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Measuring Corporate Tax Rate and Tax Base Avoidance of U.S. Domestic and U.S. Multinational Firms[1]

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Abstract

We develop an approach based on publicly available data to decompose and quantify tax avoidance into two separate components: tax *rate* avoidance and tax *base* avoidance. Our measures are based on the average statutory tax rate, which accounts for the statutory tax rates across all transactions of a firm. We illustrate and validate our measures using simulation data, the Tax Reform Act of 1986, the Tax Cuts and Jobs Act of 2017, changes in tax rate avoidance and tax base avoidance across time, bonus depreciation time periods, several sample splits of U.S. multinational and domestic firms, differences across industries, and firms operating in tax haven locations. The measures allow regulators and researchers to gain insights into these two conceptually different tax avoidance strategies.

JEL Classification: G38, H25, H26, H32

Keywords: Tax Avoidance, Tax Rate Avoidance, Tax Base Avoidance, Average Statutory Tax Rates, Effective Tax Rates

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1. Introduction

Multinational firms' corporate tax avoidance has been discussed prominently in the media (e.g., Yadron et al., 2013), in academia (e.g., the infamous "Luxembourg Tax Leaks") (Li et al., 2019; Nesbitt et al., 2017), and in the discussion on tax base erosion and profit shifting (Dharmapala, 2014).[2] Conceptually, tax avoidance strategies take three forms: (a) shifting taxable income to foreign or state jurisdictions that have low tax rates (*tax rate avoidance*), (b) lowering the domestic tax base (*tax base avoidance*), or (c) a combination of both strategies (Guenther et al., 2019; Lisowsky, 2010; Sikes and Verrecchia, 2020). However, the direct measurement of the tax rate and tax base components of tax avoidance is typically hampered by the fact that taxable income and transaction-specific tax rates are not publicly disclosed (Hanlon and Heitzman, 2010).

We develop an approach to quantify the tax rate and tax base components of tax avoidance using publicly available financial statement data. In particular, we estimate the weighted average of all statutory tax rates that a firm is exposed to. We term this the average statutory tax rate (*ASTR*). A unique feature of *ASTR* is that it overcomes the challenge of obtaining transaction-specific or country-specific statutory tax rates (e.g., statutory tax rates across multiple countries, states, income types) and their particular weighting. In our context, tax rate avoidance captures the reduction in a firm's tax burden due to shifting its income from a jurisdiction with high statutory tax rates to a jurisdiction with low statutory tax rates. The Organization for Economic Co-operation and Development refers to this tax-motivated income shifting as *base erosion and profit shifting* (Dharmapala, 2014). Our use of the term *tax rate avoidance* covers tax-motivated income shifting with the goal of base erosion in high statutory tax jurisdictions.

[2] Following Hanlon and Heitzman (2010), we define *tax avoidance* broadly as a continuum of all activities that aim to reduce explicit taxes, in which some activities are common practice while others are potentially deemed inappropriate by the Internal Revenue Service (IRS).

In contrast, *tax base avoidance* refers to the reduction in explicit taxes by reducing taxable income in a particular country. Thus, tax base avoidance captures the fact that domestic-only firms avoid taxes by reducing their taxable income in the U.S. It also captures the fact that after income is shifted for tax rate avoidance purposes, multinational firms further avoid taxes through lowering the (remaining) taxable income (i.e., their tax base) (Guenther et al., 2019; Sikes and Verrecchia, 2020). Tax *base* avoidance relates to tax avoidance after excluding the effect of tax *rate* avoidance. Well-known examples of tax base avoidance include the acceleration of expenses or the deferral of revenues to decrease taxable income (Lisowsky, 2010).

To illustrate the concepts of tax rate avoidance and tax base avoidance, we provide a conceptual example in Appendix A of a U.S.–based firm that has the opportunity to engage in tax rate and tax base avoidance through a foreign subsidiary. This example also highlights the fact that cash effective tax rates commingle tax rate and tax base avoidance.

We extend the literature by providing an estimation approach to decompose overall tax avoidance into a tax rate component, *ASTR*, and a tax base component, BTD^{ASTR}, measured by book–tax differences calculated using *ASTR*. We use the linear corporate tax function (e.g., Dyreng and Lindsey, 2009; Edwards et al., 2020; Wilkie, 1988) to estimate *ASTR* from publicly available data. We show that *ASTR* corresponds to the estimated coefficient on pretax book income when firms' corporate income taxes are regressed on pretax book income using an analytical framework and Monte Carlo simulations. We argue that changes in temporary book–tax differences should be included as control variables in the estimation of *ASTR* to control for proportional book–tax differences. We validate this control variable for our U.S. setting based on a set of benchmark control variables from Green and Plesko (2016).

Knowledge of *ASTR* allows for a new specification of book–tax differences to quantify tax base avoidance. We define the variable BTD^{ASTR} as pretax book income minus taxable income,

where we estimate taxable income as corporate income taxes divided by our estimate of *ASTR*.[3] Lower *ASTR* values indicate greater tax rate avoidance, and larger BTD^{ASTR} values indicate greater tax base avoidance.

In our empirical section, we validate *ASTR* and BTD^{ASTR} as measures of tax rate and tax base avoidance in seven different empirical settings. Our large-sample evidence complements studies that hand-collect details from the tax footnotes on temporary and permanent book–tax differences (Drake et al., 2020; Raedy et al., 2012). First, we estimate *ASTR* and BTD^{ASTR} annually for domestic-only firms from 1980 to 1995 in order to examine the change in *ASTR* and BTD^{ASTR} around the Tax Reform Act of 1986 (TRA86). TRA86 decreased the top federal statutory tax rate from 46% to 34% (i.e., a tax rate effect). TRA86 also broadened the tax base (i.e., a tax base effect) (Shevlin and Porter, 1992). We find that *ASTR* and BTD^{ASTR} both declined drastically after TRA86. These results are consistent with the changes in TRA86 and with the fact that *ASTR* and BTD^{ASTR} capture tax rate and tax base avoidance, respectively.

Second, we estimate *ASTR* and BTD^{ASTR} annually for domestic-only firms from 2012 to 2019 in order to examine the changes in *ASTR* and BTD^{ASTR} around the Tax Cuts and Jobs Act of 2017 (TCJA). The TCJA decreased statutory tax rates from 35% to 21% (i.e., a tax rate effect). TCJA also affected the tax base. Multiple business deductions were limited, and the domestic production activities deduction was eliminated (i.e., increasing the tax base), while other tax code changes potentially decreased the tax base (e.g., the elimination of the corporate alternative

[3] Book–tax differences are well-established in the literature as measures of tax avoidance (Badertscher et al., 2019; Desai, 2003; Desai and Dharmapala, 2009; Frank et al., 2009; Hanlon and Heitzman, 2010; McGuire et al., 2014; Mills, 1998). Most studies estimate taxable income by grossing up cash taxes paid (or the current portion of the tax expense) by the home country top statutory corporate tax rate (Manzon and Plesko, 2002). However, using the top statutory tax rate for this estimate ignores the income taxed at lower rates in foreign jurisdictions (Erickson et al., 2020; Hanlon, 2003). Alternatively stated, book–tax differences calculated using the top federal U.S. statutory tax rate commingle tax rate avoidance with tax base avoidance.

minimum tax, the increase in bonus depreciation) (Auerbach, 2018; Dyreng et al., 2020). We find that *ASTR* decreased drastically after TCJA, while BTD^{ASTR} remained relatively unchanged.

Third, we evaluate the time trends in *ASTR* and BTD^{ASTR} values for multinational and domestic-only firms as well as for foreign and domestic income within multinational firms for years between TRA86 and TCJA: 1988 to 2016. We find that *ASTR* values for multinational firms are below the *ASTR* values of domestic-only firms consistent with multinational firms engaging in more tax rate avoidance than domestic-only firms. In regard to foreign and domestic income within multinational firms, we find that *ASTR* values related to foreign income are significantly below the *ASTR* values related to domestic income, and we find that *ASTR* values related to foreign income decrease at a higher rate than *ASTR* values related to domestic income. In other words, multinational firms engage in more tax rate avoidance regarding their foreign income than their domestic income, and this behavior increases over time. In particular, *ASTR* values related to foreign income within multinational firms decrease at an economically significant rate of about 0.7 percentage points per year, on average, which represents a cumulative total of approximately 18.5 percentage points from 1988 to 2016.

Our analysis of BTD^{ASTR} values shows that domestic-only firms make substantially more use of tax base avoidance than multinational firms. We also find an increase over time in tax base avoidance for domestic-only firms, although this increase is only marginally significant. Further, multinational firms engage in relatively more tax base avoidance in their domestic operations than in their foreign operations, and BTD^{ASTR} values related to foreign income decrease across time. This result suggests that multinational firms have decreased their tax base avoidance in regard to their foreign operations. Our results are consistent with the notion that some countries provide low statutory tax rates as incentives to attract firms, while ensuring sufficient tax revenues by

broadening the corporate tax base (Alexander et al., 2019; Gravelle, 2014).[4] We also find that the traditional estimate of book–tax differences, in which the top statutory tax rate is used to estimate taxable income, in contrast to BTD^{ASTR}, suggests that multinational firms engage in more tax base avoidance than domestic-only firms, and that multinational firms engage in more tax base avoidance in their foreign income than in their domestic income. These results emphasize the benefit of using BTD^{ASTR} as a measure to capture tax base avoidance without being confounded by tax rate avoidance.

Fourth, we evaluate the change in BTD^{ASTR} values related to domestic-only firms and domestic income within multinational firms around times when the U.S. Congress allowed for more rapid (i.e., bonus) depreciation of certain new assets to stimulate investment. Consistent with expectations, we find that tax base avoidance among domestic-only firms and domestic income within multinational firms increased during the bonus depreciation years 2001 to 2004. Once we control for bonus depreciation years, the previously marginally significant positive trend of BTD^{ASTR} values for domestic-only firms disappears. Further, the difference between time trends during bonus depreciation years, 2001 to 2004, for domestic income within multinational firms and domestic-only firms is highly significant: Domestic-only firms engaged in more tax base avoidance than multinational firms between 2001 and 2004.

Fifth, we estimate *ASTR* for multinational firms and BTD^{ASTR} for domestic-only firms for subsamples of firms based on firm-wide specific characteristics that are expected to influence either tax rate or tax base avoidance: firm size, capital investment, R&D expense, and uncertain tax benefits. Consistent with expectations, we find that multinational firms engage in significantly

[4] Alternatively, it could be argued that tax base avoidance is not cost–benefit efficient in foreign countries. Assuming that tax planning is costly and with low foreign tax rates, the costs of further decreasing the tax base outweigh the benefits. Additionally, tax base avoidance in some countries is less feasible due to high book-tax conformity (Ali and Hwang, 2000; Atwood et al., 2012, 2010).

more tax rate avoidance when they have lower capital investments, higher R&D expenses, and higher uncertain tax benefits. For domestic-only firms, we find significantly more tax base avoidance for firms that are larger, have higher capital investments, and have higher R&D expenses. However, this is not the case for firms that have higher uncertain tax benefits.

Sixth, we validate our measures using an industry analysis, given that particular industries are more proficient in corporate tax avoidance (e.g., information technology) (Markle and Shackelford, 2012; Van Heeke et al., 2014; Yadron et al., 2013). Others (e.g., wholesale and retail trade firms) have limited possibilities to shift taxable income, while in several countries, financial firms seem to be taxed more heavily than other industries (Markle and Shackelford, 2012, 2014). Our results using our measures of tax rate avoidance and tax base avoidance are consistent with these propositions.

Seventh, we examine firms that are known to operate in tax haven locations. Prior research shows that multinational firms with subsidiaries in tax haven countries avoid taxes through tax-motivated income shifting (Dyreng and Lindsey, 2009; Hines and Rice, 1994; Klassen et al., 2017; Klassen and Laplante, 2012a, 2012b). As expected, we find that firms active in tax havens engage in more tax rate avoidance than firms that are not active in tax havens.

