Taxes and Private Firms' Capital Structure Choices

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Abstract

Using limitations to the deductibility of interest payments triggered by the introduction of interest ceiling rules globally, we show that affected private firms reduce leverage relative to unaffected firms. In support of a causal effect of taxes on corporate capital structure choices, we show that the results hold for firms near the thresholds triggering the limitations and in countries required to adopt the interest ceiling rules. Furthermore, within a country, firms with a higher fraction of nondeductible interest payments are less responsive to tax rate changes. More broadly, across 93 countries, we document that private firms tend to decrease leverage in response to tax rate cuts and increase leverage in response to corporate tax rate hikes.

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The tax deductibility of interest expenses has long been a feature of the tax codes in most countries. However, whether the resulting tax benefit of debt is sufficiently large for taxes to meaningfully affect corporate capital structure choices has remained an open question since the seminal work of Modigliani and Miller (1963). In this study, we contribute to this literature by investigating whether corporate taxes influence the capital structure decisions of private firms.

Even in the most developed countries, privately held firms represent a significant fraction of economic activity (Moskowitz and Vissing-Jorgensen (2002)). Yet, whether tax considerations should affect the capital structure choices of privately held firms is not obvious. Surprisingly, and contrary to traditional financial theory, a small set of recent studies investigating the relationship between taxes and capital structure among private firms find that private firms significantly increase their leverage following corporate tax rate cuts (Ivanov, Pettit, and Whited (2022) and Cui, Wei, Xie, and Xing (2022)), while others find no significant relationship between taxes and capital structure (Goodman, Isen, Richmond, and Smith (2023)).

To investigate whether corporate taxes influence the capital structure decisions of private firms, we exploit the introduction of interest ceiling rules across many countries from 2004 to 2022. These rules, which impose limitations on the general deductibility of interest payments to all types of lenders, including banks, have become increasingly common in the past decade. Limitations on the general deductibility of interest expenses often restrict the deductibility to a certain fraction of earnings before interest, taxes, depreciation, and amortization (EBITDA), earnings before interest and taxes (EBIT), or debt-to-equity. Countries frequently allow corporate taxpayers to deduct interest expenses fully up to a certain threshold.

Firms experiencing a reduction in the deductibility of their interest payments following the introduction of these rules have an incentive to reduce leverage, while firms in the same country

that do not experience such a reduction in the deductibility of interest payments do not. We use a difference-in-differences framework to assess the effect of the staggered introduction of interest ceiling rules across countries. In this framework, we employ many thresholds triggering the limitation to the deductibility of interest payments to provide within-country evidence that firms affected by the introduction of these rules reduce their leverage relative to unaffected firms.

In support of a causal effect of taxes on corporate capital structure choices, we show that the reduction in leverage (1) is statistically and economically significant near the thresholds triggering the limitation on the deductibility of interest expenses; and (2) is present in European Union (EU) countries (EU countries could not "opt out" of adopting such rules). Because our test includes country-year fixed effects and industry-year fixed effects, these findings are entirely driven by differences between firms experiencing a reduction in their interest deductibility and those not, all within the same country- and industry-years.

We corroborate these baseline results by exploiting changes in tax rates and other aspects of the tax reforms. Specifically, we investigate whether firms with lesser incentives to adjust leverage in response to corporate tax rate *changes* are less responsive to reforms affecting the tax rate. In particular, the incentives to change leverage depend on the extent to which interest payments are deductible. Firms with a larger fraction of deductible interest payments should increase leverage more in response to a tax rate increase. In support of this notion, we find that firms with greater incentives to adjust their leverage in response to tax rate changes adjust leverage more than other firms in the same country and industry.

We provide external validity to these findings by documenting that private firms tend to decrease leverage in response to tax rate cuts and increase leverage in response to corporate tax

rate increases. This third setting, albeit less well identified than the previous two, most closely mirrors existing literature.

Our tests encompass 215,158 unique private firms across 93 countries during 1997-2022. The cross-country focus of this study enables us to exploit a large number of reforms affecting both changes in the corporate tax base and in the corporate income tax rates. These reforms include several economically significant changes in corporate income tax rates, providing more statistical power than a one-country study. They also encompass novel and increasingly common features of the tax codes of many countries. Prior studies investigating the relationship between debt and taxes have assumed that interest expenses are fully tax deductible. Using recent tax reforms that limited interest deductibility, we provide plausibly causal evidence of the importance of tax benefit in corporate capital structure decisions. Importantly, for identification purposes, two of our tests exploit within-country limitations to the deductibility of interest expenses to assess the relationship between taxes and capital structure within each country, using granular firm-, industry-year, and country-year fixed effects. The cross-country focus of this study further mitigates concerns about external validity that are inherent in single-country studies.

As mentioned in the opening paragraph, our study is related to a small set of recent studies that investigate the relationship between debt and taxes among private firms. Ivanov et al. (2022), who use U.S. reforms affecting state-level corporate income tax rates, find that private firms, especially relatively smaller private firms, significantly *increase* their leverage following corporate tax rate cuts. They argue that tax cuts increase firm profits and reduce default probabilities, which, in turn, leads firms to lever up. Their evidence is consistent with Cui et al. (2022), who use a sample of small, privately held Chinese firms. Cui et al. (2022) argue that the cash windfall resulting from the increased tax savings relaxes small firms' financial constraints, allowing them

to more easily access the debt market. However, it is unclear whether the results are driven by the sample firms' private listing status or small size. Because small firms tend to be financially constrained and rely heavily on debt, their capital structure can be less sensitive to tax changes. Endogeneity remains a concern as well.

In contrast to Ivanov et al. (2022) and Cui et al. (2022), and in line with traditional finance theory, we find corporate income tax rates to be positively related to private firms' leverage in the time-series. We corroborate this tax rate-based evidence, in a well identified setting that exploits limitations to the deductibility of interest expenses. The exploitation of interest ceiling rules and thresholds triggering the limitations globally represents a unique contribution of this study. In two contemporaneous studies, Goodman, Isen, Richmond, and Smith (2023), and Sanati and Beyhaghi (2024) investigate the introduction of the interest ceiling rule in the US. Goodman et al. (2023) find no evidence of a reduction in leverage among small U.S. firms in response to this reform, while Sanati and Beyhaghi (2024) find that both private and public firms significantly reduce leverage.

Our large, cross-country study supports the findings of Sanati and Beyhaghi (2024), as well as those of Fleckenstein, Longstaff, and Strebulaev (2020). The latter use aggregate data from tax filings by U.S. firms during 1926-2013 and document that U.S. private firms increase (cut) their leverage in response to increases (reductions) in the federal corporate income tax rate.

Our study also relates to a large literature on the role of taxes in shaping the capital structure decisions of publicly traded firms, which we summarize in the next section. We contribute to this literature by documenting that the introduction of interest ceiling rules, which trigger limitations on the deductibility of interest payments, has a strong impact on leverage among publicly traded firms as well.

A third contribution of our study is the construction of a large database that encompasses several aspects of the tax reforms. We intend to make this database available to others upon publication. We believe the data collected will enable other researchers to address additional tax-related questions. Lastly, and no less importantly, our study makes an educational contribution by describing recent reforms that have substantially curbed the preference for corporate debt previously granted by the tax regulations in many jurisdictions.

1. Literature Review

1.1. The Relationship between Taxes and Capital Structure

A number of studies have documented a significantly positive relation between the tax benefits of debt and corporate financial leverage in the cross-section of publicly traded firms, both in the US and across countries.[1] MacKie-Mason (1990) examines choices in corporate debt and equity issuance and concludes that taxes play a significant role. Graham (1996a, 1996b) finds consistent results using estimated marginal tax rates that account for net operating losses and other details of the tax code. Graham (1999) further confirms these findings while incorporating the effect of personal taxes. Rajan and Zingales (1995) study tax reforms in G-7 countries and show that corporate and personal taxes influence aggregate corporate leverage. Desai, Foley, and Hines (2004) find multinational firms' foreign affiliates' leverage ratios increase with local tax rates. Fan, Titman, and Twite (2012) find a country's tax system is one important explanatory factor of corporate leverage and debt maturity choices. One criticism of this literature is that taxes do not appear to play a first-order role in shaping corporate leverage choices (Graham and Leary (2011),

[1] Another set of papers investigates how the determinants of capital structure vary across countries. We do not review this vast literature here but defer to de Jong, Kabir and Nguyen (2008) as one good example of such studies.

Graham (2013), Hanlon and Heitzman (2022)). This result, or lack thereof, is corroborated by survey responses from CFOs of large U.S. corporations (Graham and Harvey (2001)).

Additional research has also shown that corporate capital structure changes as a result of tax reforms. Using the Tax Reform Act of 1986, Givoly, Hahn, Ofer, and Sarig (1992) find that a substitution effect exists between debt and nondebt tax shields. Moreover, they observe that both corporate and personal tax rates play a role in influencing capital structure decisions. Faccio and Xu (2015) investigate a multitude of corporate and personal tax reforms across OECD countries and document significant effects of taxes on capital structure. Doidge and Dyck (2015) document that Canadian income trusts generally increased their leverage after a reform scrapped their tax exemption. Nevertheless, income trusts employing tax shields were less affected by the reform. Heider and Ljungqvist (2015) find consistent results using US state-level tax rate changes. Using US data during 1926-2009, Fleckenstein et al. (2020) find a positive relationship between changes in corporate leverage and changes in corporate tax rates for both public and private firms. Panier, Perez-Gonzalez, and Villanueva (2013), who study the introduction of the notional interest deduction in Belgium in 2006, document that tax incentives for equity result in less levered capital structures. An exception to the conclusion that, in the time-series, taxes matter for capital structure choices is Bargeron, Denis, and Lehn (2018), who find that leverage barely changed following the introduction of corporate and personal income taxes in the US in the early 1900s. They suggest that considerations of financial flexibility may be responsible for this outcome.

