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Interest Limitation Rules and Corporate Tax Avoidance: A Cross-Country Analysis

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ABSTRACT

This study examines the impact of interest limitation rules on corporate tax avoidance and financing decisions. Interest from debts is tax-deductible, making debt financing attractive for firms, yet it also poses a risk for tax avoidance, leading to global tax revenue losses estimated between $125 to $280 billion annually. Tax authorities have implemented rules limiting interest deductibility, such as the debt-to-equity ratio ("thin-capitalization rule") and the interest-to-EBITDA ratio ("earnings stripping rule"), to curb this. Using a novel regression discontinuity design and panel data from 33 countries, the study finds no strong evidence that these rules significantly deter tax avoidance. However, it suggests the thin-capitalization rule might be marginally more effective than the earnings stripping rule. Our study proposes that adjusting the debt-to-equity ratio threshold to 2:1 could yield better outcomes in reducing tax avoidance for countries with a thin-capitalization rule. For countries with an earnings stripping rule, a stronger enforcement is recommended. The study encourages future research to explore the interaction with other tax regulations, such as the de minimis rule and arm's length principles.

Keywords: interest limitation rule, thin-capitalization, earnings stripping, tax avoidance

1. INTRODUCTION

1.1 Background

One of the simplest profit-shifting techniques available for international tax planning is carried out via interest expense (OECD, 2016). There are two reasons for this. First, taxation affects company's capital structure differently between interests from debts and dividends from shares. Unlike dividends which is non-deductible from the company's profits, interests are typically deductible under fiscal rule (OECD, 2016). Secondly, the fungibility of money makes it a relatively easy to adjust the capital mix of debt and equity, especially in related party entities in different jurisdictions (OECD, 2016). From an economic standpoint, debt financing is preferred by corporate taxpayers, especially multinational enterprises (MNEs) compared to equity financing, as there is an incentive to finance their firm as close to 100% debt as possible. Tax authorities understandably consider that excessive debt financing provides an opportunity for tax avoidance (Modigliani & Miller, 1963).

Tax avoidance is one of major economic issues that affects almost every country in the global economy, often lies in grey area of legal loopholes (Gravelle, 2015). A conservative estimate of worldwide tax revenue loss put the amount to $125-280 biillion annually, some of which are channelled via debts (Clausing, 2016; Janský & Palanský, 2019). Another estimate put it as large as

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between $500-600 billion annually (Cobham & Janský, 2018; Crivelli et al., 2015).

The impact of such tax revenue loss is especially more severe for developing countries. Of the lost tax revenue, around $200 billion are from low-income economies – a larger hit as a percentage of GDP than advanced economies, and far larger than $150 billion those countries receive each year in foreign development assistance (Shaxson, 2019). This situation further leads to under-provision of tax-financed public goods, unfair competitive environment for small and medium domestic enterprise, and reduction in fiscal autonomy (Dietsch, 2015).

In response to these challenges, the OECD/G20 Inclusive Frameworks introduced the BEPS (Base Erosion and Profit Shifting) Action Plan 4. This plan focuses on developing best practice recommendations for designing rules to prevent base erosion via excessive interest deductions (OECD, 2013). At present, various countries have introduced a wide range of general interest limitation rules which put an overall limit on the level of interest deductions, as well as targeted rules that disallow interest for specific transactions (OECD, 2016). The OECD considers the general approach as more desirable to ensure consistency in tax treatment and to reduce the avoidance risk by companies structuring its debts into a different legal form (OECD, 2016).

The design for general interest limitation rule can take form as rules which limit the level of interest expense or debt with reference to a certain fixed ratio (OECD, 2016). A survey of the OECD/G20 Inclusive Frameworks countries shows that the most common fixed ratios used are debt-to-equity ratio (DER) and interest-to-earnings ratio (OECD, 2020). Debt-to-equity ratio (DER) approach or the "thin-capitalization" rule, refers to the proportion of debt-financing relative to equity in the firm's capital structure. Examples for countries with thin capitalization rule include China with 2:1 DER threshold (McKee, 2009), Brazil with 2:1 limit (Deloitte, 2010), and Indonesia with 4:1 maximum DER (Zaina, 2017).

Interest-to-earnings ratio, on the other hand, makes a reference to the proportion of interest expense to the firm's income. Numerous European countries implement an interest deduction limit of 30% from the firm's earnings before interest, tax, depreciation, and amortization (Deloitte, 2021).

The selection of these fixed ratios and their respective threshold values reflects a country's administrative capabilities and foreign investment policies (OECD, 2016). While the DER is simpler to apply (Webber, 2010), the interest-to-EBITDA ratio aims directly at the tax base (Barnes, 2014; Mardan, 2015). The choice in threshold settings across countries also indicates differing levels of tolerance for debt financing and the trade-offs between capital control and potential tax revenue (Fernandes, 2019). Firms will thus respond differently with regards to the different design of interest limitation rule. This study attempts to evaluate whether interest limitation rules affect corporate tax avoidance and firm's financing decision, conditional on the fixed ratio used and threshold value in different countries.

1.2 Policy Relevance

Firms in high-tax countries tend to favor debt financing over equity financing (Desai et al., 2004; Huizinga et al., 2008; Mintz & Weichenrieder, 2005; Møen, et al., 2011). This situation creates higher tax avoidance risk in developing countries where many subsidiaries of multinational enterprises are located (Fuest et al., 2011). As a result, the fiscal autonomy of developing countries is significantly impacted by reduction in tax revenue, hence limiting their ability to influence the size of the public budget relative to GDP and their capacity for redistribution according to the preferences of their citizens (Dietsch, 2015).

The results of this research may inform policymakers on whether a certain type of interest limitation rule could be associated with lower levels of tax avoidance. Additionally, existing studies typically examine the effectiveness of interest limitation rules within single-country settings. There remains a lack of cross-country empirical analysis comparing the two rule types. Furthermore, most literature focuses on either rule in isolation, without investigating wholistically how their differing threshold structures possibly affect

firm behavior in diverse regulatory contexts. This study addresses that gap by employing a novel multi-cutoff regression discontinuity design (RDD) (Cattaneo et al., 2020) using firm-level panel data from 33 countries between 2015 and 2020. By leveraging natural discontinuities in DER and interest-to-EBITDA thresholds, the study provides a cross-country causal evaluation of how different interest limitation rules affect corporate tax avoidance.

The study's key contributions are threefold:

1. It is among the first to use multi-cutoff RDD to isolate causal effects across countries with heterogeneous threshold rules.
2. It offers a direct empirical comparison between DER-based and EBITDA-based interest limitation rules.
3. It attempts to identify threshold-specific effects as a potentially optimal cutoff for improving tax compliance.

This study thus offers to answer the following research questions:

1. *What is the impact of DER-based interest limitation rules on corporate tax avoidance?*
2. *What is the impact of interest-to-EBITDA-based interest limitation rules on corporate tax avoidance?*

2. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 Interest Limitation Rules

Interest payments on debt are generally tax-deductible, unlike dividends from equity. This encourages the proliferation of thinly capitalized corporations primarily financed through debt (Buettner, et al. 2014). While in domestic settings the tax differences between debt and equity may not significantly alter the overall tax burden (due to interest being taxable income for bondholders and dividends often receiving tax relief for shareholders), the international context amplifies tax avoidance risks. This is because bilateral tax treaties typically grant tax rights on interest earnings to the creditor's home country, potentially reducing or eliminating withholding taxes, thus facilitating profit shifting through excessive debt financing (OECD, 2015).

The OECD's BEPS Action 4 Final Report aims to mitigate base erosion and profit shifting (BEPS) facilitated by the deductibility of interest and other financial payments. It recommends that interest limitation rules should encompass all forms of interest and economically equivalent payments, addressing both third-party and intragroup debts to ensure consistent treatment across different legal entities and situations, including domestic arrangements like back-to-back loans (OECD, 2015).