Overall, our results provide evidence consistent with the validity of *ASTR* and BTD^{ASTR} as measures of tax rate avoidance and tax base avoidance, respectively. Thus, our model for estimating *ASTR* and BTD^{ASTR} is relevant to regulators, researchers, and investors. First, the results of our novel approach to measure weighted average statutory tax rates and book–tax differences provides guidance to analyze and quantify the impact of tax policy changes. Second, our measures are based on publicly available financial statement data, which enable researchers and investors (who cannot access confidential tax returns) to examine the tax rate and tax base avoidance of firms to answer several important questions such as: Do firms domiciled in countries with higher statutory tax rates

exhibit more tax base avoidance? Do firms in countries with greater book–tax conformity exhibit less tax base avoidance? To what extent is tax base avoidance by US multinationals in regard to their domestic income affected by specific provisions of the TCJA such as *global intangible low taxed income* or the *base erosion anti-abuse tax*? Did tax rate avoidance decrease for foreign income among U.S. multinationals after TCJA? What effect does the 2013 OECD Action Plan on Base Erosion and Profit Shifting (BEPS) have on the tax rate and tax base avoidance of European firms? Has tax rate avoidance decreased among firms subject to BEPS country-by-country reporting? Thus, using our proposed measures, regulators and researchers can gain insights into the two conceptually different tax avoidance strategies.

2. Measuring Tax Rate Avoidance and Tax Base Avoidance

2.1. Prior Research on Tax Rate Avoidance and Tax Base Avoidance

We are not the first to measure tax avoidance.[5] The most common measures of tax avoidance relate to some definition of the effective tax rate[6] (Armstrong et al., 2015; Dyreng et al., 2017, 2008; Rego, 2003) or to book–tax differences[7] (Badertscher et al., 2019; Desai, 2005, 2003; Desai and Dharmapala, 2009; Frank et al., 2009; Manzon and Plesko, 2002; McGuire et al., 2014; Mills, 1998).

[5] A wide variety of studies examine the cross-sectional determinants of tax avoidance (e.g., Armstrong et al. (2015), Badertscher et al. (2013), Brown and Drake (2014), Cheng et al. (2012), Chyz (2013), Chyz et al. (2013), Gallemore and Labro (2015), Higgins et al. (2014), Hoi et al. (2013), Hoopes et al. (2012), Hope et al. (2013), McGuire et al. (2014, 2012), and Rego and Wilson (2012). See Wilde and Wilson (2018) for a review of the most recent literature and Hanlon and Heitzman (2010) for a review of the earlier literature.

[6] The effective tax rate is typically defined as some measure of tax liability over some measure of before-tax profits or cash flows. It is a broad measure of tax avoidance that captures any form of tax reduction relative to pretax income (Dyreng et al., 2017). As a consequence, the effective tax rate is affected by book–tax differences as well as by transaction-specific statutory tax rates (Rego, 2003; Sansing, 2005). Further, the choice of the numerator and denominator critically affects the ability of the effective tax rate to measure a particular tax avoidance strategy (Hanlon and Heitzman, 2010; Sansing, 2005).

[7] Book–tax differences are typically determined as pretax income minus taxable income, where taxable income is often estimated as some measure of a firm's tax burden divided by the top federal U.S. statutory tax rate (Manzon and Plesko, 2002). This estimate of taxable income is subject to measurement error (Hanlon, 2003), and it has been argued that these estimated book–tax differences should be treated with caution when inferring levels and trends in tax avoidance (Erickson et al., 2020; Hanlon and Shevlin, 2005).

Recent findings on cash effective tax rates (Dyreng et al., 2017; Thomsen and Watrin, 2018) question the commonly held belief that multinational firms avoid more taxes than domestic-only firms (Hopkins and Bowers, 2017; Mcintyre et al., 2011). In general, it is well known that effective tax rates commingle the effect of the tax rate component and the tax base component in firm taxation (Shevlin and Porter, 1992). However, the composition of these two distinct tax avoidance strategies is unclear. For instance, low cash effective tax rates of domestic-only firms are likely to be driven by tax base avoidance, given that domestic-only firms by design do not have access to low foreign statutory tax rates, although they can exploit differences in state tax rates for tax planning purposes. On the other hand, low cash effective tax rates of multinational firms could relate to tax rate avoidance, tax base avoidance, or a combination of both strategies.

Tax Base Avoidance: Tax base avoidance lowers the explicit tax burden of a firm by decreasing its taxable income (Guenther et al., 2019; Sikes and Verrecchia, 2020). In addition to tax shelter transactions, which are specifically designed to reduce firms' tax burdens (Graham and Tucker, 2006; Lisowsky, 2010; Wilson, 2009),[8] firms can also make use of tax base avoidance strategies with little or no tax uncertainty utilizing bonus depreciation (Dyreng et al., 2019)), tax credits for research and experimentation, or deferring income. Hence, tax base avoidance consists of a multitude of tax avoidance strategies. Some of these strategies require a higher tax avoidance appetite and can be rather costly to set up, while others are straightforward and nearly costless to implement because they are grounded in tax-advantaged laws, e.g., bonus depreciation rules (Dyreng et al., 2019).

[8] Prominent examples include lease-in-lease-out (LILO), sale-in-lease-out (SILO), corporate-owned life insurance (COLI), bank-owned life insurance (BOLI), cross-border dividend capture (CBDC), contingent-payment installment sales (CPIS), liquidation and recontribution (LR), or the contested liability acceleration strategy (CLAS) (Graham and Tucker, 2006; Lisowsky, 2010; Wilson, 2009).

Tax Rate Avoidance: Tax rate avoidance, on the other hand, is based on a decrease in transaction-specific statutory tax rates relative to the firm's home country top statutory tax rate. This typically requires that affiliates are located in countries or states that have low statutory tax rates (Beuselinck and Pierk, 2019), and it requires the implementation of transfer pricing schemes to shift income into the low–tax rate jurisdiction (Dharmapala and Riedel, 2013; Dyreng and Lindsey, 2009; Dyreng and Markle, 2016; Klassen and Laplante, 2012b; Van Heeke et al., 2014; Yadron et al., 2013). The opportunities for tax rate avoidance have increased over time, given the steady decline in the statutory tax rates of non-U.S. countries (Gravelle, 2014; U.S. Treasury, 2012). Along the same lines, Chow et al. (2020) find evidence that U.S. multinational firms substantially increase their usage of foreign corporate tax holidays.[9] In addition, prior research finds that a significant share of multinational firms shift their income to tax haven locations (Hines and Rice, 1994). Some tax haven transactions can be attributed largely to tax rate avoidance because most tax haven locations are geographically small offering limited economic incentives for foreign investment aside from tax avoidance motives (Dharmapala and Hines, 2009).

Overall, tax rate avoidance and tax base avoidance are two conceptually different strategies that, in combination, lower the tax burden of a firm. Individual firms weigh the costs and benefits of tax rate and tax base avoidance to arrive at their optimal level of tax avoidance. A firm's tax avoidance strategy depends on firm-, industry-, and country-specific factors (e.g., some firms operate in industries with few tax base avoidance opportunities). Dyreng et al. (2017) show that U.S. multinational firms exhibit similar cash effective tax rates to U.S. domestic firms which raises the question: Assuming that tax-rate avoidance is more costly (set-up costs, increased international compliance costs, potentially complex transfer pricing schemes) than tax-base avoidance

[9] Due to the U.S. system of worldwide taxation before TCJA 2017, the effect of foreign corporate tax holidays is diminished (or even offset) when U.S. firms repatriate their foreign earnings. However, in practice, U.S. firms repatriated very little of their low-taxed foreign earnings before the TCJA (Kleinbard, 2011a, 2011b).

(Beuselinck and Pierk, 2019), why do multinational firms engage in tax-rate avoidance at all, if they could achieve the same effective tax rates using tax-base avoidance. Following Myers (1998), Graham (2013), and Brav et al. (2005, 2008), we argue that firms rarely become multinational firms with the sole purpose of avoiding taxes: Firms primarily become multinational to move closer to suppliers and/or customers. Once the decision to expand overseas is taken the variations in tax laws across countries provide opportunities for tax avoidance (Erickson et al. 2020). Thus, firms individually choose their optimal level of tax base and tax rate avoidance according to their opportunities, nontax costs, and their appetite for tax avoidance. Both strategies are interrelated because decreases in the statutory tax rates diminish the incentive to further decrease taxable income using tax base avoidance strategies. For instance, with respect to foreign income of U.S. multinational firms, it may not be cost beneficial to assign potentially limited and costly tax-planning resources to reduce taxable income that is already taxed at a very low rate. In addition, in countries with high book–tax conformity (i.e., countries where the legal tradition limits deviations between pretax book income and taxable income), the potential for engaging in nonconforming tax base avoidance is severely reduced.

2.2. Analytical Framework

Conceptually, the explicit tax burden (TAX_{it}) of firm *i* at time *t* is a combination of (a) the taxable income (TI_{ijt}) specific to a particular firm, time, and transaction *j* and (b) the statutory tax rate (STR_{jt}) specific to a particular geographic area, time, and transaction *j*, across all transactions (Graham et al., 2012):[10]

$$TAX_{it} = \sum_{j=1}^{N} TI_{ijt} \cdot STR_{jt} \quad . \tag{1}$$

[10] We ignore tax credits and audit adjustments in our model development here, but we introduce them in our Monte Carlo simulations. Also, both are captured by the intercept in our empirical estimation using the linear tax model.

In general, tax avoidance of firms is defined as a ceteris paribus reduction in TAX_{it} (Hanlon and Heitzman, 2010) in which two parameters determine TAX_{it} according to Equation (1). The first parameter is the magnitude of TI_{ijt}, and the second is the magnitude of the associated STR_{jt}. We disaggregate both these effects, and we separately evaluate the tax base (*TI*) and tax rate (*STR*) component of tax avoidance.

Conceptually, nonconforming tax base avoidance is associated with an increase in the difference between pretax book income (PI_{ijt}) and TI_{ijt}. Examples of this include nontaxable municipal bond interest, accelerated depreciation for tax purposes, the corporate dividend received deduction, or direct write-offs for tax purposes. In contrast, tax rate avoidance is associated with decreases in the associated STR_{jt} (e.g., through shifting income to countries or states with lower statutory tax rates). Because neither STR_{jt} nor TI_{ijt} are publicly disclosed, we operationalize tax rate avoidance based on the concept of the average statutory tax rate and tax base avoidance based on book–tax differences using the average statutory tax rate.

The tax rate component of taxation is captured through the average statutory tax rate ($ASTR_{it}$) of firm *i* at time *t*, which is a weighted average of STR_{jt} according to the conceptual relation

$$ASTR_{it} = \sum_{j=1}^{N} \frac{TI_{ijt}}{\sum TI_{ijt}} \cdot STR_{jt} \quad . \tag{2}$$

This equation shows that $ASTR_{it}$ represents the average statutory tax rate of firm *i* at time *t* including all tax rate effects (e.g., from tax rate progressions, tax exemptions, and transaction-specific taxation). Given that $ASTR_{it}$ captures all transaction-specific tax rate effects and is not confounded by nonconforming tax base avoidance, a decrease in *ASTR* (i.e., relative to a benchmark such as for example the top federal U.S. statutory rate) can be interpreted as an increase in tax rate avoidance.

The tax base component of tax avoidance is captured through book–tax differences, where analytically $BTD_{it} = PI_{it} - TI_{it}$. Because neither STR_{jt} nor TI_{ijt} are publicly disclosed, we cannot estimate *ASTR* directly using Equation (2) and we develop a method to estimate $ASTR_{it}$ from publicly available financial statement data. Given this estimate of $ASTR_{it}$, a reformulation of Equation (2) can be used to determine BTD_{it} according to

$$BTD_{it} = PI_{it} - TI_{it} = PI_{it} - TAX_{it}/ASTR_{it} \ .^{11} \tag{3}$$

By calculating book–tax differences based on *ASTR*, we remove the effect of tax rate avoidance isolating tax base avoidance. In contrast, an estimate of book–tax differences based on the top federal U.S. statutory rate (STR_{US}) as $BTD^{STRUS} = PI - TAX / STR_{US}$ reflects both tax base and tax rate avoidance because it assumes all foreign income is taxed at the STR_{US} when in fact it is not.[12] Our definition of BTD_{it} implies that larger values of BTD_{it} correspond to more tax base avoidance.