Tax codes are generally complicated; for this reason, researchers have attempted to account for details related to changes in the tax base in addition to top statutory tax rates. For example, Graham (1996a, 1996b) estimates marginal tax rates that account for net operating losses, tax credits, and the alternative minimum tax. Ivanov et al. (2022) also control for a large set of tax base variables. In an international setting, Faccio and Xu (2015) control for the tax imputation

system a number of countries have, allowing the deduction of corporate income tax at the personal level. Blouin, Huizinga, Laeven, and Nicodème (2014) investigate the impact of thin capitalization rules on the capital structure of foreign affiliates of US multinationals in 54 countries from 1982 to 2004. They find that the introduction of such limitations reduces the leverage of affected foreign affiliates.

In nearly all prior studies, interest expenses on arm's-length debt are assumed to be fully deductible from taxable income. However, since the late 2000s, some countries have introduced limitations on the deductibility of interest expenses from corporate income taxes (i.e., interest ceiling rules). These limitations reduce the tax benefit of debt and incentivize firms to lower their financial leverage. Interest ceiling rules may also mitigate the impact of taxes on capital structure. Two contemporaneous working papers examine the introduction of the interest ceiling rule in the U.S., focusing on firms with sales near $25 million. Sanati and Beyhaghi (2024) find that both private and public firms significantly reduce leverage following the reform, while Goodman et al. (2023) find no evidence of leverage reduction among small U.S. firms.

1.2. Taxes and Capital Structure of Private Firms

Prior research on the relationship between taxes and capital structure has been mostly based on public companies, primarily due to data limitations. Few recent exceptions are Fleckenstein et al. (2020), Ivanov et al. (2022), Cui et al. (2022), Goodman et al. (2023), and Sanati and Beyhaghi (2024). These studies, however, reach different conclusions. Fleckenstein et al. (2020) find the same positive tax effects on corporate financial leverage for private firms as for public firms. By contrast, Ivanov et al. (2022) document that corporate leverage rises after US state corporate income tax cuts, particularly for small private firms, but to a lesser extent for public firms. They argue that tax hikes lower firm profits and increase default probabilities which, in turn, lead firms

to delever. Cui et al. (2022) also find small private Chinese firms increase their leverage after a corporate income tax cut. Goodman et al. (2023) investigate the introduction of the interest ceiling rule in the US. Their focus is on smaller U.S. firms with revenues close to $25 million. They find no evidence of such smaller firms being affected by the reform. By contrast, Sanati and Beyhaghi (2024), who focus on the same reform, find that firms significantly reduce their leverage in response to the reduction in the tax benefits of debt.

Theoretically, it is unclear whether the tax benefit of debt should be an important determinant of private firm capital structure. On one hand, private firms tend to be smaller than public firms and, because small firms tend to have high financial distress risks, the effect of tax benefits could be subsumed by the increase in default probabilities. A caveat is, naturally, that large private firms should not fall into that category. Another related consideration is financial constraints. If private firms are deeply financially constrained, they must rely heavily on debt.[2] Such reliance could weaken the impact of taxes on capital structure. Consistent with these ideas, Fleckenstein et al. (2020) do not find a tax effect on leverage for the smallest firms, both public and private. They also show that the adjustment of leverage to changes in corporate tax rates is slower for smaller firms facing financial constraints. They conclude that the capital structure of the smallest firms is driven much more by external shocks than for larger firms. On the other hand, private firms face lower agency costs due to their more concentrated ownership structure.[3] Hence,

[2] There is an extensive literature on the financial constraints of private firms. For instance, Campello, Giambona, Graham, and Harvey (2011) and Brown, Gustafson, and Ivanov (2021) find that private firms rely on lines of credit when faced with liquidity shocks. Brav (2009) and Saunders and Steffen (2011) document that private firms borrow more and face significantly higher borrowing costs than public firms in the UK. Research on mergers and acquisitions also suggests that private target firms fare worse in the transactions due to financial constraints (Maksimovic, Phillips, and Yang (2013)) but gain valuable access to capital through the mergers (Erel, Jang, and Weisbach (2014); Flannery, Hanousek, Shamshur, and Tresl (2023)).

[3] Consistent with lower agency costs at private firms, prior research finds that private acquirers pay less for targets than publicly traded acquirers (Bargeron, Schlingemann, Stulz, and Zutter (2008)), hold less cash (Gao, Harford, and Li (2013)), invest more and are more responsive to changes in investment opportunities than public firms (Asker, Farre-Mensa, and Ljungqvist (2015)).

their capital structure decisions will not be much influenced by managerial preferences for lower leverage (Berger, Ofek, and Yermack, 1997). As a result, leverage can be more sensitive to tax rate changes.

2. Data

2.1. Accounting Data

Accounting variables are from Orbis, version "orbis5," as archived on the NBER servers. Orbis, a Bureau Van Dijk database, contains data on firms' balance sheets and income statements, industry sectors, locations, ownership, and the consolidation levels of their annual financial accounts. In our analyses, we restrict the sample to firms with consolidated financial statements, if available (Orbis consolidation codes C1 and C2), or unconsolidated financial statements (consolidation code U1), when consolidated statements are unavailable. To minimize data errors, firm-years with missing or negative total assets (TOAS), negative long-term debt (LTDB), negative loans (LOAN), negative current liabilities (CULI), negative non-current liabilities (NCLI), negative revenues (OPRE), negative depreciation and amortization (DEPR), negative interest payments (INTE), or negative financial expenses (FIEX) are excluded from the sample.

To mitigate the possibility that the sample may include firms that are not subject to corporate income taxes, we exclude firms with total assets that never exceed USD 50 million during 1997 to 2022.[4] This initial screening results in a sample of 7,150,694 firm-years, encompassing 698,530 unique firms across 169 countries. Accounting identities are used to fill in,

[4] To investigate the possibility that the sample might still include pass-through-like companies, we compute the fraction of firms that pay no taxes during the sample period despite reporting a positive aggregate pre-tax income. Less than 1% of the firms in the sample fall into this group, suggesting that this issue, if present, is likely small.

when possible, missing values. We also use accounting identities to identify errors in the data. We drop observations when accounting identities do not hold.

The sample is further restricted to firms for which data permit the construction of our three measures of leverage: the long-term-debt-to-assets ratio, defined as end-of-year long-term debt scaled by total assets; the debt-to-assets ratio, defined as end-of-year loans plus long-term debt, scaled by total assets; and the total debt ratio, defined as the difference between end-of-year total assets and shareholders' funds, scaled by total assets.

For a firm to remain in the sample, we further require data on both concurrent and lagged revenues. We use lagged revenues as the measure of size and concurrent revenues to eliminate duplicates. Specifically, for each company in each year, we retain only the record with the highest concurrent revenues. To further mitigate the possibility that the sample may include firms that are not subject to corporate income taxes, we exclude associations, foundations, and unlimited liability companies. Imposing these restrictions results in a sample consisting of 4,350,913 firm-year observations, encompassing 500,401 unique firms in 165 countries.

We exclude firms with two-digit core NAICS codes 22 (utilities), 52 (finance and insurance companies), 92 (public administration), or three-digit core NAICS codes 611 (educational services), 622 (hospitals), 813 (religious, grantmaking, civic, professional, and similar organizations), and 814 (private households), as well as firms with no available core NAICS code in Orbis. These screenings reduce the sample to 3,799,766 firm-years, including 416,235 unique firms in 154 countries.

We further restrict the sample to firms with available data to construct the four "standard determinants" of leverage used in the literature, all lagged by one year: size (natural log of revenues), growth (natural log of revenues minus lagged natural log of revenues), profitability

(operating income (OPPL) scaled by total assets), and asset tangibility (tangible assets (TFAS) scaled by total assets). We additionally control for two other factors that firms may, and often do, employ to shield income from corporate taxation: R&D (R&D expenses (RD) scaled by revenues) and depreciation and amortization (depreciation and amortization expenses (DEPR) scaled by revenues). When data on R&D expenses (or depreciation and amortization expenses) are missing, we replace the missing value with zero. To control for potential biases resulting from this replacement, we add two "missing data" indicators to the regressions, each taking the value of one if data are missing and zero if they are available. Unless otherwise specified, all accounting variables are denominated in US dollars.

After computing the dependent and independent variables, we restrict the sample to include observations for which the dependent variables are available from 1997 to 2022. In all analyses, firm-level variables are winsorized at the 1st and 99th percentiles to mitigate the effect of outliers.

To classify firms as private or public in a given year, we begin with the classification provided in Orbis, where firms are classified as "unlisted," "delisted," or "listed." We supplement this classification using listing or delisting dates and market values. We exclude firms' IPO and delisting years to avoid ambiguity in listing status during those years. Before requiring country-level variable availability, the data include 216,474 private firms from 111 countries and 2,037,549 firm-year observations.

2.2. Corporate Income Tax Data

Our main tests focus on limitations to the deductibility of interest payments. Specifically, some tax jurisdictions (which include countries and territories) have limitations on the general deductibility of interest expenses, often referred to as "interest ceiling" rules. These rules frequently limit the deductibility of all types of interest expenses, including interest on bank loans,

to a certain fraction of EBITDA. Less frequently, the limit on the deductibility of interest expenses is triggered when the company's debt-to-equity surpasses a certain threshold or is based on earnings before interest and taxes (EBIT).

Between 2004 and 2022, 48 tax jurisdictions had, at some point, "interest ceiling" rules in place. Only two tax jurisdictions had limitations on the general deductibility of interest expenses in 2004. By contrast, in 2022, 44 tax jurisdictions had such rules in place.[5] Many of the countries with such limitations are part of the European Union (EU). Some non-EU countries, such as Egypt, Norway, Mexico, the United States, Vietnam, and Zimbabwe, have also implemented similar limitations.

