	Yes	No	Yes	Yes
Industry-Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Year FE	Yes	No	Yes	No	Yes	No	Yes	Yes
Cluster by firms	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix

Table A.1

Variable definitions

Variables	Description	Compustat Items
Total Debt Ratio	Lev Ratio is calculated as long-term plus short-term debt *divided* by total book value of assets (AT)	(DLTT+DLC)/AT
LTD Ratio	LTD Ratio is calculated as long-term debt divided by the total book value of assets	(DLTT/AT)
Size	Size is the natural logarithms of total book value of assets (AT)	LOG(AT)
Cash	Cash is cash and short-term investment (CHE) scaled by total assets (AT)	(CHE/AT)
Tangibility	Tangibility is calculated as property, plant, and equipment over total assets	(PPENT/AT)
ROA	Ratio of operating income before depreciation and amortization expenses (OIBDP) to total assets (AT)	(OIBDP/AT)
MB Ratio	MB Ratio equals market value of equity (PRCC_C*CSHO) plus book value of assets (AT) minus book value of equity (CEQ) minus deferred taxes (TXDB) divided by total assets (AT)	[(PRCC_C*CSHO) + (AT-CEQ)] AT
ITC	Investment tax credit is defined as investment tax credit divided by total assets. Missing values are set to zero	(ITCI/AT)
NOLCC	Net loss carry forward is calculated as tax low carry forward over total assets. Missing values are set to zero.	(TLCF/AT)
ETR	Effective tax rate is calculated as income taxes over total assts	(TXT/AT)
DepD	Depreciation deduction is calculated as depreciation and amortization divided by total assets	(DP/AT)
R&D Intensity	R&D intensity is calculated as R&D expenses (XRD) divided by total assets (AT). Missing values are set to zero.	(XRD/AT)
Capital	Capital is calculated as total assets minus cash and short-term investment.	(AT-CHE)
High-DepD	An indicator variable that equals 1 for the top quartile of firms and 0 otherwise	
Low-DepD	An indicator variable that equals 1 for the lowest quartile of firms and 0 otherwise	
High Taxpayer	An indicator variable that equals 1 for firms if their effective tax rate is above the 50th percentile, and 0 otherwise.	
Low Taxpayer	An indicator variable that equals 1 for firms if their effective tax rate is at or below the 50th percentile, and 0 otherwise. **Outcome variables are calculated as follows.** $\Delta Y_i = Y_{i,\frac{2018+2019}{2}} - Y_{i,\frac{2016+2017}{2}}$	