The analytical framework for our estimation approach to estimate *ASTR* is based on TAX_{it} as a linear function of PI_{it} and BTD_{it}. First, we express book–tax differences as one component that is independent of PI_{it} and one component that is proportional to PI_{it}:

$$BTD_{it} = \theta_{it}^{0} + \theta_{it}^{1} \cdot PI_{it} \ . \tag{4}$$

Second, analogous to Edwards et al. (2020),[13] we substitute and rearrange Equations (2), (3), and (4) to derive the model of TAX_{it} in terms of observed pretax book income (PI_{it}), explicitly

[11] Note that Equation (2) reduces to $ASTR_{it} = \frac{TAX_{it}}{TI_{it}}$ using Equation (1) and relation $TI_{it} = \sum_{j=1}^{N} TI_{ijt}$. If TI_{it} were directly observable, we could directly calculate *ASTR* using Equation (2) and *BTD* using this *TI* in Equation (3).

[12] Estimating taxable income by grossing up tax expense by the top statutory tax rate (Ayers et al., 2010; Hanlon and Shevlin, 2005; Manzon and Plesko, 2002) does not consider jurisdiction-specific and transaction-specific variation in *STR*. In general, if the average statutory tax rates are below the utilized *STR* (commonly 35% for the U.S. firms in our sample period (US Government Accountability Office, 2013; p. 10)), then taxable income estimated using *STR* underestimates the actual taxable income of a firm and overstates BTDs and tax base avoidance by commingling tax base avoidance with tax rate avoidance.

[13] Edwards et al. (2020) derive their linear taxes paid model to re-examine the results shown by Dyreng et al. (2017) that decreasing *CASH ETR* values are evidence of increased tax avoidance over time. They show that a linear tax paid

taking into account that firms can be subject to various transaction-specific tax rates by using *ASTR* instead of *STR*:

$$\begin{aligned} TAX_{it} &= ASTR_{it} \cdot TI_{it} \;\; = \;\; ASTR_{it} \cdot [PI_{it} - BTD_{it}] \\ &= ASTR_{it} \cdot [PI_{it} - (\theta_{it}^{0} + \theta_{it}^{1} \cdot PI_{it})] \\ &= -ASTR_{it} \cdot \theta_{it}^{0} + ASTR_{it} \cdot PI_{it} - ASTR_{it} \cdot \theta_{it}^{1} \cdot PI_{it} \;\; . \end{aligned} \tag{5}$$

Equation (5) is the basis for our empirical model to estimate *ASTR*.

2.3. Estimation Approach for ASTR and BTD^{ASTR}

For our empirical model, we utilize the linear dependency structure in Equation (5) and estimate *ASTR* from publicly available data by regressing our proxy for *TAX* (e.g., cash taxes paid, current domestic tax expense, or current foreign tax expense) on *PI* (e.g. pretax income, domestic pretax income, or foreign pretax income) according to

$$TAX_{it} = \underbrace{\beta_0}_{\approx -ASTR \cdot \theta^0} + \underbrace{\beta_1}_{\approx ASTR} \cdot PI_{it} + \underbrace{\sum(\beta_j \cdot BTD\text{-}CONTROLS_{it}}_{\approx -ASTR \cdot \theta^1 \cdot PI} + \epsilon_{it} \;\; , \tag{6}$$

where TAX_{it} denotes available tax items, and PI_{it} is pretax income reported in the financial statements of firm *i* at time *t*.

We can formally show that when regressing *TAX* on *PI*, the estimated β_1 is a proxy for $E(ASTR_t)$ when (a) $ASTR_{it}$ is constant, (b) all BTD_{it} values are independent of PI_{it} (only non-proportional (θ^0) book–tax differences exist), and (c) the variance in book–tax differences equals zero (var(*BTD*) = 0) , with E(·) denoting the expectancy operator (refer to Online-Appendix A for a proof). To generalize our findings for $ASTR_{it} \neq$ const., var(*BTD*) > 0 and to include tax credits and tax audit adjustments, we evaluate our model using Monte Carlo simulations (refer to Online-Appendix B for details and results). Overall, based on our simulations, we conclude that β_1 is a

model also gives rise to a linear *CASH ETR* model: *CASH ETR* = β_0 / *PI* + β_1. The β_0 term represents taxes paid independent of *PI*. If it is positive, then *CASH ETR* values can decrease through time due to increases in pre-tax income. Edwards et al. (2020) provide evidence consistent with this argument. Thus, Edwards et al. (2020) use the linear tax model to address a research question that differs from ours.

valid proxy for $E(ASTR_t)$. To maintain readability, we omit the expectancy operator $E(\cdot)$ (i.e., $E(ASTR_t) \equiv ASTR_t$).

We include *BTD-CONTROLS* in Equation (6) to mitigate the potential omitted variable bias in β_1 arising from nonzero proportional book–tax differences (θ^I), as identified in Equation (5), and tax credits dependent on *PI*. We use changes in temporary book–tax differences (*ΔTEMP-BTD-CONTROLS*) as *BTD-CONTROLS*, which we compare against a benchmark setting of control variables identified by Green and Plesko (2016) in our empirical section. All variables are defined in Appendix B. We initially estimate Equation (6) annually using OLS regressions, obtaining annual estimates of $ASTR = \beta_1$.[14]

We derive an estimate of book–tax differences (BTD_{it}^{ASTR}) using an estimate of taxable income (ETI_{it}^{ASTR}) according to

$$BTD_{it}^{ASTR} = PI_{it} - ETI_{it}^{ASTR} = PI_{it} - TAX_{it} \,/\, ASTR_t \tag{7}$$

In this framework, *ASTR* and BTD^{ASTR} relate to effective tax rates according to $ETR_{it} = ASTR_{it} - ASTR_{it} \cdot BTD_{it}^{ASTR} / PI_{it}$. This effective tax rate could be calculated using tax expense (total or current) or cash taxes paid. Appendix A provides a numerical example of the relations between *ASTR*, BTD^{ASTR} and *CASH ETR*. Note that while we only have sample-specific annual estimates of *ASTR*, we have firm–year estimates of BTD^{ASTR}. Further, because book–tax differences can also arise from earnings management (Blaylock et al., 2012; Graham et al., 2012; Seidman, 2010), we control for earnings management based on performance-matched absolute discretionary accruals following Kothari et al. (2005) when we further evaluate BTD^{ASTR} estimates.

[14] Depending on the research question one could also estimate Equation (6) for each firm using the time series of data obtaining a firm-specific but time invariant estimate of *ASTR*.

In this framework, *ASTR* and BTD^{ASTR} capture tax rate avoidance and tax base avoidance, respectively. In addition, ETI^{ASTR} is not subject to the commonly known matching limitations between tax returns and financial statement data due to differences in consolidation rules for tax and book purposes (Hanlon, 2003; Hanlon and Heitzman, 2010; Plesko and Mills, 2003), given that ETI^{ASTR} is derived from, and therefore directly comparable to, the financial statement consolidated group *PI*.

3. Sample Selection, Estimation of *ASTR* and BTD^{ASTR}, and Descriptive Statistics

3.1. Sample Selection

Our primary sample period covers the years 1988 to 2016, starting after the Tax Reform Act of 1986 and ending before the Tax Cuts and Jobs Act of 2017, which we examine separately. We obtain annual financial statement data from the Compustat North America database. We require that a firm's total assets exceed $10 million. Further, we require both cash taxes paid and pretax income be positive and nonmissing data for all variables necessary to estimate *ASTR*. We drop firms that have less than five annual observations. We also drop industries (based on 1-digit SIC codes) that have fewer than 25 observations per year to ensure the results are not distorted by industries or firms that have very few observations. We require nonmissing control variables for all observations. We include financial firms (SIC 6000–6999) and regulated utilities (4900–4999), given that we are interested in the average statutory tax rates of firms, where the business model is of minor relevance.[15]

Our full sample consists of 5,497 firms with 55,269 firm–year observations. Table 1 summarizes our sample selection criteria. We note that the sample size differs between the validation settings due to the availability of specific data items and additional sample criteria, as

[15] After removing financial firms (SIC 6000-6999) and regulated utilities (4900-4999) from the sample, we find very similar results for *ASTR* and BTD^{ASTR}.

noted in the specific settings. We also acknowledge the reduction in sample size due to our sample selection criteria and data requirements which must be kept in mind when interpreting and generalizing the results.

Our sample consists of 28,314 U.S. domestic-only (*do*) firm–years and 26,955 U.S. multinational (*mne*) firm–years. We classify firms as *multinational* in a given year if the absolute value of their pretax foreign income (*PIFO*) or foreign tax expenses (*TXFO*) are nonmissing and greater than zero. Otherwise, firms are categorized as *domestic-only* firms. For U.S. multinational firms, their income is the sum of their domestic and foreign income. Hence, the *ASTR* of multinational firms measures a weighted average of tax rate avoidance related to both domestic and foreign income. To disentangle this effect, we also separately examine domestic (*dom*) and foreign (*fo*) income within the sample of U.S. multinational firms. This way, we can separately evaluate the effect of domestic and foreign statutory tax rates. Here, consistent with Dyreng et al. (2017), we require nonmissing and positive *TXFO*, *TXDOM*, *PIDOM*, and *PIFO*. The resulting sample of multinational firms that have both domestic and foreign income consists of 16,143 multinational firm–years.

We estimate *ASTR* and BTD^{ASTR} for domestic-only and multinational firms using Equations (6) and (7) based on pretax income (*PI*) and cash taxes paid (*TXPD*). The estimation of *ASTR* and BTD^{ASTR} for domestic and foreign income within the sample of multinational firms is based on domestic pretax income (*PIDOM*), current domestic tax expense (*TXDOM*), foreign pretax income (*PIFO*) and current foreign tax expense (*TXFO*). *TXDOM* is calculated as current tax expenses (*TXC*) minus current foreign tax expenses (*TXFO*). We use the current portion of total tax expense as our proxy for *TAX* because data on foreign and domestic cash taxes paid are not available. We utilize *TXDOM* to explicitly capture the effect of local taxes because state taxes account for a substantial share of the income taxes paid on U.S. income (Heider and Ljungqvist, 2015).

Descriptive statistics for the resulting samples of domestic-only and multinational firms are presented in Panel A of Table 2. Detailed definitions of the variables are shown in Appendix B. We scale continuous variables with total assets (*AT*), and we winsorize them at the 1st and 99th percentiles separately each year for domestic-only and multinational firms, respectively. Panel B of Table 2 reveals that the means for almost all variables differ between domestic-only firms and multinational firms. We note that multinational firms are larger (*LN ASSETS*), but they have significantly less property, plant, and equipment (*GROSS PPE*) and capital expenditures (*CAPEX*) than domestic-only firms suggesting domestic-only firms have higher potential for tax base avoidance in the context of bonus depreciation. However, multinational firms have more intangible assets (*NON-GOODWILL INTANGIBLES*) than domestic-only firms consistent with multinational firms having a higher potential for using offshore intellectual property havens for tax rate avoidance (Graham and Tucker, 2006; Wilson, 2009).