Interest limitation rules, as defined by the OECD, are categorized into six types, ranging from 1) arm's length tests of interest rate, 2) withholding taxes, 3) de minimis threshold for interest payment, 4) fixed ratio rules, 5) group-level rule, and 6) targeted anti-avoidance measures (OECD, 2016). The rules vary in their complexity and approach to limiting interest deductions, with some focusing on the entity's debt levels compared to arm's length conditions, while others limit deductions based on fixed ratios like debt-to-equity or interest-to-earnings (OECD, 2015).

Fixed ratio rules, particularly the debt-to-equity ratio (thin-capitalization rule) and the interest-to-earnings ratio (earnings stripping rule), are widely implemented due to their simplicity and their direct correlation with economic activity (OECD, 2015). However, the effectiveness of these rules in addressing BEPS issues varies, with the OECD suggesting that some approaches may not adequately target interest payment-related BEPS concerns as standalone solutions (OECD, 2015).

The debt-to-equity ratio, while easy to administer and to obtain the relevant information on firm's debt and equity level (Webber, 2010), grants the firms significant flexibility in setting interest rates beyond arm's length rate insofar as the firms are sufficiently capitalized (OECD, 2016). Furthermore, it may incentivize entities to increase their borrowing to maximize interest deductions (i.e., "race to the threshold") (OECD, 2015). Conversely, the earnings stripping rule, which considers the firm's productivity by using earnings before interest, taxes, depreciation, and amortization (EBITDA) as a denominator, directly links to the profitability as the tax base (Barnes, 2014; Mardan, 2015; Merlo and Wamser, 2014).

However, it still allows for the possibility of claiming excessive interest deductions (OECD, 2015).

As of 2019, 67 countries in the OECD/G20 Inclusive Framework have implemented interest limitation rules, but there is no consensus on the preferred approach, with some countries adopting the debt-to-equity ratio and others opting for the interest-to-EBITDA ratio (OECD, 2020). This divergence highlights the ongoing challenge in harmonizing international efforts to curb tax avoidance and profit shifting through debt financing.

2.2 Hypotheses Development

Modigliani and Miller (1958) irrelevance proposition theorem argued that in a perfect market with no tax, no asymmetric information, no transaction cost, and no bankruptcy cost, a firm's value is unaffected by its mix of debt and equity financing. However, their subsequent revision in Modigliani and Miller (1963) acknowledged the deductibility of interest payment and found that levered firms will have greater enterprise value compared to unlevered firms depending on corporate income tax rate and the debt value.

We can illustrate a simplified version of parent-subsidiary multinational group. The after-tax income of an unlevered subsidiary (π_U^{sub}) is given by:

$$\pi_U^{sub} = \left(1 - \tau_C^{sub}\right).EBIT^{sub} \quad (1)$$

where τ_C denotes corporate tax rate and EBIT denotes earnings before interest and tax[1]. The after-tax income of levered subsidiary in the absence of DER-based thin-capitalization rule is given by:

$$\pi_U^{sub} = \left(1 - \tau_C^{sub}\right).(EBIT^{sub} - \mu.I^{sub} - \lambda.I^{sub}) \quad (2)$$

where μ denotes the proportion of subsidiary's debts that comes from internal creditor, in this case from its own parent; and λ denotes proportion of external debts (e.g., from commercial bank).[2]

If 100% of the subsidiary's after-tax income is distributed to the parent, and a fraction of γ of this dividend is taxable at the parent level (due to exemption, for example), then the after-tax income of the parent is given by:

$$\pi_L^{par} = \left(1 - \tau_C^{par}\right).EBIT^{par} + \left(1 - \tau_C^{sub}\right)\left(1 - \gamma.\tau_C^{par}\right).EBIT^{sub} \quad (3)$$

for unlevered firm, and for levered firm[3]:

$$\pi_L^{par} = \left(1 - \tau_C^{par}\right).[EBIT^{par} - I^{par}] + \left(1 - \tau_C^{sub}\right)\left(1 - \gamma.\tau_C^{par}\right).\left(EBIT^{sub} - I^{sub}\right) \quad (4)$$

Now we assume that DER-based thin-capitalization rule applies for both internal and external debts, i.e., any interest above a certain threshold is non-deductible. Denote H as the non-deductible portion of interest rate, given by (dropping the superscript):

$$H = \max\left(\left(1 - \frac{\overline{D}}{D}\right).I, 0\right) \quad (5)$$

where $\overline{D}$ denotes the debt-to-equity ratio threshold as specified by the country's interest limitation rule, and D denotes the company's current debt-to-equity ratio[4].

Suppose the rule stipulates that the non-deductible portion of the interest payment is reclassified as dividends[5], for which the after-tax profit of the subsidiary becomes:

$$\pi_{U,DER}^{sub} = \left(1 - \tau_C^{sub}\right).[EBIT^{sub} - \mu.(I^{sub} - H^{sub}) - \lambda.(I^{sub} - H^{sub})] \quad (6)$$

[1] We assume depreciation = investment, following Bachmann, et al., 2015.

[2] We assume that for taxation purpose, the interest rate for internal debt is equal to the external debt due to the application of arm's length principle rule, following De Nerée tot Babberich, 2009.

[3] Included in $EBIT^{par}$ is the interest income from subsidiary $\mu.I^{sub}$.

[4] Tax authority will not grant any "negative tax credit" if the DER of the firm is below the maximum allowable DER. For example, suppose the firm has $10 in interest payment and a DER of 2:1, and the country has thin-capitalization rule of maximum 3:1 DER. The firm can deduct all $10 of the interest. If the firm has a DER of 4:1, (1 – ¾) × $10 = $2.5 is non-deductible and the firm can only deduct $7.5.

[5] Indonesian thin-capitalization rule, for example, applies this way. Different modes of application are also discussed in Bachmann, et al., 2015.

And the parent's after-tax income becomes:

$$\pi_{L,DER}^{par} = \left(1-\tau_C^{par}\right).\left(EBIT^{par} - I^{par} + H^{par}\right) + \left(1-\gamma.\tau_C^{par}\right).\left[\left(1-\tau_C^{sub}\right).\left[EBIT^{sub} - \mu.\left(I^{sub}-H^{sub}\right) - \lambda.\left(I^{sub}-H^{sub}\right)\right]\right] \quad (7)$$

Subtracting equation (4) with (7), multiplying it by τ_C^{sub} then τ_C^{par}, and substituting *H* by equation (5) implies an increase in tax liability by:

$$\left(\tau_C^{par}.\left(1-\frac{\bar{D}^{par}}{D^{par}}\right).I^{par}\right) + \left(\gamma.\tau_C^{par}.\tau_C^{sub}.\left(1-\frac{\bar{D}^{sub}}{D^{par}}\right).I^{sub}\right) > 0 \quad (8)$$

On the other hand, according to the earnings stripping rule, the tax-deductibility of interest expense does not depend on whether the firms' debt-to-equity ratio exceeds certain threshold. The non-deductible portion *H* is given by:

$$H = \max\left(\frac{I}{EBIT+\delta+\alpha} - \chi.\left(EBIT+\delta+\alpha\right), 0\right) \quad (9)$$

where χ denotes the percentage of maximum interest-to-EBITDA as stipulated by the country's interest limitation rule, δ is depreciation, and α is amortisation.[6]

Similar to equation (8), and substituting *H* by equation (5) implies an increase in tax liability by:

$$\left(\tau_C^{par}.\frac{I^{par}}{EBIT^{par}+\delta^{par}+\alpha^{par}} - \chi^{par}.\left(EBIT^{par}+\delta^{par}+\alpha^{par}\right)\right) + \left(\gamma.\tau_C^{par}.\tau_C^{sub}.\frac{I^{sub}}{EBIT^{sub}+\delta^{sub}+\alpha^{sub}} - \chi^{sub}.\left(EBIT^{sub}+\delta^{sub}+\alpha^{sub}\right)\right) > 0 \quad (10)$$

Compared to thin-capitalization rule in equation (8), equation (10) implies that earnings stripping rule do not depend on company's capital mix of debts and equity. Theoretically, it is possible for a firm with 100% debt-financing to not be affected by the interest limitation rule, insofar as the interest payment is sufficiently small relative to EBITDA.