The EU Anti-Tax Avoidance Directive of July 12, 2016, mandated that all EU countries limit the deductibility of "net borrowing costs" (interest paid minus interest received by a corporate taxpayer) to a fraction of EBITDA, not to exceed 30%. EU countries were granted the option to allow corporate taxpayers to fully deduct interest payments up to a threshold of 3 million Euros. Belgium, for example, implemented a limitation on the deductibility of net interest expenses starting on January 1, 2019. The limit was set at the higher of 30% of EBITDA or EUR 3 million.[6]

EU countries were permitted to allow companies to (1) grandfather loans taken before June 16, 2016, a choice that 11 EU countries opted for; (2) allow for interest carrybacks and

[5] Specifically, in 2022, 33 countries had EBITDA-based limitations (including Latvia, which permits full deductibility of interest payments on loans from Latvian or European Economic Area-based banks); four had EBIT-based limitations; four had limitations based on the debt-to-equity ratio; Turkey had a limitation based on the external liabilities-to-equity ratio; the Philippines had a complex regulation designed to offset the preferential tax treatment granted to interest earned on bank deposits; and Saudi Arabia had a limitation based on a firm's income from loan charges, other taxable income, and other tax-deductible expenses.

[6] As of 2022, 15 of the 33 countries with an EBITDA-based limitation in place had an exemption threshold of EUR 3 million. Italy, Kenya, Peru, Uganda, and Zambia had an exemption threshold of zero; the Netherlands, Portugal, Romania, and Spain had an exemption threshold of EUR 1 million; and the UK had an exemption threshold of GBP 2 million. Other EU countries also had exemption thresholds below the maximum limit set by the EU. Additionally, as of 2022, the deduction limit was 30% of EBITDA in all countries except for Finland (25%), the Netherlands (20%), and Norway (25%).

carryforwards; and (3) allow standalone companies (i.e., companies that are not part of a business group) to deduct fully interest expenses. Cyprus, the Czech Republic, and Germany exempted standalone companies from the limitation.

For companies that are part of business groups, in some tax jurisdictions, the limit on the deductibility of interest expenses is applied at the group level. In some instances, different limits on the deductibility of interest expenses apply to standalone and group-affiliated firms. One such case is Norway, a non-EU country, where the limit is set at NOK 5 million for standalone firms and NOK 25 million, in aggregate, for business groups.

All EU countries were required to implement this directive by January 1, 2019, at the latest. Countries that already had rules in place, considered "equally effective" in limiting income shifting, were allowed to postpone the implementation of the directive until January 1, 2024.

As a starting point, we hand-collect information about these rules from Ernst & Young's (E&Y) "Worldwide Corporate Tax Guide[s]" for the years 2004, 2005, 2010, 2015, 2020, and 2022 (the E&Y directories are available electronically starting from 2004). We use these data to train a text-parsing program, which is then employed to extract information potentially related to these regulations from the E&Y guides for all years. The extracted information is then manually verified for accuracy. For the most recent years, data availability allows us to supplement and cross-check data from the E&Y guides with information from PricewaterhouseCoopers's "Worldwide Tax Summaries Online," the OECD's "Dataset Interest Limitation Rules (ILR)," and various reports by the Tax Foundation. Whenever the information in these sources appears inconsistent, we conduct additional online searches to resolve the inconsistency. We undertake this process for each of the 188 tax jurisdictions included in the E&Y guides.

Top statutory corporate income tax rates are from the Tax Foundation's "Corporate Tax Rates around the World" database. The database provides top statutory corporate income tax rates for the years 1980-2022, starting with 80 tax jurisdictions in 1980 and ending with 225 tax jurisdictions in 2022. We include corporate income tax rates in later regressions investigating the general association between taxes and capital structure choices.

In some of those regressions, we supplement the tax rates with control variables that account for changes in the composition of the corporate tax base. These variables are constructed from the E&Y Worldwide Tax Guides, using the procedure described earlier. For example, a small number of countries allow a notional interest deduction for equity, sometimes referred to as the "Allowance for Corporate Equity." The notional interest deduction is typically structured as a percentage of book equity, with the percentage either fixed or determined based on government bond yields. For example, Austria had such a deduction in place from 2000 until 2004, Brazil introduced the deduction for corporate equity in 1996, and Belgium introduced the deduction in 2006.[7] By 2022, 11 tax jurisdictions had such a deduction in place.

Other control variables, constructed using keyword searches based on information contained in the E&Y Worldwide Tax Guides, include an indicator denoting the presence of limitations to the deductibility of interest paid to shareholders, related parties, and/or foreign entities ("thin capitalization rules");[8] an indicator denoting whether the tax law allows recording balance sheet items at their current monetary value to account for inflation; an indicator denoting whether a "super deduction" is allowed for qualifying intellectual property ("patent box"); an

[7] For the purpose of constructing this variable, information from the E&Y Worldwide Tax Guides is supplemented with data from PricewaterhouseCoopers's Tax Summaries, Asen (2020), Klemm (2006), Kock and Gérard (2018), and Van Campenhout and Van Caneghem (2013).

[8] Thin capitalization rules most frequently take the form of a debt-to-equity ratio threshold above which interest expenses on related party debt are non-deductible. While the data in Orbis are not sufficiently granular to allow us to quantify payments to related parties, we are able to filter out most of those payments (except those to controlling shareholders or foreign unconsolidated entities) by focusing on consolidated financial statements, when available.

indicator denoting whether special tax treatment, bonuses, incentives, or tax credits are given for R&D expenses; an indicator denoting whether special incentives or aid are given for new investments; an indicator denoting whether accelerated depreciation is allowed; an indicator denoting whether consolidation at the group level is permitted for tax purposes and/or if the transfer of losses between group companies is allowed for tax purposes; and the number of years of net operating loss carrybacks and carryforwards.

Although these control variables allow us to consider numerous aspects of each tax reform, albeit sometimes imperfectly due to data limitations, they do not encompass all aspects. For this reason, in our main tests, we include country-year fixed effects to account for a wider array of features of each tax code or any other country-year factors that affect all firms equally. The inclusion of country-year fixed effects also has the additional benefit of avoiding issues related to the, often high, correlation between country-level variables.

We are also unable to control for the progressiveness of each tax system, albeit progressiveness is unlikely to be important among the large firms on which we focus, or for specialized taxation targeting particular industry sectors. Another caveat is that the accuracy of the control variables for changes in various aspects of the tax base relies on the quality of the keyword searches conducted and on the completeness of the E&Y guides. However, due to the inclusion of country-year fixed effects, our main tests - - based on the thresholds giving rise to the limitations triggered by the introduction of the interest ceiling rules - - do not suffer from these limitations.

2.3. Country-Level Controls

In later tests, we also control for nominal borrowing rates, inflation, unemployment, population, GDP per capita, and GDP per capita growth. The *Nominal borrowing rate*, defined as "the bank rate that usually meets the short- and medium-term financing needs of the private sector"

is from the International Monetary Fund's "International Financial Statistics and Data Files" (item: FR.INR.LEND). For larger countries, it is supplemented with hand-collected data from Trading Economics, or the European Central Bank (https://data.ecb.europa.eu/main-figures/bank-interest-rates/loans).

The remaining country-level variables are from the World Bank's "World Development Indicators." *Inflation* "reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly" (item: FP.CPI.TOTL.ZG). The *unemployment rate*, is defined as "the share of the labor force that is without work but available for and seeking employment" (item: SL.UEM.TOTL.ZS). *Population* is total population "based on the de facto definition of population, which counts all residents regardless of legal status or citizenship" (item: SP.POP.TOTL). Population is midyear estimates. *GDP per capita*, in current USD, is defined as "gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars" (item: NY.GDP.PCAP.CD). Finally, *GDP per capita growth* is defined as the first difference of the natural log of *GDP per capita*. Inflation, the unemployment rate, population, and GDP per capita are supplemented with data from Trading Economics when unavailable from the World Bank.

3. Identification Strategy

The analyses are based on three tests utilizing different types of specifications. The first two tests exploit cross-sectional limitations to the deductibility of interest payments. Specifically,

the first test uses a difference-in-differences regression framework to examine the effect of the staggered introduction of interest ceiling rules across many countries on corporate financial leverage. This first test represents our main specification.

The second test investigates how the effect of corporate income tax rate changes on leverage depends on cross-sectional variations in interest deductibility. In these first two tests, we are able to include country-year fixed effects, thereby controlling for any unobserved country characteristics, whether time-varying or time-invariant. The third test follows a standard regression model of leverage on corporate income tax rates.

3.1. Difference-in-Differences Regressions Using the Staggered Introduction of Interest Ceiling Rules

The first limitation exploited is triggered by the introduction of "interest ceiling" rules by many countries between 2008 and 2021, which limit the deductibility of interest payments once certain thresholds are reached. The purpose of these limitations is to mitigate the shifting of income to low-tax countries. Most notably, following the adoption of the anti-tax avoidance package by the European Union (EU) in 2016, as recommended by the OECD, all EU countries have implemented such limitations.

For example, the interest ceiling rule in force in France since 1/1/2019 limits the interest deduction to the highest of 30% of EBITDA or EUR 3 million. A consequence of this rule is that, beginning in 2019, and provided that taxable profits are sufficiently high, the deductibility of interest payments is capped at max(EUR 3 million, EBITDA x 0.30). Companies with interest payments in excess to this cap could fully deduct their net interest payments prior to 2019 but can only benefit from limited deductibility after 2019. By contrast, companies with payments below this cap could fully deduct their interest payments both prior to 2019 and after. Thus, holding

everything else unchanged, the introduction of the "interest ceiling" rule should induce firms with interest payments above the cap to delever. In our first test, we examine the effect of the staggered implementation of interest ceiling rules across 25 countries (for which sufficient data are available for private firms) using the following specification:

$$\begin{aligned} \text{Leverage}_{i,t} = {} & \alpha_1 \times \text{Post}_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\} \\ & + B' \times \mathbf{X} + \delta_i + \zeta_{s,t} + \nu_{c,t} + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where *i* denotes the firm, *c* the country, *s* the industry sector, and *t* the year. $\mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ is an indicator that takes the value of 1 if a company has an incentive to reduce its leverage following the introduction of the interest ceiling rule, as explained below, and 0 otherwise, and $\text{Post}_{c,t}$ is an indicator that takes the value of 1 if year t coincides with or follows the introduction of the interest ceiling rule in country c, and 0 if it precedes its introduction. $\mathbf{X}$ is a vector of firm-level controls, δ_i are firm-consolidation type fixed effects, $\zeta_{s,t}$ are industry-year fixed effects, and $\nu_{c,t}$ are country-year fixed effects. The firm-consolidation type fixed effects are included to account for the fact that the data in Orbis might include different types of accounting statements for the same firm over time. Including firm-consolidation type fixed effects allows us to control for structural changes in the data due to different types of accounting statements for a given firm. Due to the inclusion of the firm-fixed effects, the regression coefficients isolate how leverage changes as the independent variables change over time. The inclusion of industry-year fixed effects accounts for time-varying costs of financial distress, which, as documented by Davydenko, Strebulaev, and Zhang (2012), tend to be industry-related and time-varying, as well as other time trends that vary across industries due to

variation in regulation or competition, among many other factors. The inclusion of country-year fixed effects eliminates the need to control for country-level variables.