3.2. Impact of Proportional Book–Tax Differences on the Estimate of ASTR

We evaluate two models to mitigate the omitted variable bias of proportional book–tax differences (θ^1) when estimating *ASTR* as shown in Equations (5) and (6). First, we estimate *ASTR* with *BTD-CONTROLS*, derived from Green and Plesko (2016).[16] Second, we include an alternative proxy for book–tax differences (i.e., the change in temporary book–tax differences (Δ*TEMP-BTD-CONTROLS*)) in our analysis because book–tax differences are often country-specific, and adequate proxies to control for drivers of proportional temporary and permanent book–tax differences might not be available for countries other than the U.S.[17] We define Δ*TEMP-BTD-*

[16] We exclude from *BTD-CONTROLS* three of the variables identified by Green and Plesko (2016). First, we exclude lagged book–tax differences, given that we do not know the proper statutory tax rate related to foreign income in order to determine book–tax differences. Second, we exclude the positive pretax income dummy because we drop all variables that have negative *PI*. Third, we exclude foreign pretax income, given that we also evaluate domestic-only firms where this variable is not populated.

[17] We note that in countries with high book–tax conformity (Ali and Hwang, 2000; Atwood et al., 2012, 2010), the impact of proportional book–tax differences on the estimation of *ASTR* is limited, by definition.

CONTROLS as the change in the sum of short- and long-term deferred tax assets (*TXDBCA* + *TXDBA*) minus short- and long-term deferred tax liabilities (*TXDBCL* + *TXDB*) scaled by total assets (*AT*), where missing numerator values are replaced with zero. We use changes in temporary book–tax differences instead of level values to capture period-specific effects in temporary book–tax differences.

Table 3 presents results for the two specifications. In this context, we focus on domestic-only firms and domestic income within multinational firms, given that Green and Plesko (2016) derived the *BTD-CONTROLS* for a U.S. sample. Comparing both estimation models, we find significant differences between estimated *ASTR* values for both domestic-only firms and domestic income within multinational firms. However, differences are economically small. We also note that *ASTR* estimates for domestic-only firms and for domestic income within multinational firms are both slightly higher when using *ΔTEMP-BTD-CONTROLS* and closer to the U.S. benchmark of the top federal statutory tax rate. We recommend using *ΔTEMP-BTD-CONTROLS* as the control variable when estimating *ASTR*, because *BTD-CONTROLS* might not be widely available in non-U.S. settings, so using *ΔTEMP-BTD-CONTROLS* allows for a broader estimation and thus a broader application of *ASTR* in international settings. Thus, in the following, we utilize *ΔTEMP-BTD-CONTROLS* to control for proportional book–tax differences.

3.3. Descriptive Statistics for ASTR and BTD^{ASTR}

Table 4 presents descriptive statistics for *ASTR* and BTD^{ASTR} estimated using *ΔTEMP-BTD-CONTROLS*, where we also include *TAX*, *PI*, and BTD^{STRUS}. These descriptive statistics highlight some of our main validation results. First, *ASTR* values are clearly below the top federal U.S. *STR* during the sample period. Thus, overall, firms utilize statutory tax rates below the top federal U.S. *STR*. Second, multinational firms have lower *ASTR* values than domestic-only firms, and within multinational firms, *ASTR* values related to foreign income are lower than *ASTR* values related to

domestic income. Third, *ASTR* values related to domestic income within multinational firms are higher than *ASTR* values for domestic-only firms. These results show that multinational firms engage in more tax rate avoidance than domestic-only firms, particularly in relation to their foreign operations.

In addition, multinational firms have lower BTD^{ASTR} values than domestic-only firms, and within multinational firms, BTD^{ASTR} values related to foreign income are below the BTD^{ASTR} values related to domestic income. This latter result suggests that multinational firms engage in more tax base avoidance in their domestic operations than in their foreign operations.

Further, traditional BTD^{STRUS} values using the top statutory tax rate to estimate taxable income are above BTD^{ASTR}. Recall that $BTD = PI - TI$, and TI estimated as TAX / STR_{US} is lower than taxable income estimated as $TAX / ASTR$ when estimated $ASTR$ values are below the top STR_{US} of 35%. Table 4 also shows that BTD^{STRUS} values suggest the opposite relation for tax base avoidance than BTD^{ASTR} values. In other words, BTD^{STRUS} values suggest that multinational firms engage in more tax base avoidance than domestic-only firms, and they suggest that multinational firms engage in more tax base avoidance in regard to their foreign income than their domestic income. The latter result is driven by the fact that *ASTR* values are below STR_{US}. These results illustrate that BTD^{STRUS} combines both tax rate avoidance and tax base avoidance. These findings also illustrate the importance of using BTD^{ASTR} when evaluating tax base avoidance.

4. Empirical Validation of *ASTR* and BTD^{ASTR}

4.1. ASTR and BTD^{ASTR} around the Tax Reform Act of 1986

To empirically evaluate the validity of our measures of tax rate avoidance and tax base avoidance, we estimate *ASTR*, BTD^{ASTR}, and *CURRENT ETR*, defined as current tax expenses (*TXC*) over pretax income (*PIDOM*), for the years 1980 to 1994, which cover the pre- and post-tax reform era of the U.S. Tax Reform Act of 1986 (TRA86). We use current tax expense as a proxy

for *TAX* because cash taxes paid is not available before 1987. TRA86 initially reduced the top federal corporate statutory tax rate from 46% in 1986 to 40% in 1987, then it further reduced the rate to 34% in 1988. TRA86 also included several tax law changes aimed at broadening the tax base to increase corporate tax revenues through an increase in taxable income. As a consequence, TRA86 decreased the effective tax rates of firms through a decrease in statutory tax rates, but TRA86 also increased effective tax rates by broadening the tax base (Shevlin and Porter, 1992).

To evaluate *ASTR* and BTD^{ASTR} in the context of TRA86, we collect annual financial statement data for U.S. domestic-only firms in the Compustat North America database that have total assets (*AT*) above $10 million between 1980 and 1994. We estimate *ASTR* values using *ΔTEMP-BTD-CONTROLS*. We require that data are nonmissing for all variables necessary to estimate *ASTR* and *CURRENT ETR*. All variables are defined in Appendix B. Our resulting sample contains 2,935 domestic-only firms with 23,485 firm–year observations. We estimate annual cross-sectional OLS regressions, and we plot the estimated annual *ASTR*, BTD^{ASTR}, and *CURRENT ETR* values in Figure 1, where the STR_{US} serves as a reference point.

First, it is evident that *CURRENT ETR* is mainly increasing from 1985 to 1991. The net effect of a decrease in STR_{US} and an increase in the tax base from TRA86 resulted in an increase in *CURRENT ETR*. Therefore, *CURRENT ETR* did not mirror the decrease in STR_{US}. Second, estimated *ASTR* values capture the regime shift in STR_{US} and decrease drastically after 1986. Third, BTD^{ASTR} values also decreased drastically from 1985 to 1991, which means that the changes in TRA86 decreased opportunities for tax base avoidance because the tax base was broadened. This empirical finding is consistent with our estimated *ASTR* and BTD^{ASTR} values capturing tax rate avoidance and tax base avoidance.

4.2. ASTR and BTD^{ASTR} around the Tax Cuts and Jobs Act (TCJA) of 2017

To further assess the validity of our measures of tax rate avoidance and tax base avoidance, we estimate *ASTR*, BTD^{ASTR}, and *CASH ETR*, defined as cash taxes paid (*TXPD*) over pretax income (*PI*) for 2012 to 2019, which is the pre- and post-tax reform era of the TCJA. TCJA reduced the top corporate tax rate from 35% in 2017 to 21% in 2018. The net effect of TCJA on the tax base is less clear. Multiple business deductions were limited, and the domestic production activities deduction was eliminated increasing the tax base. Other tax code changes, for example, the elimination of the corporate alternative minimum tax and the increase in bonus depreciation (Auerbach, 2018; Dyreng et al., 2020) decreased the tax base.

To evaluate *ASTR* and BTD^{ASTR} in the context of TCJA, we use the same data collection procedures as in our TRA86 analysis, except we use cash taxes paid (*TXPD*) as our proxy for *TAX*. We also omit TCJA transition years before the TCJA was fully implemented (i.e., observations with fiscal years ending between December 2017 and November 2018, as suggested by Dyreng et al. (2020)). Our resulting sample contains 3,715 domestic-only firms with 29,652 firm–year observations. We estimate annual cross-sectional OLS regressions, and we plot the estimated annual *ASTR*, BTD^{ASTR}, and *CASH ETR* values in Figure 2, where the U.S. STR_{US} is plotted as a reference point.

First, it is evident that *CASH ETR* is fairly constant for 2012 to 2017, with a reduction in 2018 and 2019, which means the net effect of TCJA is a decrease in *CASH ETR*, consistent with Dyreng et al. (2020). Second, estimated *ASTR* values capture the decrease in the STR_{US} of the tax reform. Third, the mean of BTD^{ASTR} values decreases in 2018, followed by a slight increase in 2019. However, we find no statistical difference between pre- and post- TCJA BTD^{ASTR} values.

Overall, our results in regard to estimated *ASTR* and BTD^{ASTR} are consistent with observations of *CASH ETR* values and with the discussion in Dyreng et al. (2020). Our empirical

analysis shows that estimated *ASTR* values capture the statutory tax rate decline, and our BTD^{ASTR} estimates quantify the net tax base avoidance effect of the TCJA tax provisions.

4.3. Examination of the Time Trends of ASTR and BTD^{ASTR}

In this section, we examine the level and time trends of tax rate avoidance and tax base avoidance for the years 1988 to 2016. To evaluate the level and time trend of tax rate avoidance and tax base avoidance, we regress *ASTR* and BTD^{ASTR} on time ($TIME_t$) using

$$\gamma_{it} = \delta_0 + \delta_1 \cdot TIME_t + \nu_{it} \ . \tag{8}$$

Here, γ_{it} is defined as either $ASTR_t$ or BTD_{it}^{ASTR}, and the estimated intercept (δ_0-coefficient) and slope (δ_1-coefficient) reflect the level and trend, respectively. The integer time variable $TIME_t$ is set to 0 for the first sample year and then incremented each subsequent year by 1. The error term is represented by v_{it}. When estimating Equation (8) for $\gamma_{it} \equiv ASTR_t$, we have 29 annual observations, and we use robust standard errors. For $\gamma_{it} \equiv BTD_{it}^{ASTR}$, the BTD^{ASTR} values are firm specific, and standard errors are clustered by firm and year. For $\gamma_{it} \equiv BTD_{it}^{ASTR}$, we control for earnings management based on performance-matched absolute discretionary accruals, following Kothari et al. (2005).

We examine the time trends of tax rate avoidance and tax base avoidance for multinational and domestic-only firms, and for multinational firms, we examine these time trends in regard to their domestic versus foreign income. We plot the mean annual *ASTR* and BTD^{ASTR} values across time, and we include the estimated regression lines from Equation (8) for domestic-only and multinational firms (Figure 3 and Figure 5 and for domestic and foreign income within multinational firms in Figure 4 and Figure 6). Regression results are reported in Table 5 and Table 6.

Tax Rate Avoidance Time Trends Related to Multinational and Domestic-Only Firms: First, a visual inspection of Figure 3 indicates that all *ASTR* values are clearly below the STR_{US}. Second, most *ASTR* values related to multinational firms are below the *ASTR* values related to domestic-only firms, and the intercepts in Panel A of Table 5 differ. In other words, multinational firms engage in more tax rate avoidance than domestic-only firms. Third, the estimated slopes in Panel A of Table 5 are both negative, meaning that *ASTR* values related to multinational and domestic-only firms decrease across time. Fourth, there is no significant difference between the slopes related to the *ASTR* values of multinational or domestic-only firms.