Given that companies will seek to optimize their debt level considering tax rate, interest limitation rule, as well as the costs and benefits of using debt-financing based on the theoretical framework as outlined above, we are interested in posing the following hypotheses:

Hypothesis 1 (DER-based Rule):

- *H_{01} (Null Hypothesis): The implementation of DER-based interest limitation rules has no significant effect on corporate tax avoidance.*
- *H_{a1} (Alternative Hypothesis): The implementation of DER-based interest limitation rules has a significant effect on corporate tax avoidance.*

Hypothesis 2 (Interest-to-EBITDA-based Rule):

- *H_{02} (Null Hypothesis): The implementation of interest-to-EBITDA-based interest limitation rules has no significant effect on corporate tax avoidance.*
- *H_{a2} (Alternative Hypothesis): The implementation of interest-to-EBITDA-based interest limitation rules has a significant effect on corporate tax avoidance.*

Firms may seek to achieve favorable tax treatment simply by adjusting the amount of debt within its group (OECD, 2015). Empirically, Graham (1996) found evidence based on US firm data which indicates that high-tax-rate firms issue more debt than their low-tax-rate counterparts. Similar findings of tax-motivated debt-financing can also be found in studies in Italian firms (Alworth & Arachi, 2001), Japanese firms (Kunieda et al., 2011), German firms (Hartmann-Wendels et al., 2012), and Indian firms (Sinha and Bansal, 2013). A meta-analysis by Feld et al. (2013) based on 48 previous studies further found that an increase of marginal tax rate by 1 percentage point increase debt ratio of about 0.27 percentage point.

[6] Similar to footnote 4, tax authority will not grant any "negative tax credit" if the interest-to-EBITDA of the firm is below the maximum percentage. For example, suppose the firm has $10 in interest payment and $100 in EBITDA (10% interest-to-EBITDA), and the country has an earnings stripping rule of maximum 30% of interest-to-EBITDA ratio. The firm can deduct all $10 of the interest. If the firm has $40 in interest payment, only $30 is deductible for tax purpose.

3. RESEARCH METHODOLOGY

3.1 Data Sources

This study will employ secondary, quantitative data. The firm-level data is available on Bureau van Dijk's Orbis database.

Our country selection is based on the interest limitation rule statistics publicly available on the OECD's Corporate Tax Statistics Database. We remove countries with both DER- and interest-to-EBITDA-based rules in place (e.g., Japan, South Korea, and France) due to the limitation of our RDD methodology that is not designed to decompose the effect from such a dual rule[7].

We first collect data from 2015-2020, with the starting year 2015 corresponds to the reaching of the consensus marked by the issuance of BEPS Action 4 Final Reports.

Certain countries exempt or set higher debt limits for financial institutions due to their nature of being highly debt-financed, such as banks recording customer deposits as liabilities. Similarly, extractive industries may be exempted because their contracts often mandate maintaining sufficient capital without excessive debt (Mitchell, 2013). Consequently, this study excludes financial and extractive industries based on their NACE codes (NACE code B – mining and quarrying and K – financial and insurance activities), along with public service (NACE code O) and extraterritorial bodies (NACE code U), as they are exempt from corporate income tax anyway.

Our preliminary sample consists of 213,900 firms × 6 years = 1,283,400 firm-year observations. Nevertheless, some countries such Germany or Mexico had implemented interest limitation rule prior to 2015. This is not an issue from methodological standpoint as we are still interested to evaluate their implementation. However, we note that countries such as Indonesia and Sweden introduced their interest limitation rules later than 2015. Subsequently, we remove the observations from the years prior to interest limitation rule implementation based on the implementation year data from BIAC (2015), Crowe Horwath (2016), Deloitte (2021), De Mooij & Hebous (2017).

The country list, the sample selection criteria, and the final sample per country are available on the Appendix A, B, and C respectively.

3.2 Identification Strategy

The study adopts a quantitative approach using RDD, leveraging the quasi-experimental conditions created by arbitrary thresholds (e.g., DER or interest-to-EBITDA). The underlying assumption that the relationship between effective tax rate and DER, for example, would have been "smooth" apart from the discontinuity at the cut-off.

To accommodate varying interest limitation ratio and thresholds across countries, this study uses a method by Cattaneo, et al. (2020) for handling multiple noncumulative cut-offs, employing local polynomial and robust bias-corrected estimations. This approach extends RDD to scenarios with multiple groups sharing similar variables but differing in cut-off points. This approach enhances the understanding of treatment effects without reducing the data to a single effect estimate, by allowing for both pooled and cut-off-specific effect analyses. The analysis employs Stata's **rdmc** package for the implementation.

The estimation for hypothesis (1) would take the general form of:

$$ETR_{ijt} = \alpha_{ijt} + \beta(ILR|DER_{ijt}, C_j)_{ijt} + f(DER)_{ijt} + \gamma Z_{ijt} + \epsilon_{ijt} \quad (11)$$

where ETR_{ijt} denotes the effective tax rate, which is calculated by dividing the tax expense of taxpayer *i* domiciled in country *j* in year *t* by its pre-tax income in the same year.

$ILR|DER_{ijt}$ denotes our treatment variable, which is a dummy equals to 1 if the taxpayer is subject to interest limitation rule based on a country specific cut-off C_j. DER_{ijt} denotes our running variable, the debt-to-equity ratio. Due to methodological limitation, we do not take *de minimis rule* or interplay with arm's length principle

[7] While Cattaneo, et al. (2020)'s method may allow for more than one running variables, it does not allow for multiple running variables with multiple different cut-off values.

rule into account. However, we provide robustness check (Cattaneo et al., 2018) as well as supplementary analysis to strengthen our conclusion which will be outlined in the next section.

f(DER) would take polynomial in the order of 2 (quadratic) at most to avoid the following issues that higher order polynomial > 2 poses: 1) it assigns too much weight to points that are far from discontinuity, leading to noisy estimates; 2) the point estimates become wider as the order of polynomial gets higher, leading to overly "sensitive" and unstable estimates; 3) the standard errors get larger and the confidence intervals get narrower thus failing to take into account Type 1 error, i.e. it tends to over-reject the null (Gelman and Imbens, 2019). Z_{ijt} denotes the control variables as specified in the next section, and ε_{ijt} represents the error term.[8]

In the similar vein, the estimation for hypothesis (2) would take the form of:

$$ETR_{ijt} = \alpha_{ijt} + \beta(ILR|INT\_EBITDA_{ijt}, C_j)_{ijt} + f(INT\_EBITDA)_{ijt} + \gamma Z_{ijt} + \epsilon_{ijt} \quad (12)$$

where INT_EBITDA_{ijt} denotes our second running variable, the interest-to-EBITDA ratio, which is calculated by dividing the interest expense of taxpayer *i* domiciled in country *j* in year *t* by its EBITDA in the same year. $ILR|INT\_EBITDA_{ijt}$ denotes our treatment variable, which is a dummy equals to 1 if the taxpayer is subject to interest limitation rule based on a country specific cut-off C_j. *f(INT_EBITDA)* would similarly take the polynomial in the order of 2 at the maximum. Z_{ijt} denotes the control variables, and ε_{ijt} represents the error term.