Standard errors are double-clustered at the country-year level to account for the correlation of responses to the same tax reform across different firms in the country passing the reform, and at the four-digit NAICS industry code level to allow for time-series correlations and within-industry comovements.

To determine a company's incentive to reduce its leverage following the introduction of the interest ceiling rule, we use interest payments and earnings measured over the years t-3 through t-1, where t is the year the interest ceiling rule becomes effective. Firms are likely to use data from the most recent years when making long-term decisions. To account for the possibility that the deduction limit may change after the initial adoption, we compute the exemption threshold and the deduction limit using their average values over years t, t+1, and t+2. Consequently, for firms in countries with EBITDA-based deduction limits, the change in the amount of non-deductible interest payments is calculated as:

$$\Delta \text{ Non-deductible interest payments}_i = \max(0, \min(\Sigma \text{ EBIT}, \Sigma \text{ Interest})) - \max\{0, \min[\Sigma \text{ EBIT}, \Sigma \text{ Interest}, \max(\Sigma \text{ Exemption threshold}, \Sigma \text{ EBITDA x Deduction limit})]\} \quad (2)$$

for firms in countries with EBIT-based deduction limits, the change in the amount of non-deductible interest payments amounts to:

$$\Delta \text{ Non-deductible interest payments}_i = \max(0, \min(\Sigma \text{ EBIT}, \Sigma \text{ Interest})) - \max\{0, \min[\Sigma \text{ EBIT},$$

$$\Sigma \text{ Interest, } \max(\Sigma \text{ Exemption threshold, } \Sigma \text{ EBIT x Deduction limit})]\} \quad (3)$$

and, for firms in countries with limits based on the debt-to-equity ratio, the change in the amount of non-deductible interest payments amounts to:

$$\Delta \text{ Non-deductible interest payments}_i = \max(0, \min(\Sigma \text{ EBIT, } \Sigma \text{ Interest})) - \max\{0, \min[\Sigma \text{ EBIT,}$$

$$\Sigma \text{ Interest, } \Sigma \text{ Interest x } (\Sigma \text{ Deduction limit}/3) / (\Sigma \text{ debt-to-equity}/3)]\} \quad (4)$$

All variables in (2)-(4) are measured in local currency. In the equations above, the term before the subtraction represents the allowed interest deduction before the implementation of the interest ceiling rule, and the term after the subtraction represents the allowed interest deduction after the implementation of the interest ceiling rule.

With this in mind, we construct an indicator, $\mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$, that takes the value of one if the allowed interest deduction before the introduction of the interest ceiling rule exceeds the allowed interest deduction after the introduction of the interest ceiling rule, and zero otherwise. By construction, the firm-level variable $\mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ is time-invariant. Therefore, the inclusion of firm fixed effects in the specifications eliminates the need to estimate the coefficients of the variable itself.

For this test, we consider all countries that implemented EBITDA-, EBIT-, or debt-to-equity-based interest ceiling rules between 2004 and 2022. We exclude the Philippines, Saudi Arabia, and Turkey because their rules are based on criteria that cannot be addressed with the available data, as well as Myanmar and Romania, which already had interest ceiling rules in place in 2004. Additionally, we exclude three territories (Guam, Northern Mariana Islands, and the US

Virgin Islands) with no large private firms in Orbis, along with 15 countries (5 for publicly traded firms) with insufficient Orbis data to calculate changes in non-deductible interest payments. This results in a final sample of 25 countries for private firms (and 35 countries for publicly traded firms), which are used in our main tests presented in Tables 2 and 8.

Of the 25 reforms in the private firms sample, three took effect in 2008, one in 2012, one in 2013, one in 2014, four in 2018, 12 in 2019, two in 2020, and one in 2021.

To mitigate the impact of confounding factors, we focus on a narrow time window around the introduction of the interest limitation rule in a given country, starting the sample three years prior to the introduction and ending the sample at the end of the second year following the introduction of the rule. The resulting sample, used in Panel A of Table 2, contains 290,962 firm-years and 55,283 firms from 25 countries.

In Panel B of Table 2, we further restrict our sample to focus on a subset of firms with interest payments near the deduction limit imposed by the new interest ceiling rule. Specifically, we focus on firms with interest payments within USD 1.25 million or within 25% of the maximum deduction allowed. Doing so enables us to make strong causal claims. This test captures the local effect of an increase in non-deductible interest payments after the introduction of the new rule among firms with similar leverage ratios (such as the ratio of interest payments to EBITDA) or interest payments. Alternatively, in Panel C, we restrict the sample to EU countries, as the introduction of such limitations in these countries was imposed by the EU rather than being an endogenous choice of each country.

3.2. Within-Country Cross-Sectional Variations in The Leverage Effect of Taxes Depending on Interest Deductibility

Next, in addition to the limitations triggered by the introduction of the interest ceiling rules, we incorporate two other limitations that are triggered by provisions normally contained in the tax laws. A common limitation occurs when taxable profits are zero or negative. Ignoring tax carrybacks and carryforwards, interest payments are not deductible when taxable profits are negative. Furthermore, interest payments are fully deductible only when taxable profits are sufficiently large. As a result, a second limitation arises when interest payments exceed EBIT. We combine these additional limitations with those triggered by the introduction of the interest ceiling rules, and for each year and firm, we calculate the ratio of deductible interest as a fraction of total interest paid (Fraction of deductible interest).

We investigate the role of this variable in the tax-leverage relationship in a sample containing all countries with available corporate income tax rate data from 1997 to 2022 using the following specification:

$$\begin{aligned} \text{Leverage}_{i,t} = {} & \alpha_1 \times \text{Fraction of Deductible Interest}_{i,t} \\ & + \alpha_2 \times \text{Fraction of Deductible Interest}_{i,t} \times \text{Corporate Income Tax Rate}_{c,t-1} \\ & + B' \times \mathbf{X} + \delta_i + \zeta_{s,t} + \nu_{c,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

Naturally, the fraction of deductible interest should be negatively correlated with leverage. Additionally, firms with a higher fraction of deductible interest have a greater incentive to increase leverage following an increase in the corporate income tax rate.

3.3. Standard Regressions of How Leverage Responds to Tax Rate Changes

The third test is based on a standard model that examines how leverage responds to tax rate changes:

$$\text{Leverage}_{i,t} = \alpha \times \text{Corporate Income Tax Rate}_{c,t-1} + B' \times \mathbf{X} + \Gamma' \times \mathbf{Z} + \delta_i + \zeta_{s,t} + \varepsilon_{i,t} \quad (6)$$

The country-level controls, **Z**, include lagged nominal borrowing rates (*Nominal borrowing rate$_{t-1}$)*, lagged inflation (*Inflation$_{t-1}$)*, lagged unemployment (*Unemployment$_{t-1}$)*, the logarithm of lagged population (*Ln(Population$_{t-1}$)*, the logarithm of GDP per capita (*Ln(GDP-Per-Capita$_{t-1}$)*), and lagged GDP per capita growth defined as *Ln(GDP-Per-Capita$_{t-1}$) - Ln(GDP-Per-Capita$_{t-2}$)*. In this specification, we employ country-level controls in lieu of country x year fixed effects which would be perfectly multicollinear with the key variable of interest, the corporate income tax rate. In some specifications, we supplement these controls with a set of variables that reflect other features of each tax code.

In the next four sections, we discuss our results. We begin by providing univariate statistics for the sample used in the main regression analyses (Section 4). We continue by presenting our regression results. The results from the two tests based on limitations to interest deductibility are presented in Section 5 and those from the test using the standard model in Section 6, along with the results including additional tax base controls. Robustness tests are presented in Section 7.

4. Descriptive statistics

Table 1 reports the univariate statistics for all private firms in the sample. The sample includes 97 countries and spans the years 1997-2022. For some countries, data coverage begins after 1997, and for all countries, coverage is relatively sparse during the early years of the sample.

The sample includes 2,020,037 private firm-years and 215,158 private firms that are included in any of the regression analyses.

[Insert Table 1 here]

The average long-term-debt-to-assets ratio is 13.96%, the average debt-to-assets ratio is 25.34%, and the average total debt ratio is 64.91%. Leverage naturally increases as we move from the first measure, which is the least inclusive, to the third measure, which is the most inclusive.

The average rate of revenue growth is 4.05%, the average profitability is 5.01%, and the average asset tangibility is 28.02%. The median firm's operating revenue is $49 million (=exp(17.7148)), which is about a third of the median revenues of public firms in OECD countries during 1981–2009 (Faccio and Xu, 2015).

Of the firms affected by the introduction of interest ceiling rules, 9.41% experience a reduction in the deductibility of interest payments. More generally, for the overall sample, 75.31% of a firm's total interest payments are tax deductible.