Tax-Rate Avoidance Time Trends related to Foreign and Domestic Income within Multinational Firms: First, visual inspection of Figure 4 indicates that *ASTR* values related to foreign income are most often below the STR_{US}. The same holds for *ASTR* values related to domestic income in years after 1997. Second, most *ASTR* values related to foreign income are below *ASTR* values related to domestic income and the intercepts in Panel A of Table 6 differ, i.e., multinational firms engage in more tax-rate avoidance in their foreign than in their domestic income. Third, the *ASTR* values related to domestic and foreign income decrease across time; the slopes in Panel A of Table 6 are negative. Fourth, the slopes in Panel A of Table 6 differ significantly. In other words, the *ASTR* values related to foreign income decrease faster than the *ASTR* values related to domestic income. We note that the level and the change in tax rate avoidance across time is not only statistically significant but also economically significant. The slope of the *ASTR* values related to foreign income (domestic income) within multinational firms indicates a decrease of about 0.7 (0.2) percentage points per year on average, which constitutes an approximate 18.5 (4.8) percentage points cumulative decrease over the sample period.

The decrease in the *ASTR* values for foreign income (i.e., the increase in tax rate avoidance) is consistent with (a) the decrease in statutory tax rates of foreign countries across time (Gravelle,

2014), (b) an increase in corporate tax holidays (Chow et al., 2020), and (c) an increase in the use of transfer pricing strategies (Dharmapala and Riedel, 2013; Hopkins and Bowers, 2017; Klassen and Laplante, 2012b; Klassen et al., 2017).

For domestic-only firms' income, we find a decrease in *ASTR* of approximately 0.2 percentage points per year in Panel A of Table 5, constituting an approximate 5.8 percentage points cumulative decrease over the sample period. The decrease in *ASTR* values (i.e., the increase in tax rate avoidance) is consistent with concurrent U.S. state corporate income tax cuts. From 1989 to 2012, almost twice as many state tax cuts were observed compared to tax increases, and state tax cuts affected about three times more firms than state tax increases (Heider and Ljungqvist, 2015). Additionally, the U.S. reduced tax rates on foreign sales to encourage exports from domestic manufacturing. During our sample period, which begins in 1988, firms could reduce their U.S. taxes under the foreign sales corporation (FSC) rules. After the World Trade Organization found that this rule was an illegal export subsidy, Congress replaced the FSC rules with a provision in 2000 that excluded certain extraterritorial income from U.S. taxation. This was also eventually declared illegal, and the U.S. then enacted a deduction for qualified domestic production (Section 199) in 2004, which reduced the statutory tax rate on qualified U.S. income (Gravelle, 2014). Finally, several studies provide evidence that suggests that firms relocate their economic activity across U.S. states in response to formulary apportionment rules to reduce their taxes (Goolsbee and Maydew, 2000; Gupta et al., 2009; Klassen and Shackelford, 1998). However, Clausing (2016) finds less sensitivity using an updated sample period. Thus, across time, firms had the opportunity to exploit tax rate avoidance on their domestic income as well.

Tax Base Avoidance Time Trend Results Related to Multinational and Domestic-Only Firms: First, a visual inspection of Figure 5 indicates that BTD^{ASTR} values are more volatile than *ASTR* values. This volatility is consistent with the notion that book–tax differences change across

time in a cyclical pattern (e.g., Plesko, 2002; Mills et al., 2002) and are affected by economy-wide changes (Gaertner et al., 2016; Graham, 2012). Second, almost all BTD^{ASTR} values for multinational firms are below the BTD^{ASTR} values for domestic-only firms, and the intercepts in Panel B of Table 5 differ significantly. Third, BTD^{ASTR} values increase across time, where the slopes in Panel B of Table 5 are positive, but these values do not differ between the two sets of firms. Taken together, we find that domestic-only firms engage in more tax base avoidance than multinational firms.

Tax Base Avoidance Time Trend Results Related to Foreign and Domestic Income within Multinational Firms: First, a visual inspection of Figure 6 again indicates that BTD^{ASTR} values are more volatile than *ASTR* values. Second, almost all BTD^{ASTR} values related to foreign income are below BTD^{ASTR} values related to domestic income, meaning that multinational firms engage in more tax base avoidance in regard to their domestic income. Third, BTD^{ASTR} values related to domestic income are fairly constant across time; the slope in Panel B of Table 6 is not different from zero. Meanwhile, the BTD^{ASTR} values related to foreign income indicate a decreasing trend (i.e., the slope in Panel B of Table 6 is negative).

Multinational firms exhibit less tax base avoidance in their foreign income, potentially due to tax base–broadening reforms outside the U.S. (Alexander et al., 2019) or high book–tax conformity in foreign jurisdictions (Ali and Hwang, 2000; Atwood et al., 2012, 2010). Alternatively, tax base avoidance in this context might not be cost–benefit efficient, given that tax planning is costly and, with low foreign tax rates, the costs of reducing the tax base might outweigh the benefits.

Overall, we find that multinational firms engage in more tax base avoidance in regard to their domestic income than their foreign income. For foreign income within multinational firms, tax base avoidance even decreases across time. Apparently, some countries seem to finance their statutory tax rate reductions by being less lenient about tax base avoidance (Alexander et al., 2019;

Gravelle, 2014; Hanlon and Shevlin, 2005). This situation is similar to TRA86, in which the STR_{US} was decreased but the tax base was broadened (Shevlin and Porter, 1992).

4.4. Bonus Depreciation

To further validate the concept of tax base avoidance, we examine the change in BTD^{ASTR} values for domestic-only firms as well as the change in values for domestic income within multinational firms in times when the U.S. Congress allowed for more rapid (i.e., bonus) depreciation of certain new assets to stimulate investment. The dummy variable *BONUS-DEP-1* takes a value of 1 for years 2001–2004, and *BONUS-DEP-2* takes a value of 1 for 2008–2014. Both variables are set to zero outside these time frames. We interact the bonus depreciation dummies with a time (*TIME*) variable defined as an integer time variable (set to 0 for the first sample year and incremented by 1 each following year) to evaluate the time trend in BTD^{ASTR} values during bonus depreciation periods. We estimate the following model:

$$\begin{aligned} BTD_{it}^{ASTR} = {} & \delta_0 + \delta_1 \cdot TIME_t + \delta_2 \cdot BONUS\text{-}DEP\text{-}1_t \times TIME_t \\ & + \delta_3 \cdot BONUS\text{-}DEP\text{-}2_t \times TIME_t + \delta_4 \cdot BONUS\text{-}DEP\text{-}1_t \\ & + \delta_5 \cdot BONUS\text{-}DEP\text{-}2_t + v_{it} \end{aligned} \quad (9)$$

We expect BTD^{ASTR} values to increase during bonus depreciation periods, given that bonus depreciation reduces the tax burden by narrowing the tax base (i.e., we expect δ_2 and δ_3 to be positive). We focus our interpretation on the interaction term because the interaction term captures increases or decreases in BTD^{ASTR} values during the bonus depreciation periods.

In Figure 5 and Figure 6, the gray shaded areas indicate periods of bonus depreciation, where the regression results using bonus depreciation dummies *BONUS-DEP-1* and *BONUS-DEP-2* and the interaction terms with *TIME* are presented for domestic-only firms and for domestic income within multinational firms in Models 1 and 2 of Table 7. For both models, we find that the

slope, which captures tax base avoidance across time (δ_1), is not significant after separating out the bonus depreciation time periods.

Further, the *BONUS-DEP-1* interaction term with *TIME* for domestic-only firms and the domestic income of U.S. multinational firms is highly significant. The BTD^{ASTR} values increased for U.S. firms that could take advantage of bonus tax regulation in 2001 to 2004, a finding that is visually captured in Figure 5 and Figure 6. However, this relation is not apparent for the *BONUS-DEP-2* time period (2008 to 2014), where the interaction term of *BONUS-DEP-2* with *TIME* is positive but not significant.[18] Here, we note that the change in tax base avoidance in 2001 to 2004 is not only statistically significant but also economically significant. The BTD^{ASTR} values related to domestic-only firms, which are scaled by total assets, indicate an average increase of around 1 percentage point per year from 2001 to 2004.

We also find that the difference between the interaction terms *BONUS-DEP-1* with *TIME* for domestic income within multinational firms and for domestic-only firms is highly significant. The difference between these slopes is 0.562 (t-statistic = 2.731), meaning that domestic-only firms engaged in more tax base avoidance between 2001 and 2004 than multinational firms did in regard to their domestic income. One possible explanation is that multinational firms' tax rate avoidance strategies regarding their foreign income are more cost efficient than their tax base avoidance strategies for their domestic income. This result is also consistent with the notion that domestic-only firms are active in industries that are more capital intensive than multinational firms, as shown in Panel B of Table 2.

Further, in untabulated analyses, we compare the industry associations of multinational and domestic-only firms based on the 2-digit North American Industry Classification System (NAICS).

[18] The coefficient estimates on *BONUS-DEP-1* and *BONUS-DEP-2* are an artifact of the slope estimate due to extrapolation.

We find that, compared to multinational firms, domestic-only firms consist of significantly more transportation firms and more wholesale and retail trading firms. Transportation firms are more capital intensive than other industries, and wholesale and retail trading firms are known to be very low tax–planning industries (Heitzman and Ogneva, 2019). Thus, domestic-only firms exhibit more tax base avoidance. Taken together, these results imply that the overall increase in tax base avoidance among U.S. domestic operations (as identified in Panel B of Table 5 and Table 6) can be explained largely by the bonus depreciation time periods, where we find a more pronounced effect for domestic-only firms.

4.5. Examination of ASTR and BTD^{ASTR} for Subsamples

To further validate our measures, we estimate *ASTR* and BTD^{ASTR} for subsamples based on firm-specific characteristics that we hypothesize are related to either tax rate avoidance or tax base avoidance. To do so, we split our multinational and domestic-only sample based on the median of the average firm characteristic under consideration. Then, we estimate *ASTR* and BTD^{ASTR} for the split samples separately for each year. Thus, for 1988–2016, we have 29 *ASTR* values below the median and 29 above the median of the split-variable (i.e., 58 *ASTR* values). The same logic applies to BTD^{ASTR} values; however, here we have firm–year BTD^{ASTR} values, which yields a total of 28,314 observations.

We focus on multinational firms and domestic-only firms because the firm characteristics required to define the split-samples are available only at the firm level. Therefore, separate data are not available for foreign income and domestic income within multinational firms. Further, we focus on the tax base avoidance of domestic-only firms and on the tax rate avoidance of multinational firms because, in our time trend analysis, we find that domestic-only firms generally engage in tax base avoidance and multinational firms generally engage in tax rate avoidance. We estimate and compare annual *ASTR* values and firm-specific BTD^{ASTR} values based on sample partitions using

firm size, capital investment, the level of intangibles of firms (captured through R&D expenses), and uncertain tax benefits (*UTB*). All results are reported in Table 8.

Firm Size: Prior literature suggests economies of scale in tax planning; large firms allocate more resources to tax avoidance and are more proficient in avoiding taxes (Mills et al., 2003; Plesko, 2002; Rego, 2003). Thus, we expect to find significantly more tax *rate* avoidance for large multinational firms (i.e., lower *ASTR* values) and significantly more tax *base* avoidance for large domestic-only firms (i.e., higher BTD^{ASTR} values). Specifically, we split our samples based on the median of the average firm assets, utilizing the variable *LN ASSETS*. We do not find that large multinational firms exhibit more tax rate avoidance than small multinational firms. However, we find that large domestic-only firms have higher BTD^{ASTR} values than small domestic-only firms, meaning that large domestic-only firms exhibit more tax base avoidance than small domestic-only firms.

Capital Investment: Differences in depreciation methods between book and tax are well-known components of tax base avoidance, especially when bonus depreciation rules are applicable, which allow firms to instantly expense large portions of (or all of) their qualified purchases (Gaertner et al., 2016). To evaluate the impact of bonus depreciation on tax base avoidance, we split our samples based on the median of the average capital expenditures (*CAPEX* scaled by lagged total assets), and we re-estimate *ASTR* and BTD^{ASTR} for the split samples of high– versus low–*CAPEX* firms.