3.3 Variable Construction

3.3.1. Dependent Variable

Measuring true corporate tax avoidance is complex due to tax return and audit confidentiality. This study thus adopts the effective tax rate (*ETR*) as a proxy generally used in tax avoidance studies (Hanlon and Heitzman, 2010), calculated by dividing income tax expense by pre-tax income, under the premise that lower *ETR* suggests higher tax avoidance.

3.3.2. Independent Variable

The summary statistics is provided in Appendix D Our independent variable *ILR* is a dummy variable for the presence of an interest limitation rule. For hypotheses (1), first we calculate the debt-to-equity ratio (*DER*) from the firm's debt divided by shareholders' equity. For hypotheses (2), we calculate the interest-to-EBITDA ratio (*INT_EBITDA*) from dividing the firm's interest expense by earnings before interest, tax, depreciation, and amortization. Then we label 1 for all firms exceeding the *DER* or *INT_EBITDA* threshold based on the rule within their domiciled country, and 0 for others.

3.3.3. Control Variables

We include several control variables that are commonly associated with both tax avoidance behavior and capital structure decisions. These variables capture firm-specific characteristics that may confound the relationship between interest limitation rules and effective tax rates.

SIZE, measured by the natural logarithm of total assets. Larger firms are more likely to engage in complex tax planning due to greater resources and scale economies in tax avoidance (Taylor and Richardson, 2013). They also tend to face lower bankruptcy risk, making them more capable of sustaining higher debt levels (Clemente-Almendros & Sogorb-Mira, 2016).

PROFITABILITY, calculated as pre-tax income over total assets. More profitable firms generally have a higher incentive to reduce taxable income, but also greater capacity to service debt.

[8] Country or time fixed effects are not included in the regression model. Lee and Lemieux (2010) argue that in RDD, fixed effects are not necessary for identification, since it relies on comparing individuals just below and above the threshold, and can be effectively done using a single cross-section. Adding fixed effects could unnecessarily complicate the model without improving identification. Nevertheless, we include country and time fixed effects in the supplementary OLS analyses below.

Prior studies show mixed findings on the relationship between profitability and tax avoidance, warranting its inclusion as a control (Clemente-Almendros & Sogorb-Mira, 2016; Rego, 2003; Taylor & Richardson, 2013).

CAPITAL_INTENSITY, the ratio of net property, plant, and equipment to total assets. Capital-intensive firms often benefit from higher depreciation tax shields and may prefer debt financing to fund long-term investments (Clemente-Almendros & Sogorb-Mira, 2016; Taylor & Richardson, 2013). Including this variable helps isolate the effect of interest limitation rules from other tax shield mechanisms (Taylor and Richardson, 2013).

INVENTORY_INTENSITY, the inventory to total assets ratio. Firms with high inventory levels typically have fewer opportunities for tax avoidance, as inventory costs are not directly deductible. (Stickney & McGee, 1982; Taylor & Richardson, 2013). Furthermore, inventories are typically current assets and not financed using long-term debts, in contrast to the decision making faced by the firm for their capital expenditures.

MULTI, a binary variable indicating whether a firm has at least one foreign subsidiary. Multinational enterprises often exploit cross-border tax differentials and use intra-group financing for tax purposes, making them more susceptible to interest limitation rules (Egger et al., 2014; Haufler & Runkel, 2008; Rego, 2003; Taylor & Richardson, 2013; Webber, 2010).

RISK, proxied by the Altman (1968) Z-score, accounts for bankruptcy risk**.** Financially distressed firms may engage in aggressive tax planning to preserve liquidity, while also facing constraints in accessing external debt (Clemente-Almendros & Sogorb-Mira, 2016; Graham, 1996; Mackie-Mason, 1990; Richardson, et al., 2015). This variable controls for the possibility that higher-risk firms systematically differ in their tax behavior and financing structure.

3.4 Robustness Checks

3.4.1. Density Manipulation Test

A key assumption that underpins the validity of RDD is that there should be no manipulation or systematic selection into treatment. Suppose we are measuring student's future income conditional on getting scholarship, with scholarship assignment based on test score. If students systematically cheat during test, students with lower ability may have gotten the scholarship, which will bias the estimation toward zero. Similarly, variables like interest-to-EBITDA or DER might not be completely exogenous due to influence from other tax strategies or financing choices, necessitating a manipulation check in the data.

McCrary (2008) introduced manipulation testing in RDD to ensure the running variable near the cut-off hasn't been systematically altered, where a continuous density of units suggests no manipulation. Discontinuities at the cut-off (i.e., "kinking" or "bunching") could indicate self-selection or nonrandom sorting (Cattaneo et al., 2018).

This study will use the estimator developed by Cattaneo et al., (2018), which is based on a novel local-polynomial density estimator and kernel function which does not require pre-binning of the data. It takes the general form of:

$$T_p(h) = \frac{\hat{f}_{+,p}(h) - \hat{f}_{-,p}(h)}{f}$$

$$\hat{V}_p^2(h) = \hat{\mathbb{V}}\{\hat{f}_{+,p}(h) - \hat{f}_{-,p}(h)\} \qquad (13)$$

where $\boldsymbol{T_p(h) \sim \mathcal{N}(0,1)}$ under appropriate data-collection assumptions, and the notation $\hat{\mathbb{V}}\{.\}$ denotes some plug-in consistent estimator of the population quantity $\mathbb{V}\{.\}$. $\boldsymbol{\hat{f}_{+,p}(h)}$ and $\boldsymbol{\hat{f}_{-,p}(h)}$ denote local-polynomial density estimators, and $\boldsymbol{\widehat{V_p}(h)}$ is the corresponding standard error estimator (Cattaneo et al., 2018). The null hypothesis for this test is that there is no discontinuity in density near the cut-off value. If the test fails to reject the null at statistically significant level, we can assume that there is no systematic manipulation in our running variable in our data.

3.4.2. Placebo/Falsification Test

This study includes a falsification test to assess if the treatment effect is nonexistent when expected, utilizing placebo cut-offs distinct from the actual

interest limitation rule thresholds. The absence of discontinuity at these placebo thresholds, based on the assumption that no other relevant policies are introduced at these alternative scores, indicates the treatment effect's validity (Cattaneo & Titiunik, 2022).

The test involves modifying the cut-off points by +7.5% and +10% and checking for discontinuities in outcomes like ***ETR*** against these placebo thresholds. The estimation for placebo cut-off would take the form of:

$$Y_{ijt} = \alpha_{ijt} + \beta(X|C^*)_{ijt} + f(X)_{ijt} + \gamma Z_{ijt} + \phi_j + \tau_t + \epsilon_{ijt} \quad (14)$$

where Y_{ijt} denotes the outcome variable (***ETR***), X_{ijt} denotes our running variable (DER or interest-to-EBITDA) with a placebo cut-off C^*_{ijt} which is the original cut-offs +7.5% and +10%. Z_{ijt} denotes covariates and ε_{ijt} represents the error term.

Additionally, the study investigates the relationship between covariates and the running variable (DER or interest-to-EBITDA) to ensure no discontinuity exists in variables unaffected by the treatment, fulfilling the null hypothesis that these covariates remain continuous across the threshold (Rosenbaum, 2010).