During the 1,686 country-years in the sample, the corporate income tax rate decreased 286 times and increased 84 times. The average corporate income tax rate is 28.03%. The tax rate exhibits wide variability across countries, ranging from a minimum of 0% in Bermuda and other tax havens to a maximum of 56.80% in Germany. The average tax decrease is 287 basis points per year, ranging from nearly zero basis points in France to a maximum of 4,000 basis points in Kuwait. The average tax increase is 224 basis points per year, ranging from nearly zero basis points in Switzerland to a maximum of 1,200 basis points in Moldova. Due to the high frequency of these reforms, which in some countries involve changes in corporate income tax rates that, over time, go in opposite directions and do not always involve sufficiently meaningful changes, we employ a traditional regression design rather than an event study approach.

The average nominal borrowing rate is 4.72%; the average rate of inflation is 2.48%; the average rate of GDP growth is 2.69%; and the average unemployment rate is 7.47%. Population and GDP per capita vary greatly across the sample. For example, the smallest country has a population of less than half a million, while the largest country has a population of almost 1.4 billion.

Interest ceiling rules are relatively common during the sample period, affecting 29.29% of the firm-years in the sample. Thin-capitalization rules are even more common, affecting 66.17% of the firm-years in the sample. Table 1 also reports summary statistics for other tax-related control variables, which we do not describe here for the sake of conciseness.

5. Exploiting limitations to interest deductibility

In this section, we present the results from the first two of our main tests, those exploiting limitations to the deductibility of interest payments. We focus on limitations in two settings. In the first setting, we investigate how firms adjust their leverage when a reform makes their interest payments no longer fully deductible. In this setting, we hold tax rates constant and focus on reforms that have introduced limitations to the deductibility of interest payments. The second setting examines how tax rate changes have different impacts on firms depending on their profitability. In the extreme, changes in the corporate income tax rate should be inconsequential for firms that have no taxable profits in the long run.

5.1. The Introduction of Limitations to the General Deductibility of Interest Payments

Our strongest (i.e., best-identified) test of the effect of tax reforms on capital structure involves the introduction of limitations on the general deductibility of interest payments. We focus on all countries that introduced EBITDA-, EBIT-, or debt-to-equity-based limitations and for

which sufficient data are available to determine whether a private firm is affected by the newly introduced rules. The test is based on model (1), which was discussed in detail in Section 3.1. The regression results are reported in Panel A of Table 2.

[Insert Table 2 here]

Consistent with a tax narrative, the results in Panel A of Table 2 show that firms that experience a reduction in the deductibility of interest payments following the introduction of the interest ceiling rule significantly reduce their leverage after the introduction of the reform. We note that only 9.41% of the firms in the sample experience a reduction in the deductibility of interest payments after the introduction of the reform in their country. As an example, the total debt-to-assets ratio declines by 214 percentage points, or 8.45% of the sample mean.

Firms with higher leverage ratios or more interest payments are more likely to have positive non-deductible interest payments. At the same time, such firms are also more likely to be over-leveraged and plan to deleverage. To alleviate this concern, we next focus on the interest payments and examine the subsample of firms with interest payments within a narrow bandwidth of the interest ceiling. This bandwidth is defined as firms with interest payments either (a) within USD1.25 million or (b) within 25% of the maximum deduction allowed.[9] Fewer than 25% of the firms in the sample fall into this bandwidth. The results, presented in Panel B of Table 2, show that, among these plausibly similar firms, only those experiencing an increase in non-deductible interest payments reduce leverage after the implementation of the new interest ceiling rule. The effects remain economically similar to those in the full sample.

A potential concern with these results is that a country may adopt an interest ceiling rule voluntarily for reasons related to corporate capital structure. (The reason portrayed in official EU

[9] We allow both a fixed dollar amount and a fractional bandwidths because the deduction limit is either a fixed amount or a fixed fraction of EBITDA, EBIT, or debt-to-equity.

documents was to limit the shifting of income to low-tax jurisdictions.) To alleviate this concern, we focus on EU countries. The introduction of EBITDA-based limitations was mandated in the EU, which imposed a terminal date by which all EU countries had to introduce the reform in question. The EU further specified the maximum extent of interest deductibility that countries could allow. Most countries chose to permit firms to deduct interest payments up to the maximum ceiling permitted by the EU and postponed the introduction of the reform for as long as permitted, making the reforms in question, and their introduction, plausibly exogenous.

The results using just EU countries are summarized in Panel C of Table 2. The coefficients on $Post_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ remain statistically significant and economically similar to those in the full sample.

Figure 1 plots the coefficients of $Post_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ separately estimated for each of 14 countries with at least 500 firms that enter the regression specification. Across the 42 specifications using the three measures of leverage as the dependent variable, the coefficient of interest is negative in 31 instances, negative and significant in 21 instances, positive in 11 instances, and positive and significant in 3 instances. Thus, in the majority of cases, the country-level results align with the traditional tax view.

[Insert Figure 1 here]

Figure 2 displays the coefficients of the year-by-year interaction between T, the time relative to the introduction of the interest ceiling rule in a country, and the indicator $\mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$. The year prior to the introduction of the rule serves as the benchmark. Regardless of the leverage measure used, the results point to an immediate, persistent, and significant reduction in the leverage of affected firms following the introduction of

the interest ceiling rule. The plot also demonstrates that the reductions in the leverage ratios are unlikely due to the continuation of their pre-existing time trends.

[Insert Figure 2 here]

5.2. Firms More Likely to Be Affected by A Tax Reform

As discussed in Section 3.2, a tax reform should have a greater impact on firms that fully deduct interest payments. To investigate whether the data support this notion, we estimate regressions that test model (5). These regressions include country-year fixed effects (in addition to industry-year and firm consolidation level fixed effects). The focus is on the extent of interest deductibility, along with its interaction with the corporate income tax rate. The regression results are tabulated in Table 3.

[Insert Table 3 here]

The results show that firms with a larger fraction of deductible interest payments increase leverage more in response to a tax-increasing reform. Following a 10 percentage point tax rate increase, a firm with fully deductible interest payments increases its total debt-to-total assets ratio by 163 basis points (=0.1628 x 0.10), or 6.4% of the mean leverage. In contrast, a firm with interest payments that are only half deductible increases its total debt-to-total assets ratio by 81 basis points.

6. External validity

In our third test, we use standard regressions of the form of model (6) discussed in Section 3.3. In these regressions, the impact of taxes on capital structure is assessed by regressing end-of-year leverage on lagged tax rates, firm-level control variables, and country-level control variables. Each regression includes fixed effects for each firm-consolidation type and each industry-year

pair. In some specifications, we also include country-level control variables that capture other changes in the tax base.

6.1. Full Sample Standard Regressions

We employ a standard regression model that relates changes in lagged tax rates to changes in end-of-year leverage. A benefit of this approach is that it allows for combining all reforms without imposing any censoring or truncation in the data. Indeed, using a cross-country sample of tax reforms across OECD countries, Faccio and Xu (2015) document that, in their sample, the response of leverage to tax-reducing reforms is immediate and permanent.

The results in Table 4 show that corporate taxes have a positive and significant effect on the total debt-to-assets ratio, as well as on the total liabilities-to-assets ratio. The coefficient on corporate tax rates is positive, albeit insignificant, for the long-term debt-to-assets ratio.

[Insert Table 4 here]

In line with prior studies, we find that asset tangibility is positively correlated with leverage, while firm profitability exhibits a negative correlation with leverage. Revenues and revenue growth are positively related to leverage, again consistent with prior literature.

6.2. Other Provisions Contained in the Tax Reforms

Tax rate changes are only one of the many provisions that may be included in each tax reform. Other potential aspects of a reform that can affect the tax base include limitations on the deductibility of interest expenses or allowances for corporate equity deductions. Additional reform provisions may introduce special tax incentives or credits for patents, R&D investments, general investments, and allowances for accelerated depreciation. A reform may also affect the number of years for loss carrybacks and carryforwards, and so on. The data we collect from the E&Y guides allow us to control for many of these provisions. Since the E&Y guides are only available electronically starting in 2004, accounting for these provisions shortens our sample period by eight

years. This shorter time period is analyzed in Table 5.

[Insert Table 5 here]

In the regressions included in Table 5, which parallel Table 4, we find that some other aspects of the tax reforms matter. The "Patent box" indicator, reflecting a "super deduction" for qualifying intellectual property, is negative and significant in two of the three models, consistent with patents being a nondebt tax shield. The indicator for having the combined reporting rule is positive and significant in all specifications. This result is consistent with the idea that such rules enhance the capacity to exploit the deductibility of interest payments across companies.

The sign of other statistically significant indicators is, however, counterintuitive. The "Thin capitalization rules" indicator, for example, has a positive sign. The "R&D bonus/incentives/tax credit" indicator, capturing special tax treatment, bonuses, incentives, or tax credits for R&D expenses, is also positive. The coefficient of the inflation accounting indicator is negative and significant. (Inflation accounting allows companies to revalue assets to account for inflation and offset the increase in the value of assets by creating an equity reserve for the same amount.)

Importantly, when controlling for these variables, the coefficient of the corporate income tax rate variable becomes negative in two of the three models. Multicollinearity explains this loss of significance and the substantially smaller regression coefficients compared to Table 4. It likely also explains some of the other counterintuitive results. In the analyses reported in Table 6, we circumvent the issue of multicollinearity by conducting a principal component analysis on the tax base variables.

[Insert Table 6 here]

We conduct a principal component analysis of all country-level control variables, including the tax base variables, and retain the first five principal components (PCs), which collectively

explain 54.15% of the total variation of the country-level variables (excluding the tax rate). We then rerun the regressions from Table 5, replacing the country-level controls with the five PCs. Table 6 reports the results. Changes in corporate tax rates now have positive coefficients in all regressions, and two of the coefficients are statistically significant.

7. Robustness tests

This section presents and discusses robustness tests of the main test.

7.1. Smaller Private Firms

The effect of taxes on capital structure may vary with firm size. As discussed in Section 1.2, small firms tend to be financially constrained and rely heavily on debt, which makes their capital structure less sensitive to tax changes. In Figure 3, we plot the results for each size quintile. (Quintiles are defined based on total assets). The conclusions are similar to those drawn for the entire sample. Specifically, the results do not become insignificant or counterintuitive when we focus on smaller private firms.