We propose that firms with high–*CAPEX* can take advantage of more bonus depreciation. In other words, we expect higher BTD^{ASTR} values for the high–*CAPEX* subsample. Further, firms with high–*CAPEX* might find it difficult to shift their income to foreign jurisdictions, thus we expect low tax rate avoidance for high–*CAPEX* multinational firms. Consistent with expectations, we find that for domestic-only firms, the high–*CAPEX* subsample has significantly higher BTD^{ASTR}

values than the low–*CAPEX* subsample. We also find significantly higher *ASTR* values for the high–*CAPEX* multinational subsample.

Intangibles (*R&D*): Multinational firms with more intangibles have more opportunities to shift their taxable income to foreign subsidiaries located in low-tax jurisdictions resulting in more tax rate avoidance (Markle and Shackelford, 2012). Further, domestic-only firms with more intangibles have access to research and experimentation tax credits. Therefore, in the high-intangibles subsample, we expect more tax *rate* avoidance for multinational firms and more tax *base* avoidance for domestic-only firms.

To examine the effect of intangibles on tax rate avoidance and tax base avoidance, we follow Markle and Shackelford (2012) and split our multinational firm sample and the domestic-only sample at the median of the average firm values for research and development expenses (*R&D EXPENSE* scaled by lagged total assets) as a proxy for the intangibles in place. We use *R&D EXPENSE* as a proxy because accounting standards limit the usefulness of intangible assets as a measure of firms' intangibles (Kothari et al., 2010). We find that multinational firms with high *R&D EXPENSE* have significantly lower *ASTR* values than low–*R&D EXPENSE* multinational firms, and high–*R&D EXPENSE* domestic-only firms have significantly higher BTD^{ASTR} values. This suggests that multinational firms with high *R&D EXPENSE* exhibit more tax rate avoidance than low–*R&D EXPENSE* firms, and domestic-only firms with high *R&D EXPENSE* exhibit more tax base avoidance than low–*R&D EXPENSE* firms.

Further, in untabulated analyses, we examine whether multinational firms with more tax rate avoidance opportunities utilize tax base avoidance to the same extent (for their domestic income) as multinational firms that have fewer opportunities for tax rate avoidance. Specifically, we compare the BTD^{ASTR} values related to domestic income within multinational firms for firms with high *R&D EXPENSE* against firms with low *R&D EXPENSE*. We find that multinational

firms with high *R&D EXPENSE* engage in significantly less domestic tax base avoidance than multinational firms with low *R&D EXPENSE*. This result is consistent with the conjecture that some firms go overseas to engage in tax rate avoidance because they have few opportunities to lower their tax base in the U.S. or because tax rate avoidance strategies are more cost efficient than tax base avoidance strategies.

Uncertain tax benefits (*UTB*): Prior literature analyzes the relation between tax uncertainty and tax avoidance based on the notion that tax planning strategies can be challenged by tax authorities (Dyreng et al., 2019; Guenther et al., 2019). Accordingly, we evaluate the relation between tax uncertainty and tax rate avoidance and tax base avoidance using uncertain tax benefits (*UTB*). Based on the anecdotal evidence of large multinational firms (e.g. Yadron et al., 2013), we assume that tax rate avoidance schemes are highly complex, and the involvement of at least two tax jurisdictions further increases tax uncertainty. Therefore, we expect that firms with high *UTB* values are associated with more tax rate avoidance. Further, we expect lower *ASTR* values for the high–*UTB* subsamples. In contrast, we assume that the majority of tax base avoidance is based on tax rules that result in low uncertainty, e.g., bonus depreciation (Dyreng et al., 2019) or industry-specific tax preferences (Heitzman and Ogneva, 2019). Thus, we expect no difference in BTD^{ASTR} values (i.e., no difference in tax base avoidance) between the high– and low–*UTB* firms.

We pool and split our samples based on two *UTB* variables. First, we use actual *UTB* values (scaled by total assets). Second, because *UTB* information is missing for a material fraction of the firms in our sample (Lisowsky et al., 2013), we augment our results using predicted *UTB* values (*PREDICTED UTB*) according to the model of Rego and Wilson (2012). This validation setting covers 2006 to 2016, since *UTB* data in Compustat are available only from 2006 onwards. Results are reported in Table 8. Consistent with expectations, we find that the high–*UTB* subsample has lower *ASTR* values than the low–*UTB* subsample for the *UTB* and *PREDICTED UTB*

specifications, but no differences exist in BTD^{ASTR} values for the high–*UTB* and high–*PREDICTED UTB* subsample.

4.6. Industry Analysis

Prior research finds that industry preferences play a significant role in tax planning (Heitzman and Ogneva, 2019; Markle and Shackelford, 2012). To assess whether tax rate avoidance and tax base avoidance differ across industries, we estimate *ASTR* for multinational and BTD^{ASTR} for domestic-only firms separately per industry–year, and we regress the resulting *ASTR* and BTD^{ASTR} values on industry dummies to identify any discernable differences.

Following Markle and Shackelford (2012), we categorize industries using the 2-digit North American Industry Classification System (NAICS) codes. To ensure consistent industry groups across time, we require at least 10 consecutive years of NAICS classification observations per firm, and we remove all firms whose current NAICS code differs from any past NAICS codes. After applying these selection criteria, we are left with nine industries in the sample: mining, quarrying, and oil and gas extraction (*MINING*); manufacturing (*MANUFACTURING*); wholesale trade and retail trade (*WHOLESALE & RETAIL TRADE*); transportation and warehousing (*TRANSPORTATION*); information (*INFORMATION*); finance and insurance (*FINANCE*); real estate, rental, and leasing (*REAL ESTATE*); professional, scientific, and technical services (*PROFESSIONAL*); and other (*OTHER*).

Our resulting sample consists of 2,575 (32,245) firms (firm–years) with 1,328 (16,035) domestic-only and 1,247 (16,210) multinational firms (firm–years). In the regression, we define *MANUFACTURING* firms as the base group (i.e., as a benchmark for comparison with other industries), since *MANUFACTURING* firms account for about 45% of our resulting sample. The results are presented in Table 9.

We find that *WHOLESALE & RETAIL TRADE*, *TRANSPORTATION*, *INFORMATION*, and *FINANCE* firms differ in their tax rate avoidance from *MANUFACTURING* firms. Specifically, *INFORMATION* firms exhibit considerably more tax rate avoidance. This result is consistent with anecdotal evidence that information technology firms are highly effective tax avoiders (Van Heeke et al., 2014; Yadron et al., 2013). Further, and consistent with Markle and Shackelford's (2012, 2014) findings on *CURRENT ETRs*, we find that *FINANCE*, *TRANSPORTATION*, and *WHOLESALE & RETAIL TRADE* firms have significantly higher *ASTR* values than *MANUFACTURING* firms. The latter is probably caused by the limited possibilities of *WHOLESALE & RETAIL TRADE* firms for shifting taxable income.

When evaluating results on tax base avoidance, we find that *TRANSPORTATION* and *REAL ESTATE* firms engage in significantly more tax base avoidance than *MANUFACTURING* firms, while *FINANCE* and *INFORMATION* firms engage in significantly less tax base avoidance than *MANUFACTURING* firms. These findings are consistent with the notion that industries with more potential to utilize bonus depreciation rules through qualified assets engage in more tax base avoidance. In summary, we conclude that our measures can capture differences in tax rate avoidance and tax base avoidance across industries.

4.7. Tax Haven Firms

We extend our analysis of *ASTR* to compare (a) multinational firms that have subsidiaries in tax haven countries with (b) multinational firms that do not have subsidiaries in tax haven countries. In particular, we examine the foreign portion of multinational firms' income. We examine whether *ASTR* values are lower for tax haven firms, under the assumption that multinational firms that operate in tax havens engage in more tax rate avoidance. This assumption is based on findings by Hines and Rice (1994), Dyreng and Lindsey (2009), and Klassen and Laplante (2012a, 2012b), who show that tax haven activities are related to income shifting.

Last but not least, tax haven countries are often small economies in terms of population and land area (e.g., Dharmapala and Hines (2009)), thus there are natural limits to locating production plants or research facilities in tax haven countries. Overall, we expect the *ASTR* estimates of tax haven firms to be lower than the *ASTR* estimates of non–tax haven firms, given that tax haven countries typically offer very low tax rates (Dharmapala and Riedel, 2013; Dyreng and Markle, 2016; Klassen and Laplante, 2012b).

We identify tax haven firms using two different methods: First, we separate firms based on the information disclosed in Exhibit 21 of the 10-K annual financial statements, following Dyreng and Lindsey (2009), then we classify firms as tax haven firms if they report having a subsidiary in a tax haven country in Exhibit 21[19] for any year of our sample period (*TAX-HAVEN-DUMMY*).[20] Second, we modify the classification *TAX-HAVEN-DUMMY* to allow firms to switch between years based on the information disclosed in Exhibit 21 (*TAX-HAVEN-YEAR-DUMMY*). This validation setting covers 1993 to 2014 because the Dyreng and Lindsay Exhibit 21 dataset for the *TAX-HAVEN-YEAR-DUMMY* covers years up to 2014.

To evaluate tax haven firms, we estimate the annual *ASTR* for the split samples (i.e., tax haven firms versus non–tax haven firms), and we evaluate the differences based on a comparison of means. The results are reported in Table 10, where we find that the *ASTR* values of tax haven firms and tax haven firm–years are significantly lower than the *ASTR* values of non–tax haven firms. In untabulated analysis, we find quantitatively similar results after extending the *TAX-HAVEN-DUMMY* analysis to 2016 and defining a firm as a tax-haven firm if it had any tax haven

[19] Countries are defined as tax havens based on the EX-21 Dataset provided by Scott D. Dyreng as of 31 May 2015. For a full list of all tax haven countries, we refer to the documentation of the EX-21 Dataset.

[20] We classify firms as tax haven firms for the *TAX-HAVEN-DUMMY* based on only one observation in any year in Exhibit 21, since it is conceivable that firms changed their policy on disclosing tax haven activities in Exhibit 21 due to increased public pressure to abandon tax avoidance strategies (Dyreng et al., 2016; Gramlich and Whiteaker-Poe, 2013). We expect the resulting estimates of *ASTR* to be conservative, since some firms classified as tax haven firms might in reality have become non–tax haven firms during the sample period. Further, some firms might be active in tax haven countries but do not disclose this information in Exhibit 21 (Donohoe et al., 2012).

location in previous years. These results are consistent with *ASTR* capturing increases in the tax rate avoidance of firms that have operations in tax haven locations.

5. Conclusion

We contribute to the tax literature by developing and validating two measures to separately quantify the tax rate avoidance and tax base avoidance components of cash effective tax rates. To estimate tax rate avoidance, we use a linear tax model that allows us to develop an estimation approach using publicly available financial statement data to derive the weighted average statutory tax rate (*ASTR*). *ASTR* captures the various statutory tax rates related to various business transactions that determine the tax burden of a firm. Knowledge of *ASTR* allows us to isolate the tax base component of book–tax differences, while the traditional measure of book-tax differences that uses the top U.S. statutory tax rate to estimate taxable income commingles tax rate avoidance with tax base avoidance. We analytically develop and validate *ASTR* and BTD^{ASTR} in Monte Carlo simulations, and we provide guidance on how to estimate both measures.

We validate *ASTR* and BTD^{ASTR} using various empirical settings. First, we examine the TRA86 tax law changes. TRA86 decreased the statutory tax rate while simultaneously broadening the tax base. We find that *ASTR* and BTD^{ASTR} both capture these changes for TRA86. Second, we examine the TCJA 2017 tax law changes. TCJA lowered the top statutory tax rate; some TCJA tax law changes broadened the tax base, while others decreased it. We find that *ASTR* drastically decreases after the TCJA, whereas BTD^{ASTR} values remain unchanged, on average.

Third, we find that *ASTR* values related to the foreign income of U.S. multinational firms decreased by approximately 0.7 percentage points each year between 1988 and 2016, compared to approximately 0.2 percentage points each year for domestic-only firms and for the domestic income of multinational firms. Fourth, BTD^{ASTR} values related to domestic-only firms increase by

approximately 1 percentage point each year, on average, during the bonus depreciation years 2001 to 2004.