This analysis uses arbitrary variable as placebo outcomes in place of the actual outcome variable (***ETR***). We then examine their behavior around the actual interest limitation rule cut-offs. The estimation for placebo output would take the form of:

$$Y^*_{ijt} = \alpha_{ijt} + \beta(X|C)_{ijt} + f(X)_{ijt} + \gamma Z_{ijt} + \phi_j + \tau_t + \epsilon_{ijt} \quad (15)$$

where Y^*_{ijt} denotes the placebo outcome, which in this case are ***SIZE***, ***PROFITABILITY***, and ***RISK***. X_{ijt} denotes our running variable with a cut-off C_{ijt} in accordance with the current interest limitation rule. Z_{ijt} denotes all covariates (except one being designated as placebo), and ε_{ijt} represents the error term (Cattaneo & Titiunik, 2022).

3.5 Supplementary OLS Analysis

To supplement our RDD, we will also conduct an ordinary least square (OLS) regression. We incorporate a computationally efficient estimator from Correia (2017) for handling multiple fixed effects across individuals, countries, and years. This approach allows for the absorption of varied fixed effects levels within the data.

In accordance with hypothesis (1), we will estimate the following model:

$$ETR_{ijt} = \alpha_{ijt} + \beta(SUBJECT)_{C_jijt} + \eta(DER)_{ijt} + \mu(SUBJECT \times DER)_{ijt} + \gamma Z_{ijt} + \phi_j + \tau_t + \epsilon_{ijt} \quad (16)$$

where $SUBJECT_{Cijt}$ is a dummy variable equals to 1 if the taxpayer is subject to interest limitation rule based on a country specific cut-off C_j. DER_{jt} denotes the debt-to-equity ratio and $SUBJECT \times DER_{ijt}$ represents interaction term to take into account difference in slope between untreated and treated taxpayers. Z_{ijt} denotes the covariates, i.e., ***SIZE***, ***PROFITABILITY***, ***CAPITAL_INTENSITY***, ***INVENTORY_INTENSITY***, ***MULTI***, and ***RISK*** as defined in the previous section. Φ_j and τ_t denote country fixed effects and time fixed effects, respectively. ε_{ijt} represents the error term.

In a similar vein, the OLS estimation for hypothesis (2) would take the form of:

$$ETR_{ijt} = \alpha_{ijt} + \beta(SUBJECT)_{C_jijt} + \eta(INT\_EBITDA)_{ijt} + \mu(SUBJECT \times INT\_EBITDA)_{ijt} + \gamma Z_{ijt} + \phi_j + \tau_t + \epsilon_{ijt} \quad (17)$$

where everything is defined similarly except the fixed ratio of choice.

4. RESULTS AND DISCUSSIONS

The regression discontinuity (RD) plots for hypotheses (1) and (2) are as follows. Visual analysis of the 5 ***DER*** cut-offs reveals tax payment discontinuities around 1:1, 2:1, and 3:1, as shown in the top RD plot of Figure 1. Conversely, the bottom RD plot in Figure 1 shows no clear ***ETR*** discontinuity near various ***INT_EBITDA*** cut-offs, except for a notable jump near zero.

To strengthen our analysis beyond visual observations, we conduct RDD analyses for each hypothesis, yielding 4 models—two per hypothesis, varying by covariate inclusion and polynomial order. This approach rigorously assesses the impact of different ***DER*** and

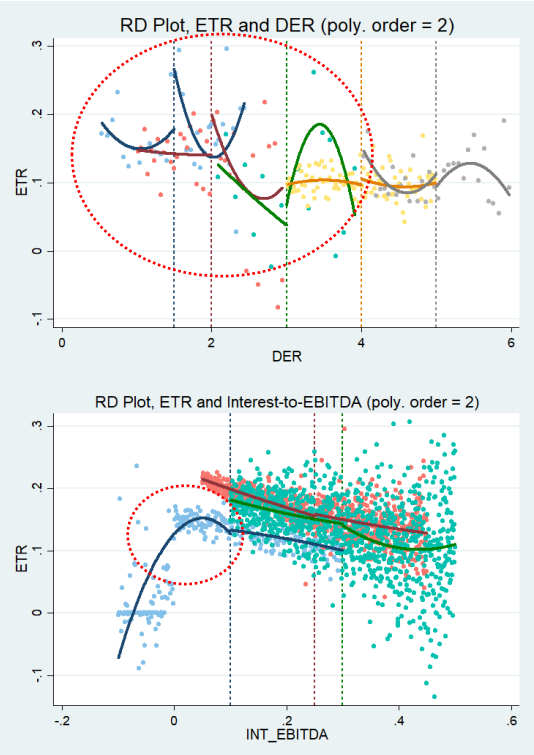
INT_EBITDA thresholds on the effective tax rate, as shown in Appendix E.

The RDD analyses find a statistically significant positive relationship between *DER* and *ETR*, indicating that thin-capitalization rules increase firms' effective tax rates. Estimates range from 0.014 to 0.05 (p-value < 0.1) and more conservatively between 0.026 and 0.034 (p-values < 0.05), controlling for other variables. A notable tax increase is observed at the 2:1 *DER* cut-off, with increases between 0.047-0.089 (p-values < 0.05), though this significance diminishes with covariates included.

No significant relationship is found between *ETR* and the *INT_EBITDA* ratio. OECD (2015) suggests that at the threshold of 30%, around 87% of MNE groups would be able to deduct all their net third-party interest expense. Indeed, the OECD also found that around half of publicly traded MNE groups with positive EBITDA have a net third-party interest expense of 5% to EBITDA. This suggests that the threshold might be too low and may perversely incentivize the MNE group to instead increase their interest expense up to 30% of EBITDA.

Figure 1

Regression Discontinuity Plot for ***ETR***



Note. Author calculation

Furthermore, the complexities of earnings stripping rule (e.g. the needs for adjusting for branch profits and dividends income) might contribute to this disparity. The use of EBITDA also seems to favor MNE with high level of fixed assets, as the depreciation and amortization expense, alongside any capitalized interest expenses in the assets, are "added in" (OECD, 2015). Additionally, the recent introduction of earnings stripping rules in Europe post-EU Anti-Tax Avoidance Directive 2016/1164 suggests potential enforcement challenges not yet captured in the analysis (Deloitte, 2021).

4.1 Robustness Checks

To ensure our results do not violate the assumption of no systematic selection, we employ density manipulation tests for different polynomial orders and cut-off values. All tests fail to reject the null hypothesis, indicating no systematic selection into the treatment group. The density plot and manipulation test results are included in Appendix F and G, respectively.

For additional robustness, we perform a falsification test by setting new placebo thresholds from the original *DER* and *INT_EBITDA* cut-offs plus 7.5% and 10%. We find no statistically significant relationship between dependent variables and our placebo cut-offs. A second falsification test using placebo outcomes (*SIZE*, *PROFITABILITY*, and *RISK*) also yields no statistically significant results. Therefore, we conclude there is no discontinuity besides the one identified in our main specification. The falsification test results for placebo thresholds and outcomes are included in Appendix H and I, respectively.

4.2 Supplementary OLS Result

According to our OLS result in Appendix I, firms in countries with thin-capitalization rule ultimately bear the same *ETR* on average as firms that are not subject to the rule. An increase in DER is also not statistically significantly correlated with lower *ETR*. On the other hand, firms that are subject to earnings stripping rule are associated with 0.09 reduction of *ETR* on average (p-value < 0.01) while

a 1 unit increase in *INT_EBITDA* is associated with -0.03 *ETR* on average (p-value < 0.01), holding other variables constant. There is no evidence of a moderating effect from the implementation of earnings stripping rule as the coefficient on *SUBJECT×INT_EBITDA* is not statistically significant.

Our RDD result in Appendix I previously shows a statistically significant increase in *ETR* for treated firms just above the threshold. Although the OLS result does not constitute a causal inference, we can observe that thin capitalization rule is at least associated with the similar level of compliance for treated and untreated firms. For earnings stripping rule, in contrast, we obtain no statistically significant increase in *ETR* based on the RDD result and negative correlations based on the OLS result. We can at least conclude that thin capitalization is marginally more effective in suppressing tax avoidance compared to the earnings stripping rule.