[Insert Figure 3 here]

7.2. Pre-Covid Years

Another concern is that the results might be biased due to the effect of Covid in the last years of the sample. During those years, many governments provided debt financing, especially to small and private firms. To investigate the extent to which our conclusions are driven by Covid, we re-estimate our main specification after excluding the years 2020 and beyond. The results, presented in Panel A of Table 7, indicate that our conclusions are not driven by the pandemic.

[Insert Table 7 here]

7.3. Publicly Traded Firms

We also investigate whether the interest ceiling rules have similar effects on publicly traded firms. The results, presented in Panel B of Table 7, parallel those in Panel A of Table 2. Due to greater data availability for publicly traded firms, the results in Panel B of Table 7 cover interest ceiling rules introduced in 35 countries.

The results are highly consistent with those found in Table 2 for private firms. The coefficients on the interaction term, $Post_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$, are negative and significant in all specifications.

8. Conclusions

Using a large sample of 215,158 unique private firms spanning over a quarter of a century, we document that corporate taxes are a significant determinant of corporate capital structure choices.

Our main results exploit a large number of limitations introduced following the adoption of interest ceiling rules globally, as well as other limitations to the full deductibility of interest payments around reforms affecting the corporate income tax rate. The results of these tests provide strong evidence supporting a causal link between taxes and corporate capital structure choices. Specifically, in support of a causal effect of taxes on leverage, the results are present among (1) firms with interest payments within a narrow bandwidth of the new interest ceiling limit, and (2) in countries that could not opt out of the introduction of the interest ceiling rule.

We further show that the results based on the interest ceiling rule have external validity. Specifically, in line with standard theory, we find that private firms increase their borrowing when corporate tax rates rise and reduce their borrowing when corporate tax rates fall.

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Figure 1. Difference-in-differences coefficient plots by country

The figure below plots the coefficient estimates, along with the 10% and 90% confidence intervals, of $Post_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ in regressions run separately for each one of the 14 countries with at least 500 unique private firms. In the regressions, which parallel those in Panel A of Table 2, standard errors are clustered at the industry level.

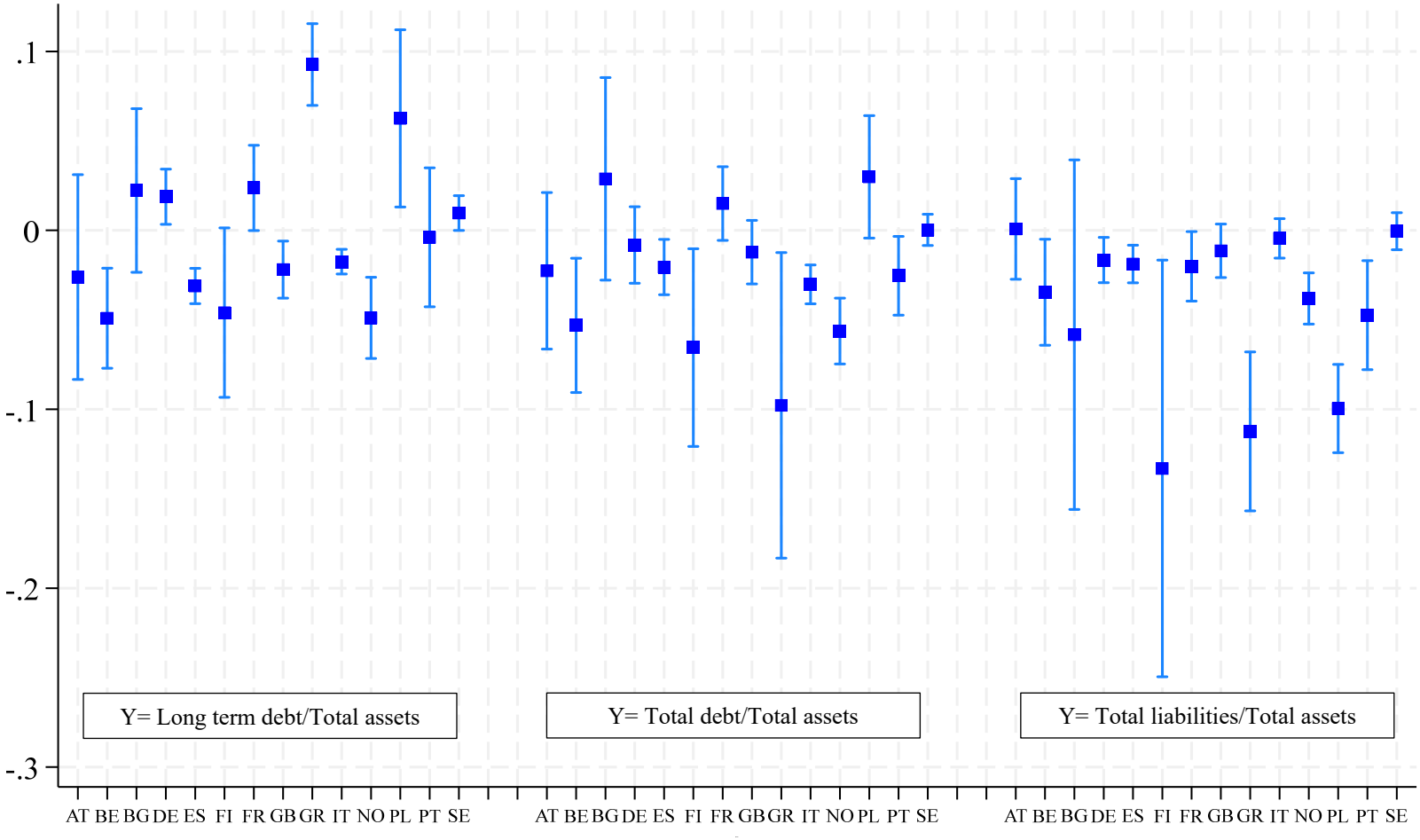


Figure 2. Parallel trends plots

The figure below plots the coefficient estimates, along with the 10% and 90% confidence intervals, of T $\times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$, where T is the time relative to the year in which the interest ceiling rule was introduced in a given country. The year preceding the introduction of the rule serves as the benchmark year.

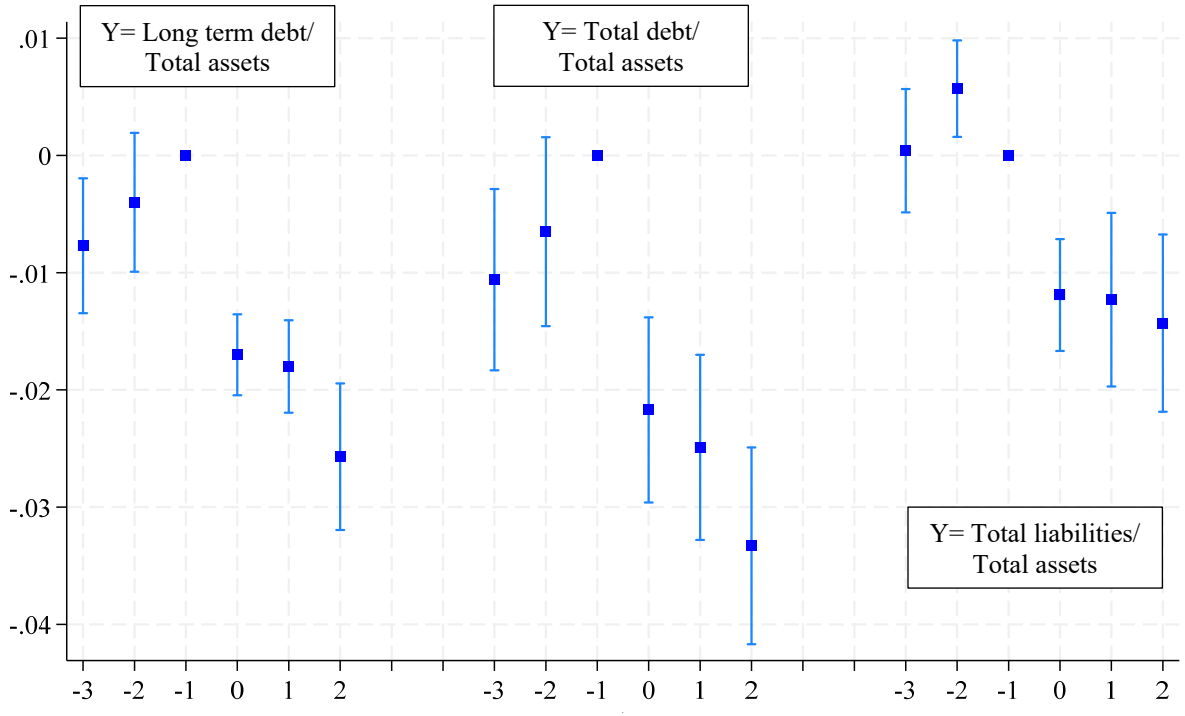


Figure 3. Results by firm size

The figure below plots, by size quintile (Q1-Q5), the coefficient estimates, along with the 10% and 90% confidence intervals, of T $\times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$, where T is the time relative to the year in which the interest ceiling rule was introduced in a given country. Q1 (Q5) is the smallest (largest) quintile of firms by total assets.