Fifth, we analyze the *ASTR* and BTD^{ASTR} related to various subsamples, based on firm characteristics. Larger firms should be able to engage in both more tax rate avoidance and more tax base avoidance. Capital-intensive firms should have more tax base avoidance potential, and firms with more intangibles should have more tax rate avoidance and tax base avoidance potential through income shifting and R&E tax credits, respectively. Our results are mainly consistent with these expectations. We also find that more tax rate avoidance is associated with more tax uncertainty, suggesting a higher complexity of tax rate avoidance strategies, while more tax base avoidance is not related to higher tax uncertainty.

Sixth, consistent with prior literature, we find distinct differences across industries. For example, firms in the information sector have more tax rate avoidance opportunities (i.e., lower *ASTR*), while transportation firms and real estate firms engage in more tax base avoidance (i.e., higher BTD^{ASTR}). Seventh, based on *ASTR*, we find that multinational firms with subsidiaries in tax haven locations exhibit significantly lower *ASTR* (i.e., more tax rate avoidance) regarding their foreign income than non–tax haven multinational firms.

While our results are consistent with our measures capturing tax rate avoidance and tax base avoidance, we do not have any evidence on how precisely the measures capture the underlying constructs. Further, it is not possible to estimate tax rate avoidance, *ASTR*, for each firm by year. We derive our estimates using annual cross-sectional regressions which result in sample-year specific estimates, not firm-year specific estimates. Finally, we also acknowledge the reduction in sample size due to our sample selection criteria and data requirements which must be kept in mind when interpreting and generalizing the results.

With these caveats in mind, our research is relevant for researchers, as it enables researchers who lack access to confidential tax returns to derive estimates of tax rate avoidance and tax base avoidance strategies using publicly available financial statement data. In addition, knowledge of *ASTR* and BTD^{ASTR} allows for a quantification of the effect of tax stimulus rules on firms, such as the impact of bonus depreciation. Further, our measures are relevant for regulators, given that they provide information on the impact of tax policy changes on firms, for instance, with respect to specific industries.

Our measures allow future research to address questions such as: Do firms in countries with lower statutory tax rates exhibit less tax base avoidance when countries broaden their tax base? Do firms in countries with greater book–tax conformity exhibit less tax base avoidance? What effect does the OECD Base Erosion and Profit Shifting (BEPS) project have on the tax rate avoidance and tax base avoidance of European firms? Has tax rate avoidance decreased among firms subject to BEPS country-by-country reporting?

We also look forward to additional analysis of the effects of TCJA on tax rate avoidance and tax-base avoidance as more data become available. Such analysis may determine the impact of specific TJCA provisions (e.g., GILTI, BEAT) on tax base avoidance concerning the domestic income of US multinationals. Future research may also determine whether tax rate avoidance decreased in regard to the foreign income of U.S. multinationals after TJCA.

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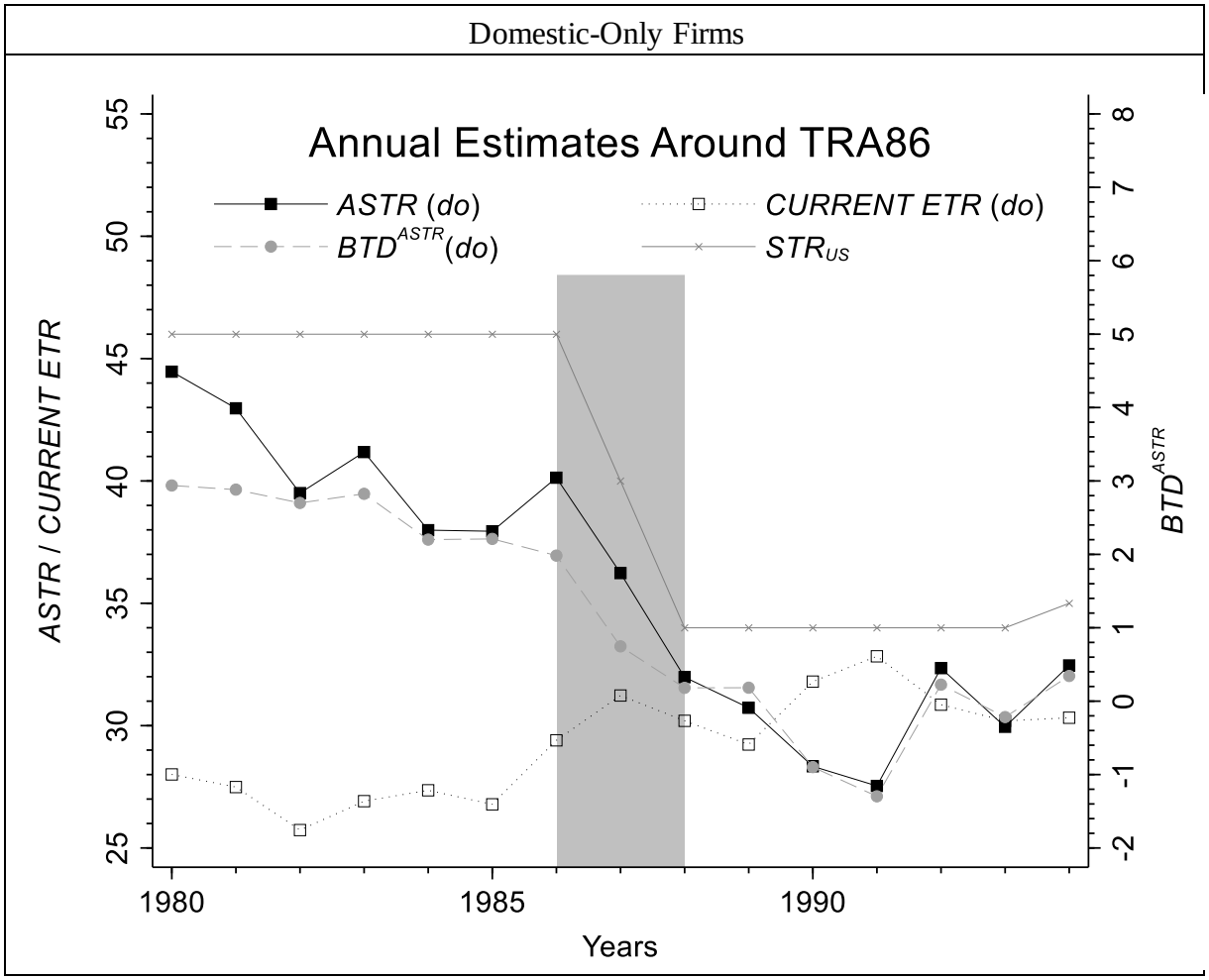

Figure 1: The graph represents estimated mean values of annual average statutory tax rates (*ASTR*), book-tax differences (BTD^{ASTR}), and current effective tax rates (*CURRENT ETR*), defined as current tax expense (*TXC*) over pretax income (*PI*), for domestic-only (*do*) firms for years 1980 to 1994. All variables are multiplied by 100 for readability and defined in Appendix B. STR_{US} denotes the top federal U.S. statutory tax rate for each year. Decreases in *ASTR* indicate an increase in tax-rate avoidance; increases in BTD^{ASTR} indicate an increase in tax-base avoidance.

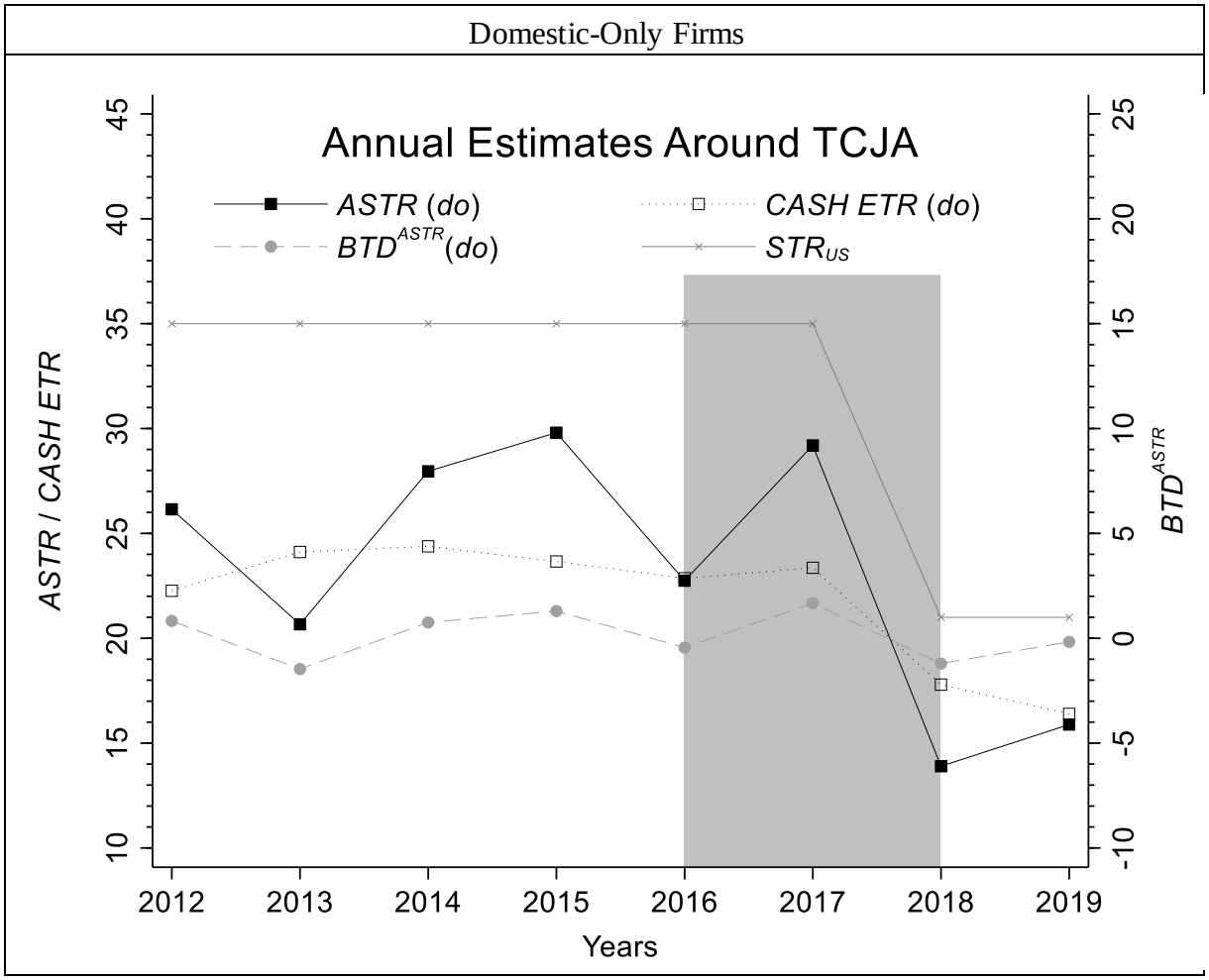

Figure 2: The graph represents estimated mean values of annual average statutory tax rates (*ASTR*), book-tax differences (BTD^{ASTR}), and cash effective tax rates (*CASH ETR*), defined as cash taxes paid (*TXPD*) over pretax income (*PI*), for domestic-only (*do*) firms for years 2012 to 2019. All variables are multiplied by 100 for readability and defined in Appendix B. STR_{US} denotes the top federal U.S. statutory tax rate for each year. Decreases in *ASTR* indicate an increase in tax-rate avoidance; increases in BTD^{ASTR} indicate an increase in tax-base avoidance.