Additionally, our result also shows that *CAPITAL_INTENSITY* is negatively correlated with *ETR* (p-value < 0.01). This suggests the existence of tax shield generated by depreciation expense and the preference of debt-financing for capital expenditures, in line with Clemente-Almendros and Sogorb-Mira (2016), Stickney and McGee (1982), and Taylor and Richardson (2013).

5. CONCLUSION

This study provides a cross-country empirical evaluation of the effectiveness of interest limitation rules in curbing corporate tax avoidance, using a novel multi-cutoff RDD. Contrary to Buettner et al. (2014), we find no consistent evidence that these rules, in general, reduce tax avoidance across the board, as the RDD result weakens with the inclusion of covariates. Nevertheless, our results suggest that thin-capitalization rules, particularly those with a 2:1 DER threshold, are marginally more effective than earnings stripping rules in increasing firms' *ETR*.

In contrast, the earnings stripping rules based on EBITDA do not show significant effects in our regression discontinuity results. Our supplementary OLS analysis furthermore shows a significant negative relationship (i.e., lower *ETR*) in earnings stripping countries. This may be due to the threshold that is too high to deter earnings stripping, complexities in implementation, the advantage that the rule provides for companies with high fixed assets, and/or potential enforcement issues stemming from its relatively recent application (Deloitte, 2021; OECD, 2015; Webber, 2010).

6. IMPLICATIONS AND LIMITATIONS

6.1. Policy Implications

For countries with thin-capitalization rules, we recommend changing the debt-to-equity threshold to 2:1, as this appears to be the most effective cut-off for increasing the effective tax rate according to our RDD results. While we do not necessarily suggest changing the fixed ratio reference to DER, for countries with earnings stripping rules, there needs to be stronger enforcement, as we have not observed improvements in tax compliance or changes in financing decisions.

6.2. Research Limitation

This study offers a general observation on the implementation of interest limitation rules in various countries, leaving out several elements. Firstly, we cannot include interactions with transfer pricing/arm's length rules, which are case-specific but may impact tax avoidance. Secondly, the models are incomplete as they do not reference *de minimis* value thresholds and MNE group ratios used in some countries. Additionally, due to methodological limitations, we exclude countries like Japan, South Korea, and France, which implement both DER and interest-to-EBITDA ratios, as it is not yet possible to disentangle which rule contributes to what effect. Lastly, there may be a concern since countries with earnings stripping rules generally adopted the regulations later than those with thin-capitalization rules, thus reducing data points.

For future studies, we recommend building more robust models to account for the interplay between these fixed ratios and other aspects of a

country's interest limitation rule design. To address different adoption times, we suggest using a difference-in-difference estimation strategy with heterogeneous treatment and/or staggered adoption (Callaway & Sant'Anna, 2020; Sun & Abraham, 2020).

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APPENDICES

Appendix A
Country Selection and Corresponding Interest Limitation Rule

No	Country	Financial accounting measure for the interest limitation rule	Ratio value	Year ruling start	No	Country	Financial accounting measure for the interest limitation rule	Ratio value	Year ruling start
1	Belgium	Debt-to-equity	5:1	2012	17	Argentina	Interest-to-EBITDA	30%	2018
2	Brazil	Debt-to-equity	2:1	2011	18	Finland	Interest-to-EBITDA	25%	2013
3	Canada	Debt-to-equity	1.5:1	2012	19	Germany	Interest-to-EBITDA	30%	1994
4	Chile	Debt-to-equity	3:1	2012	20	Greece	Interest-to-EBITDA	30%	2010
5	China	Debt-to-equity	2:1	2008	21	Hungary	Interest-to-EBITDA	30%	2018
6	Croatia	Debt-to-equity	4:1	2005	22	Iceland	Interest-to-EBITDA	30%	2018
7	Egypt	Debt-to-equity	4:1	2005	23	India	Interest-to-EBITDA	30%	2017
8	Indonesia	Debt-to-equity	4:1	2016	24	Luxembourg	Interest-to-EBITDA	30%	2018
9	Kazakhstan	Debt-to-equity	4:1	2001	25	Netherlands	Interest-to-EBITDA	30%	2018
10	Kenya	Debt-to-equity	3:1	2006	26	Norway	Interest-to-EBITDA	25%	2014
11	Mexico	Debt-to-equity	3:1	2005	27	Poland	Interest-to-EBITDA	30%	2018
12	Oman	Debt-to-equity	2:1	2012	28	Portugal	Interest-to-EBITDA	30%	1996
13	Pakistan	Debt-to-equity	3:1	2001	29	Romania	Interest-to-EBITDA	10%	2018
14	Russia	Debt-to-equity	3:1	2015	30	Slovakia	Interest-to-EBITDA	25%	2015
15	Sri Lanka	Debt-to-equity	3:1	2006	31	Sweden	Interest-to-EBITDA	30%	2018
16	Turkey	Debt-to-equity	3:1	2006	32	United Kingdom	Interest-to-EBITDA	30%	2016
					33	United States	Interest-to-EBITDA	30%	2017

Note. Source: Deloitte (2021), De Mooij and Hebous (2017), Crowe Horwath (2016), and BIAC (2015)

Appendix B
Sample Selection Criteria

Selection criteria	No. of firms
1. Status: Active companies	316,946,068
2. Country selection	2,351,270
3. Financial information available from 2015-2020	276,387
4. Exclude NACE code B (mining and quarrying), K (financial and insurance activities), O (public administration, defense, social security), and U (activities of extraterritorial organisations and bodies)	213,900

Note. Orbis, via author's calculation

Appendix C.
Final Sample per Country

Source: Orbis, via author's calculation

No.	Country	No. of observations
1	Belgium	55,836
2	Brazil	408
3	Canada	1,404
4	Chile	144
5	China	21,792
6	Croatia	156,114
7	Egypt	444
8	Indonesia	1,485
9	Kazakhstan	132
10	Kenya	108
11	Mexico	228
12	Oman	246
13	Pakistan	1,272
14	Russia	1,602
15	Sri Lanka	822
16	Turkey	612
17	Argentina	57
18	Finland	492
19	Germany	29,802
20	Greece	27,144
21	Hungary	14,763
22	Iceland	2,868
23	India	11,140
24	Luxembourg	534
25	Netherlands	180
26	Norway	99,114
27	Poland	741
28	Portugal	57,648
29	Romania	13,335
30	Slovakia	31,302
31	Sweden	792
32	United Kingdom	65,775
33	United States	5,984
Total		**604,320**