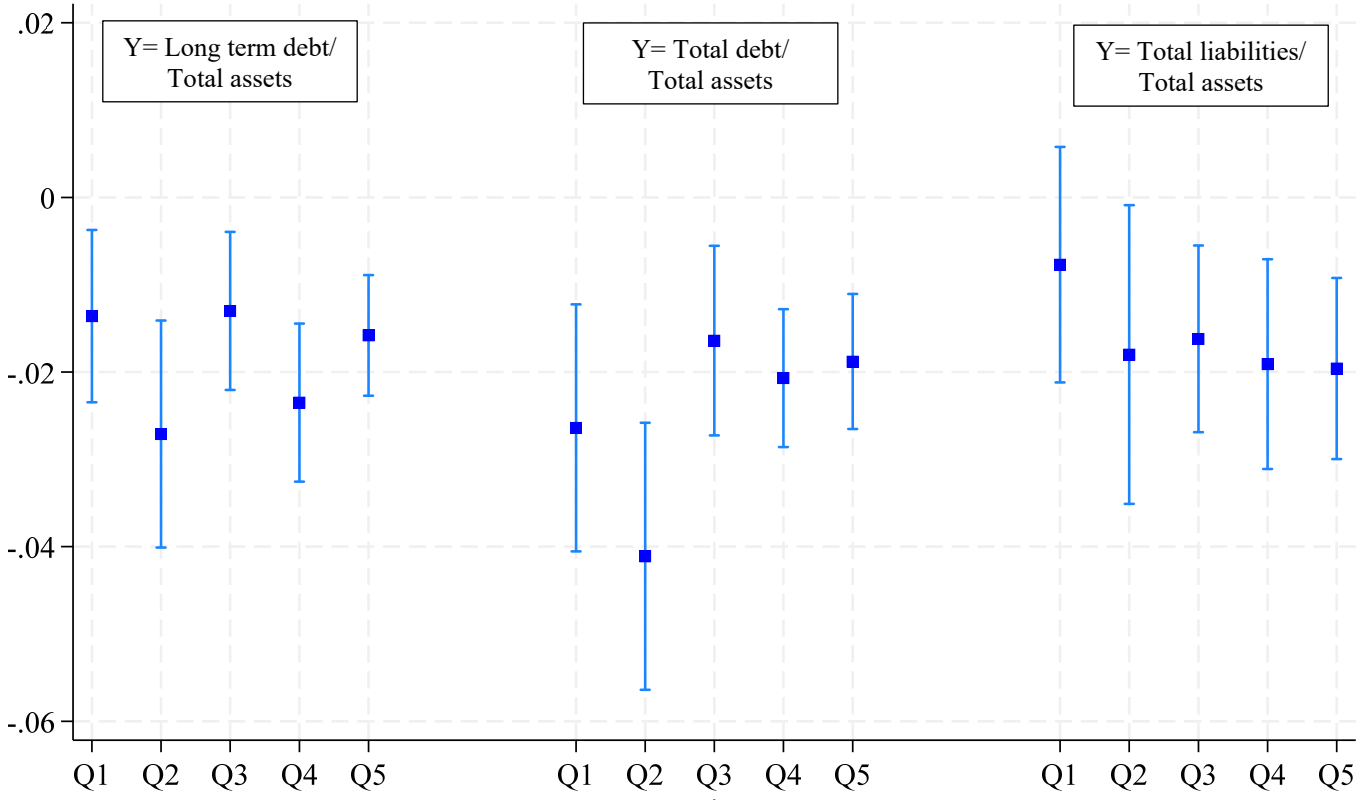


Table 1. Summary statistics.

The sample is restricted to private firms with available end-of-year data on long-term debt, loans, shareholders' funds, total assets, revenues, and lagged revenues. Variable definitions are provided in Section 2. Some of the variables are available only for a subset of country-years.

	Mean	Std. Dev.	Min	10th Pct	Median	90th Pct	Max
$(\text{Long term debt/Total assets})_t$	0.1396	0.2259	0.0000	0.0000	0.0123	0.4821	0.9835
$(\text{Total debt/Total assets})_t$	0.2534	0.2903	0.0000	0.0000	0.1529	0.6742	1.3065
$(\text{Total liabilities/Total assets})_t$	0.6491	0.3443	0.0065	0.2046	0.6630	0.9777	2.1906
$\ln(\text{Revenues})_{t-1}$	17.3952	2.0583	9.6664	14.8228	17.7148	19.5792	22.5731
$\ln(\text{Revenues})_{t-1}$-$\ln(\text{Revenues})_{t-2}$	0.0405	0.5522	-2.4480	-0.3223	0.0374	0.4233	2.4325
$(\text{Operating income/Total assets})_{t-1}$	0.0501	0.1079	-0.4140	-0.0286	0.0375	0.1621	0.4612
$(\text{Tangible assets/Total assets})_{t-1}$	0.2802	0.2868	0.0000	0.0008	0.1858	0.7638	0.9752
$(\text{R\&D/Revenues})_{t-1}$	0.0004	0.0046	0.0000	0.0000	0.0000	0.0000	0.0794
Missing $\text{R\&D}_{t-1}$	0.9339	0.2485	0.0000	1.0000	1.0000	1.0000	1.0000
$(\text{Depreciation/Revenues})_{t-1}$	0.0604	0.1345	0.0000	0.0000	0.0132	0.1608	0.9351
Missing $\text{depreciation}_{t-1}$	0.2483	0.4320	0.0000	0.0000	0.0000	1.0000	1.0000
$\mathbf{1}\{\Delta$ Non-deductible interest $\text{payments}_i > 0\}$	0.0941	0.2920	0.0000	0.0000	0.0000	0.0000	1.0000
$(\text{Fraction of deductible interest})_t$	0.7531	0.4113	0.0000	0.0000	1.0000	1.0000	1.0000
$(\text{Corporate income tax rate})_{t-1}$	0.2803	0.0656	0.0000	0.1900	0.2922	0.3699	0.5500
$(\text{Nominal borrowing rate})_{t-1}$	0.0472	0.0476	-0.0043	0.0141	0.0364	0.0915	1.1000
$(\text{Inflation})_{t-1}$	0.0248	0.0412	-0.0448	-0.0001	0.0182	0.0463	2.5531
$\ln(\text{GDP pc})_{t-1}$	10.1402	0.8231	5.9904	9.0292	10.4565	10.7795	11.8034
$\ln(\text{GDP pc})_{t-1}$-$\ln(\text{GDP pc})_{t-2}$	0.0269	0.1046	-1.3318	-0.0961	0.0299	0.1419	0.6437
$\ln(\text{Population})_{t-1}$	17.7297	1.1731	12.5022	16.0583	17.9188	18.7781	21.0676
$(\text{Unemployment rate})_{t-1}$	0.0747	0.0427	0.0010	0.0339	0.0683	0.1190	0.3111
$(\text{General interest expense limitation rule})_{t-1}$	0.2929	0.4551	0.0000	0.0000	0.0000	1.0000	1.0000
$(\text{Thin capitalization rules})_{t-1}$	0.6617	0.4731	0.0000	0.0000	1.0000	1.0000	1.0000
$(\text{Notional interest deduction})_{t-1}$	0.1220	0.3272	0.0000	0.0000	0.0000	1.0000	1.0000
$(\text{Inflation accounting dummy})_{t-1}$	0.0614	0.2400	0.0000	0.0000	0.0000	0.0000	1.0000
$(\text{Patent box})_{t-1}$	0.2017	0.4013	0.0000	0.0000	0.0000	1.0000	1.0000
$(\text{Investment incentives dummy})_{t-1}$	0.1856	0.3888	0.0000	0.0000	0.0000	1.0000	1.0000
$(\text{Number of years of operating loss carryback})_{t-1}$	0.5044	0.7243	0.0000	0.0000	0.0000	1.0000	5.0000

(Number of years of operating loss carryforward)$_{t-1}$	3.6212	4.7325	0.0000	0.0000	0.0000	10.0000	20.0000
(Indicator for indefinite years of carryback)$_{t-1}$	0.0002	0.0124	0.0000	0.0000	0.0000	0.0000	1.0000
(Indicator for indefinite years of carryforward)$_{t-1}$	0.5565	0.4968	0.0000	0.0000	1.0000	1.0000	1.0000
(Indicator for N/A carryback and carryforward years)$_{t-1}$	0.0022	0.0473	0.0000	0.0000	0.0000	0.0000	1.0000
(R&D bonus/incentives/tax credit)$_{t-1}$	0.4121	0.4922	0.0000	0.0000	0.0000	1.0000	1.0000
(Accelerated depreciation dummy)$_{t-1}$	0.7497	0.4332	0.0000	0.0000	1.0000	1.0000	1.0000
(Indicator of having combined reporting rules)$_{t-1}$	0.7052	0.4560	0.0000	0.0000	1.0000	1.0000	1.0000

Table 2. Limitations triggered by the introduction of interest ceiling rules.

The table presents OLS regression results. $\mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$ is an indicator that takes the value of 1 if a company has an incentive to reduce its leverage following the introduction of the interest ceiling rule, and 0 otherwise. $\text{Post}_{c,t}$ is an indicator that takes the value of 1 if year t coincides with or follows the introduction of the interest ceiling rule in country c, and 0 if it precedes its introduction. The sample is restricted to the three years that precede the introduction of the interest ceiling rule in a country through the two years that follow the introduction of the rule. Non-deductible interest payments are determined based on equations (2) through (4). The remaining variables are defined in Sections 2 and 3. Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Regressions for all firms affected by the introduction of interest ceiling rules.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
$\text{Post}_{c,t} \times \mathbf{1}\{\Delta \text{ Non-deductible interest payments}_i > 0\}$	-0.0167***	-0.0214***	-0.0146***
	(0.0030)	(0.0048)	(0.0044)
ln(Revenues)$_{t-1}$	0.0020*	0.0039***	0.0004
	(0.0011)	(0.0015)	(0.0024)
ln(Revenues)$_{t-1}$-ln(Revenues)$_{t-2}$	0.0011	0.0027**	0.0103***
	(0.0008)	(0.0012)	(0.0016)
(Operating income/Total assets)$_{t-1}$	-0.0654***	-0.1646***	-0.3501***
	(0.0093)	(0.0208)	(0.0260)
(Tangible assets/Total assets)$_{t-1}$	0.0620***	0.0585***	0.0216
	(0.0113)	(0.0144)	(0.0187)
(R&D/Revenues)$_{t-1}$	-0.0375	-0.1474	0.0121
	(0.0867)	(0.1639)	(0.1592)
Missing R&D$_{t-1}$	0.0005	-0.0034	-0.0034
	(0.0029)	(0.0060)	(0.0061)
(Depreciation/Revenues)$_{t-1}$	0.0170**	0.0319***	0.0343***
	(0.0067)	(0.0069)	(0.0107)
Missing depreciation$_{t-1}$	0.0065*	0.0084**	0.0060
	(0.0038)	(0.0038)	(0.0046)
Country-year FEs	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	290,862	290,862	290,862
Number of countries	25	25	25
Number of firms	55,283	55,283	55,283
R^2	0.8301	0.8585	0.8758

Panel B: Regressions for the subset of firms with interest payments either (a) within $1.25 million or (b) within 25% from the maximum deduction allowed.