Note. Orbis, via author's calculation

Appendix D
Summary Statistics

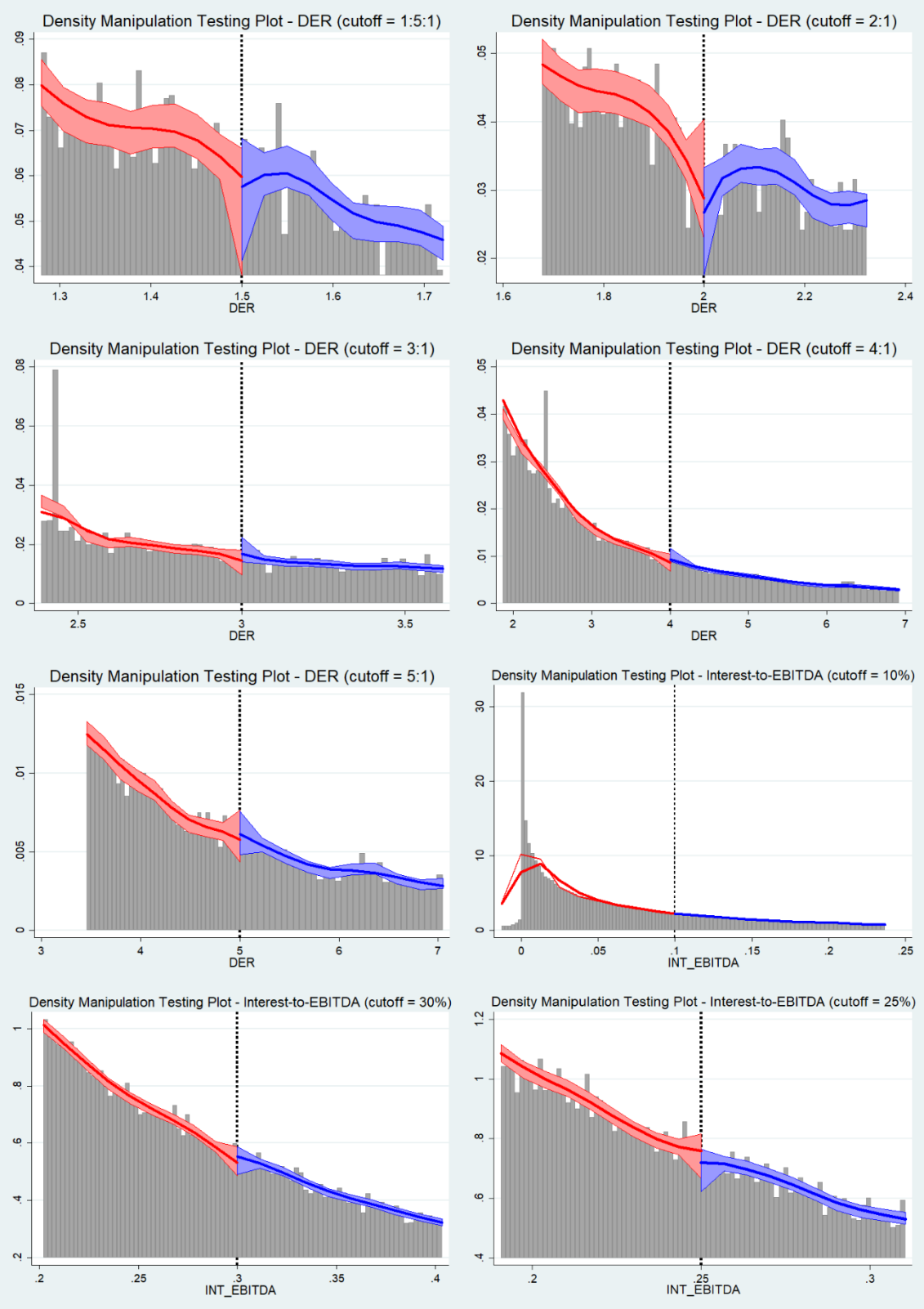
Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variable:					
ETR	585,410	0.158423	0.212291	-6.3612	3.863071
Independent variable:					
DER	242,586	0.482203	2.206553	-9.28479	16.50502
INT_EBITDA	361,643	0.124827	0.591105	-9.88542	11.32967
SUBJECT	604,320	0.157197	0.363986	0	1
Control variable:					
SIZE	604,293	8.469809	2.699957	-4.60517	20.22898
PROFITABILITY	604,293	0.070803	0.802381	-223.116	266.2162
CAPITAL_INTENSITY	604,293	0.291524	0.271645	-0.50976	17.93154
INVENTORY_INTENSITY	604,293	0.14966	0.188305	-0.39896	1.609233
RISK	51,137	0.844084	58.26181	-5793.38	10178.37
MULTI	604,320	0.235379	0.424236	0	1

Appendix E
RDD Regression Result

Dep. Variable: Effective Tax Rate (ETR)									
Running variable:		Hypothesis (1) DER -> ETR				Hypothesis (2) Interest-to-EBITDA -> ETR			
Robust bias corrected estimation									
Weighted		0.026**	0.050*	0.034**	0.063	-0.006	0.038	-0.009	0.007
		(0.013)	(0.033)	(0.018)	(0.045)	(0.005)	(0.035)	(0.006)	(0.045)
Pooled		0.014*	0.014*	0.014*	0.014*	-0.006	-0.006	-0.006	-0.006
		(0.009)	(0.009)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.005)
Cut-off-specific									
DER cut-off	1.5:1	0.067	0.076	0.091	0.100	-	-	-	-
	2:1	0.047***	0.033	0.089**	0.047	-	-	-	-
	3:1	0.076	0.078	-0.003	-0.005	-	-	-	-
	4:1	0.003	-0.001	0.008	-0.060	-	-	-	-
	5:1	0.016	0.000	-0.024	0.000	-	-	-	-
Interest-to-EBITDA cut-off	10%	-	-	-	-	-0.018	-0.005	0.008	0.003
	25%	-	-	-	-	0.003	0.415	0.003	0.396
	30%	-	-	-	-	-0.008	0.041	-0.011**	0.022
Polynomial order		1	1	2	2	1	1	2	2
Baseline covariates		No	Yes	No	Yes	No	Yes	No	Yes
Observations, total		232,220	232,220	232,220	232,220	353,131	353,131	353,131	353,131

Notes: Robust standard errors are in parentheses. rdmc does not report standard errors for cut-off-specific estimates. Bandwidth selection method, kernel choice, and variance-covariance matrix estimator are using mean squared error, triangular kernel, and heteroskedasticity-robust nearest neighbor variance estimator, respectively (all of which are default rdmc options). Covariates included are *SIZE*, *PROFITABILITY*, *CAPITAL_INTENSITY*, *INVENTORY_INTENSITY*, *MULTI*, and *RISK*. *** p < 0.01, ** p < 0.5, * p < 0.1.

Appendix F
Density of Units near the Cut-off Value



Appendix G
Density Manipulation Test Result

Robust RD manipulation test using local polynomial density estimation.		T	P>|T|	Number of obs. (Eff. Number of obs.)		BW est.	
				Left of c	Right of c	Left of c	Right of c
DER cut-off							
Poly. order = 1	1.5:1	0.7904	0.4293	219,653 (125)	23,230 (153)	0.010	0.010
	2:1	-1.1811	0.2376	225,349 (570)	17,534 (772)	0.068	0.097
	3:1	1.1150	0.2649	231,450 (575)	11,433 (755)	0.140	0.214
	4:1	0.3178	0.7506	234,398 (763)	8,485 (542)	0.313	0.238
	5:1	-0.5494	0.5827	236,169 (440)	6,714 (243)	0.293	0.168
Poly. order = 2	1.5:1	0.2903	0.7716	219,653 (1,154)	23,230 (1,070)	0.073	0.073
	2:1	-1.0248	0.3055	225,349 (957)	17,534 (857)	0.107	0.108
	3:1	1.4774	0.1396	231,450 (852)	11,433 (720)	0.205	0.205
	4:1	1.3742	0.1694	234,398 (1,910)	8485 (1,723)	0.701	0.963
	5:1	0.1591	0.8736	236,169 (799)	6714 (832)	0.513	0.678
Interest-to-EBITDA cut-off							
Poly. order = 1	10%	-0.3184	0.7502	227,828 (2,783)	133,815 (3,470)	0.003	0.004
	25%	-0.7130	0.4758	298,912 (428)	62731 (439)	0.002	0.002
	30%	1.3589	0.1742	359,677 (27)	1,966 (22)	0.035	0.035
Poly. order = 2	10%	-0.7248	0.4686	227,828 (37,735)	133,815 (30,857)	0.038	0.046
	25%	-0.8952	0.3707	298,912 (5,622)	62,731 (5,162)	0.020	0.020
	30%	0.075	0.9402	310,639 (7,275)	51,004 (6,421)	0.033	0.034

Notes: Density estimation method uses unrestricted model. Bandwidth selection method, kernel choice, and variance-covariance matrix estimator are using combination, triangular kernel, and jackknife, respectively (all of which are default rddensity options). *** p < 0.01, ** p < 0.5, * p < 0.1

Appendix H
Falsification Test – Placebo Threshold

- Placebo threshold = original value + 7.5%

Dependent Variable: Effective Tax Rate (ETR)

Running variable:	DER				Interest-to-EBITDA			
Robust bias corrected estimation								
Weighted	0.003	-0.016	-0.007	-0.051	0.000	-0.012	0.008	0.055
	(0.013)	(0.034)	(0.017)	(0.045)	(0.006)	(0.050)	(0.008)	(0.064)
Pooled	0.002	0.002	0.002	0.002	-0.006	-0.006	-0.006	-0.006
	(0.009)	(0.009)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.005)
Polynomial order	1	1	2	2	1	1	2	2
Baseline covariates	No	Yes	No	Yes	No	Yes	No	Yes
Observations, total								

Notes: Robust standard errors are in parentheses. The placebo DER thresholds are: 1.575:1, 2.075:1, 3.075:1, 4.075:1, and 5.075:1. The placebo interest-to-EBITDA thresholds are: 17.5%, 32.5%, and 37.5%. For brevity, we do not report cut-off specific result because none of them has statistically significant association with dependent variable. Bandwidth selection method, kernel choice, and variance-covariance matrix estimator are using mean squared error, triangular kernel, and heteroskedasticity-robust nearest neighbor variance estimator, respectively (all of which are default rdmc options). Covariates included are *SIZE*, *PROFITABILITY*, *CAPITAL_INTENSITY*, *INVENTORY_INTENSITY*, *MULTI*, and *RISK*. *** p < 0.01, ** p < 0.5, * p < 0.1.

Placebo threshold = original value + 10%

Dependent Variable: Effective Tax Rate (ETR)

Running variable:	DER				Interest-to-EBITDA			
Robust bias corrected estimation								
Weighted	0.016	-0.001	0.014	-0.025	0.000	-0.016	0.006	0.024
	(0.013)	(0.034)	(0.017)	(0.046)	(0.007)	(0.051)	(0.009)	(0.068)
Pooled	0.009	0.009	0.009	0.009	-0.002	-0.002	-0.002	-0.002
	(0.009)	(0.009)	(0.009)	(0.009)	(0.005)	(0.005)	(0.005)	(0.005)
Polynomial order	1	1	2	2	1	1	2	2
Baseline covariates	No	Yes	No	Yes	No	Yes	No	Yes
Observations, total	232220	232220	232220	232220	353131	353131	353131	353131

Notes: The placebo DER thresholds are: 1.6:1, 2.1:1, 3.1:1, 4.1:1, and 5.1:1. The placebo interest-to-EBITDA thresholds are: 20%, 35%, and 40%. All the rest are similarly defined as the previous part of Appendix 7.

Appendix I
Falsification Test – Placebo Outcome

Placebo outcome (dependent variable): *SIZE*

Running variable:	DER				Interest-to-EBITDA			
Robust bias corrected estimation								
Weighted	-0.007	-0.067	-0.042	-0.036	-0.007	-0.073	0.022	-0.284
	(0.171)	(0.312)	(0.227)	(0.412)	(0.041)	(0.184)	(0.054)	(0.250)
Pooled	-0.294	-0.294	-0.294	-0.294	-0.023	-0.023	-0.023	-0.023
	(0.296)	(0.296)	(0.296)	(0.296)	(0.039)	(0.039)	(0.039)	(0.039)
Polynomial order	1	1	2	2	1	1	2	2
Baseline covariates	No	Yes	No	Yes	No	Yes	No	Yes
Observations, total	242581	242581	242581	242581	361622	361622	361622	361622

Placebo outcome (dependent variable): *PROFITABILITY*

Running variable:	DER				Interest-to-EBITDA			
Robust bias corrected estimation								
Weighted	0.012	0.018	0.006	0.012	-0.007	-0.012	0.004	-0.004
	(0.009)	(0.015)	(0.011)	(0.018)	(0.002)	(0.010)	(0.003)	(0.007)
Pooled	0.006	0.006	0.006	0.006	-0.000	-0.000	-0.000	-0.000
	(0.007)	(0.007)	(0.007)	(0.007)	(0.002)	(0.002)	(0.002)	(0.002)
Polynomial order	1	1	2	2	1	1	2	2
Baseline covariates	No	Yes	No	Yes	No	Yes	No	Yes
Observations, total	242581	242581	242581	242581	361622	361622	361622	361622

Placebo outcome (dependent variable): *RISK*

Running variable:	DER				Interest-to-EBITDA			
Robust bias corrected estimation								
Weighted	-1.664	-1.631	-0.710	-0.776	-0.071	0.006	-0.254	-0.165
	(1.474)	(1.415)	(2.114)	(2.027)	(0.234)	(0.232)	(0.445)	(0.442)
Pooled	-1.664	-1.664	-1.664	-1.664	0.143	0.143	0.143	0.143
	(1.713)	(1.713)	(1.713)	(1.713)	(0.310)	(0.310)	(0.310)	(0.310)
Polynomial order	1	1	2	2	1	1	2	2
Baseline covariates	No	Yes	No	Yes	No	Yes	No	Yes
Observations, total	30827	30827	30827	30827	20307	20307	20307	20307

Notes: Robust standard errors are in parentheses. The cut-offs are from the original value. For the sake of brevity, we do not report cut-off specific result because none of them has statistically significant association with the placebo outcome. Bandwidth selection method, kernel choice, and variance-covariance matrix estimator are using mean squared error, triangular kernel, and heteroskedasticity-robust nearest neighbor variance estimator, respectively (all of which are default rdmc options). Covariates included are *SIZE*, *PROFITABILITY*, *CAPITAL_INTENSITY*, *INVENTORY_INTENSITY*, *MULTI*, and *RISK*. *SIZE*, *PROFITABILITY*, and *RISK* is respectively taken out if it is designated as our placebo outcome. *** $p < 0.01$, ** $p < 0.5$, * $p < 0.1$.

Appendix J
Supplementary OLS Regression Result

Dependent variable	ETR	
Hypothesis	(1)	(2)
Independent variable		
SUBJECT	-0.0166245	-0.0930022***
	(0.0175235)	(0.0181362)
DER	-0.0033156	-
	(0.0036044)	
SUBJECT × DER	0.0002909	-
	(0.0055475)	
INT_EBITDA	-	-0.0325323***
		(0.0107648)
SUBJECT × INT_EBITDA	-	0.018169
		(0.017337)
Control variables		
SIZE	0.0019002	-0.0196008
	(0.0036109)	(0.0224011)
PROFITABILITY	0.1262992***	0.0534038**
	(0.0182995)	(0.0237472)
CAPITAL_INTENSITY	-0.0737141***	-0.0881723
	(0.0188022)	(0.0827136)
INVENTORY_INTENSITY	-0.0209868	0.0980354
	(0.020778)	(0.1248064)
MULTI	(omitted)	(omitted)
RISK	-0.0000145	-0.0000108
	(0.0000117)	(0.0000215)
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
F-stat	22.66	40.54
Prob. > F	0.000	0.000
R^2	0.3693	0.8541
Adjusted R^2	0.2388	0.8242
n	30,437	30,810

Notes: Robust standard errors are in parentheses. Country and year fixed effects are absorbed and standard errors are clustered by individual firm. *MULTI* is omitted due to multicollinearity with the individual firm fixed effects. *** p < 0.01, ** p < 0.5, * p < 0.1.