	(1) (Long term debt/Total assets)$_t$	(2) (Total debt/ Total assets)$_t$	(3) (Total liabilities/ Total assets)$_t$
$Post_{c,t} \times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$	-0.0111**	-0.0240***	-0.0157**
	(0.0047)	(0.0059)	(0.0063)
Other control variables as in Table 2, Panel A	Yes	Yes	Yes
Country-year FEs	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	77,492	77,492	77,492
Number of countries	20	20	20
Number of firms	13,537	13,537	13,537
R^2	0.8348	0.8518	0.8513

Panel C: Regressions for the subset of EU-based firms.

	(1) (Long term debt/Total assets)$_t$	(2) (Total debt/ Total assets)$_t$	(3) (Total liabilities/ Total assets)$_t$
$Post_{c,t} \times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$	-0.0152***	-0.0199***	-0.0138***
	0.0030	0.0047	0.0041
Other control variables as in Table 2, Panel A	Yes	Yes	Yes
Country-year FEs	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	53,150	53,150	53,150
Number of countries	20	20	20
Number of firms	279,548	279,548	279,548
R^2	0.8265	0.8573	0.8763

Table 3. All limitations combined.

The table presents OLS regression results. The variables are defined in Sections 2 and 3. Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
(Fraction of deductible interest)$_t$	-0.0262***	-0.0916***	-0.1473***
	(0.0052)	(0.0089)	(0.0130)
(Fraction of deductible interest)$_t$ x	0.0339**	0.1628***	0.2828***
x (Corporate income tax rate)$_{t-1}$	(0.0154)	(0.0252)	(0.0403)
Other control variables as in Table 2, Panel A	Yes	Yes	Yes
Country-year FEs	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	1,301,533	1,301,533	1,301,533
Number of countries	75	75	75
Number of firms	153,803	153,803	153,803
R^2	0.7423	0.7711	0.7676

Table 4. Tax rate changes and leverage.

The table shows OLS regression results with variables defined in Sections 2 and 3. Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
(Corporate income tax rate)$_{t-1}$	0.0453	0.0621*	0.1523***
	(0.0357)	(0.0339)	(0.0368)
(Nominal borrowing rate)$_{t-1}$	0.1168***	0.1178**	0.0513
	(0.0408)	(0.0487)	(0.0703)
(Inflation)$_{t-1}$	-0.0165	-0.0219	-0.0111
	(0.0249)	(0.0333)	(0.0602)
(Unemployment rate)$_{t-1}$	0.1355***	0.1851***	0.2004***
	(0.0292)	(0.0429)	(0.0491)
ln(Population)$_{t-1}$	-0.0920***	-0.0148	-0.1374**
	(0.0346)	(0.0338)	(0.0661)
ln(GDP pc)$_{t-1}$	0.0306***	0.0600***	0.0570***
	(0.0053)	(0.0059)	(0.0074)
ln(GDP pc)$_{t-1}$-ln(GDP pc)$_{t-2}$	-0.0299***	-0.0436***	-0.0709***
	(0.0081)	(0.0100)	(0.0137)
ln(Revenues)$_{t-1}$	0.0021***	0.0036***	-0.0029
	(0.0007)	(0.0010)	(0.0024)
ln(Revenues)$_{t-1}$-ln(Revenues)$_{t-2}$	0.0026***	0.0034***	0.0130***
	(0.0006)	(0.0006)	(0.0014)
(Operating income/Total assets)$_{t-1}$	-0.0993***	-0.2491***	-0.4946***
	(0.0050)	(0.0104)	(0.0139)
(Tangible assets/Total assets)$_{t-1}$	0.0830***	0.0758***	0.0112
	(0.0061)	(0.0078)	(0.0082)
(R&D/Revenues)$_{t-1}$	-0.1486**	-0.3922***	-0.0801
	(0.0736)	(0.1007)	(0.1017)
Missing R&D$_{t-1}$	-0.0056***	-0.0144***	-0.0033
	(0.0019)	(0.0032)	(0.0034)
(Depreciation/Revenues)$_{t-1}$	0.0210***	0.0374***	0.0276***
	(0.0044)	(0.0056)	(0.0090)
Missing depreciation$_{t-1}$	-0.0022	-0.0031	0.0029
	(0.0017)	(0.0020)	(0.0028)
Industry-year FEs	Yes	Yes	Yes

Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	1,958,663	1,958,663	1,958,663
Number of countries	93	93	93
Number of firms	213,518	213,518	213,518
R^2	0.7201	0.7535	0.7514

Table 5. Controls for other changes in the tax base.

The table presents OLS regression results with variables defined in Sections 2 and 3. Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
(Corporate income tax rate)$_{t-1}$	-0.0352	-0.0246	0.1376***
	(0.0323)	(0.0346)	(0.0417)
(General interest expense limitation rule)$_{t-1}$	-0.0005	0.0020	0.0029
	(0.0026)	(0.0027)	(0.0033)
(Notional interest deduction)$_{t-1}$	0.0017	0.0034	0.0095
	(0.0036)	(0.0039)	(0.0060)
(Thin capitalization rules)$_{t-1}$	0.0073***	0.0073***	0.0081**
	(0.0020)	(0.0023)	(0.0034)
(Patent box)$_{t-1}$	-0.0004	-0.0053*	-0.0072**
	(0.0031)	(0.0029)	(0.0036)
(R&D bonus/incentives/tax credit)$_{t-1}$	0.0105***	0.0056**	-0.0018
	(0.0024)	(0.0024)	(0.0036)
(Accelerated depreciation dummy)$_{t-1}$	-0.0010	0.0053	-0.0080**
	(0.0052)	(0.0057)	(0.0039)
(Indicator of having combined reporting rules)$_{t-1}$	0.0061*	0.0077*	0.0127*
	(0.0036)	(0.0041)	(0.0065)
(Inflation accounting dummy)$_{t-1}$	-0.0075**	-0.0082**	0.0011
	(0.0030)	(0.0033)	(0.0036)
(Investment incentives dummy)$_{t-1}$	-0.0027	-0.0039	0.0009
	(0.0026)	(0.0030)	(0.0032)
(Number of years of operating loss carryback)$_{t-1}$	-0.0083***	-0.0069***	-0.0048*
	(0.0025)	(0.0020)	(0.0025)
(Number of years of operating loss carryforward)$_{t-1}$	0.0007	0.0000	-0.0003
	(0.0005)	(0.0004)	(0.0007)
(Indicator for indefinite years of carryback)$_{t-1}$	0.0016	-0.0066	-0.0040
	(0.0238)	(0.0176)	(0.0240)
(Indicator for indefinite years of carryforward)$_{t-1}$	0.0102	0.0055	0.0051
	(0.0068)	(0.0063)	(0.0074)
Other control variables as in Table 4	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes

Number of observations	1,809,246	1,809,246	1,809,246
Number of countries	91	91	91
Number of firms	208,095	208,095	208,095
R^2	0.7333	0.7686	0.7674

Table 6. Addressing multicollinearity in country-level variables: Principal component analysis.

The table presents OLS regression results with variables defined in Sections 2 and 3. The country-level control variables are replaced by the first five principal components (PC1 though PC5). Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
(Corporate income tax rate)$_{t-1}$	0.0372	0.0662*	0.1875***
	(0.0336)	(0.0361)	(0.0389)
PC1	-0.0006	0.0019	0.0012
	(0.0011)	(0.0016)	(0.0028)
PC2	-0.0009	0.0013	-0.0004
	(0.0010)	(0.0013)	(0.0021)
PC3	-0.0011	-0.0036**	-0.0012
	(0.0013)	(0.0015)	(0.0025)
PC4	0.0044***	0.0019	0.0018
	(0.0014)	(0.0013)	(0.0019)
PC5	-0.0040***	-0.0044***	-0.0040***
	(0.0012)	(0.0013)	(0.0015)
Other control variables as in Table 4	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes
Firm-consol. type FEs	Yes	Yes	Yes
Number of observations	1,809,246	1,809,246	1,809,246
Number of countries	91	91	91
Number of firms	208,095	208,095	208,095
R^2	0.7329	0.7681	0.7670

Table 7. Robustness tests

The table presents robustness tests for the results in Panel A of Table 2. Panel A shows results for the pre-Covid years, and Panel B shows the results for publicly traded firms. The variables are defined in Sections 2 and 3. Standard errors double-clustered at the industry and at the country-year levels are shown in parentheses below the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	(Long term debt/Total assets)$_t$	(Total debt/ Total assets)$_t$	(Total liabilities/ Total assets)$_t$
Panel A: Pre-Covid years			
$Post_{c,t} \times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$	-0.0168***	-0.0221***	-0.0135***
	(0.0032)	(0.0052)	(0.0048)
Other control variables as in Table 2	Yes	Yes	Yes
Number of observations	247,052	247,052	247,052
R^2	0.8474	0.8727	0.8897
Panel B: Publicly traded firms			
$Post_{c,t} \times \mathbf{1}\{\Delta$ Non-deductible interest payments$_i > 0\}$	-0.0210***	-0.0285***	-0.0258***
	(0.0073)	(0.0075)	(0.0093)
Other control variables as in Table 2	Yes	Yes	Yes
Number of observations	26,430	26,430	26,430
Number of countries	35	35	35
Number of firms	5,018	5,018	5,018
R^2	0.8468	0.8782	0.8683