Multinational and Domestic-Only Firms

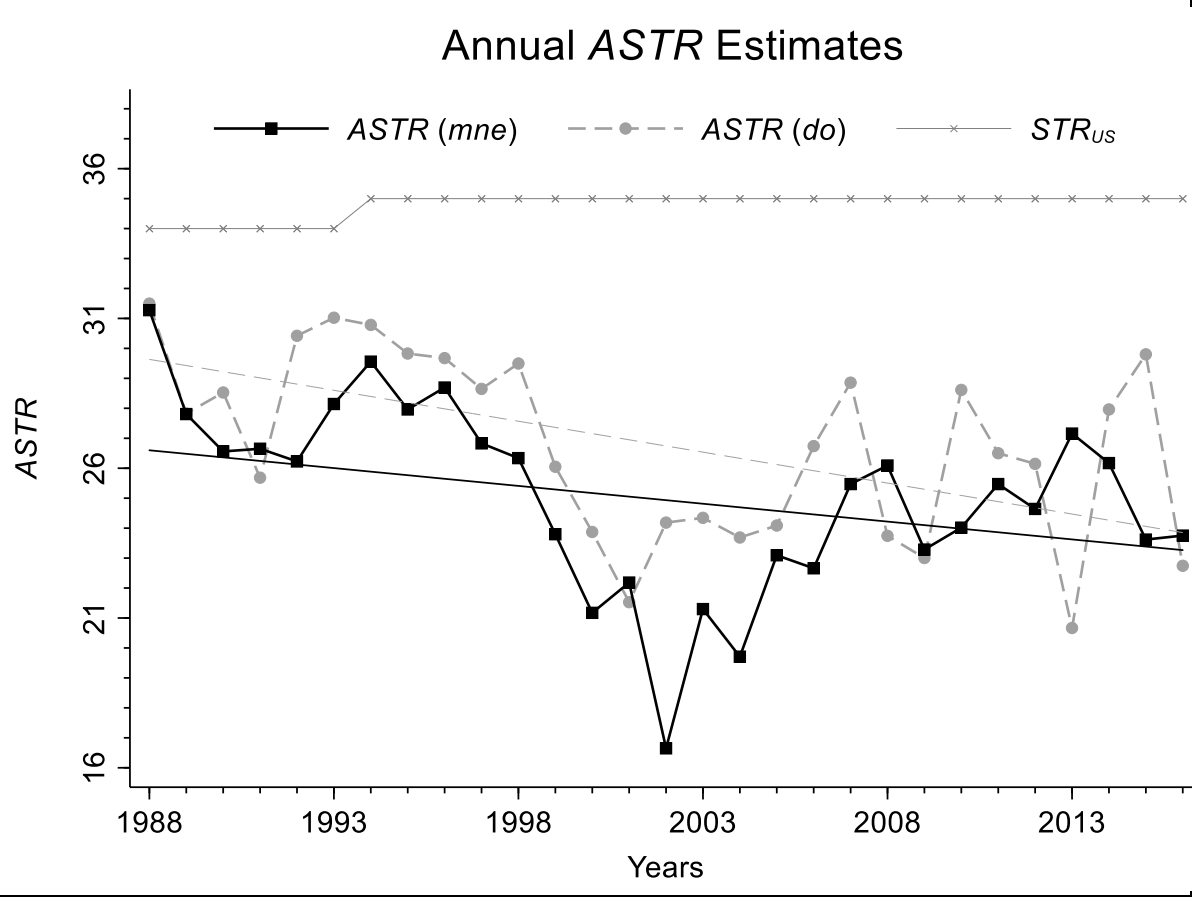

Figure 3: The graph represents estimated annual values of average statutory tax rates (*ASTR*) for multinational (*mne*) and domestic-only (*do*) firms for years 1988 to 2016. All variables are multiplied by 100 for readability and defined in Appendix B. Decreases in *ASTR* indicate an increase in tax-rate avoidance. For illustrative purposes we include the linear time trends of *ASTR* values as estimated in Panel A of Table 5. STR_{US} denotes the top federal U.S. statutory tax rate for each year.

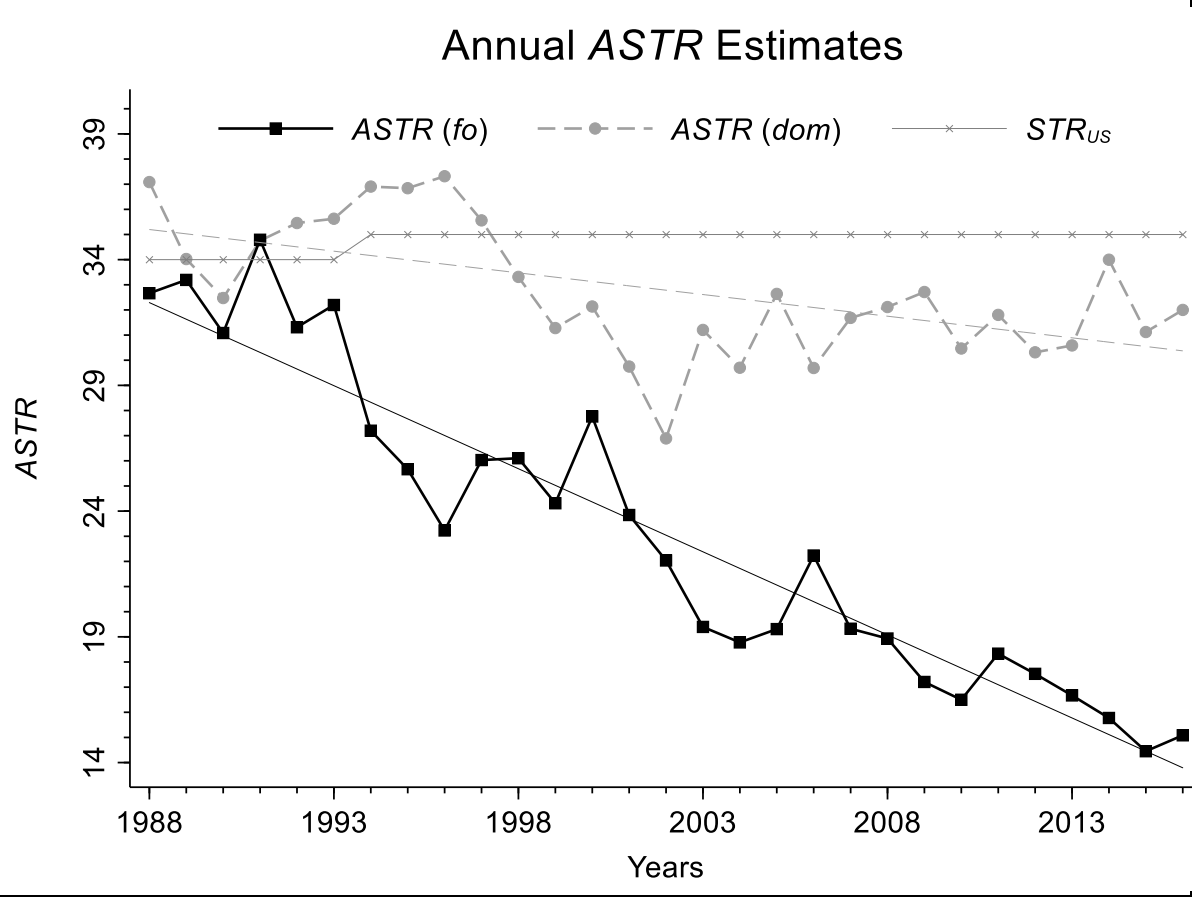

Figure 4: The graph represents estimated annual values of average statutory tax rates (*ASTR*) in percent for foreign (*fo*) and domestic (*dom*) income within multinational firms for years 1988 to 2016. All variables are multiplied by 100 for readability and defined in Appendix B. Decreases in *ASTR* indicate an increase in tax-rate avoidance. For illustrative purposes we include the linear time trends of *ASTR* values as estimated in Panel A of Table 6. STR_{US} denotes the top federal U.S. statutory tax rate for each year.

Multinational and Domestic-Only Firms

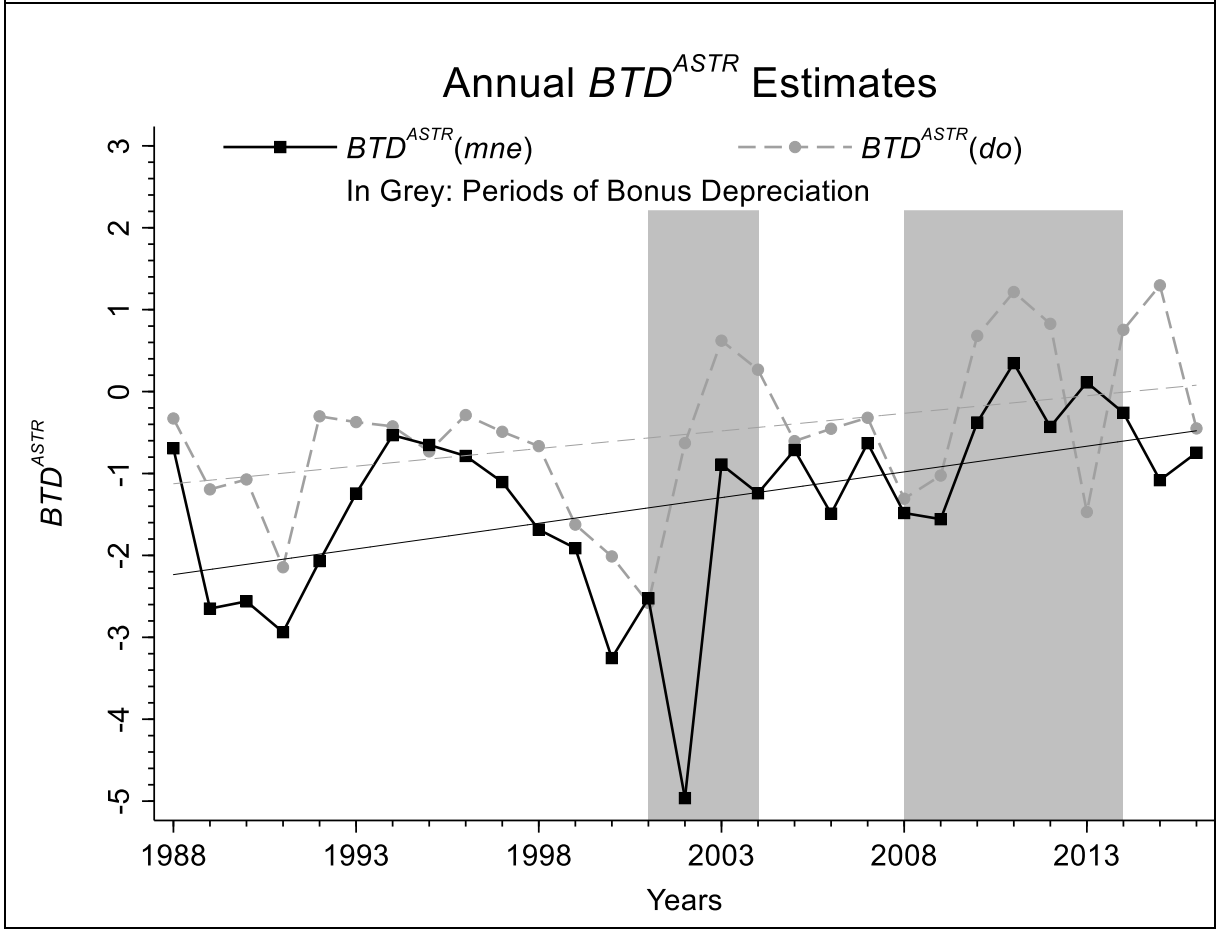

Figure 5: The graph represents estimated mean values of annual book-tax differences (BTD^{ASTR}) for multinational (*mne*) and domestic-only (*do*) firms for years 1988 to 2016. All variables are multiplied by 100 for readability and defined in Appendix B. Increases in BTD^{ASTR} indicate an increase in tax-base avoidance. Grey shaded areas denote periods of bonus depreciation. For illustrative purposes we include the linear time trends of BTD^{ASTR} values as estimated in Panel B of Table 5.

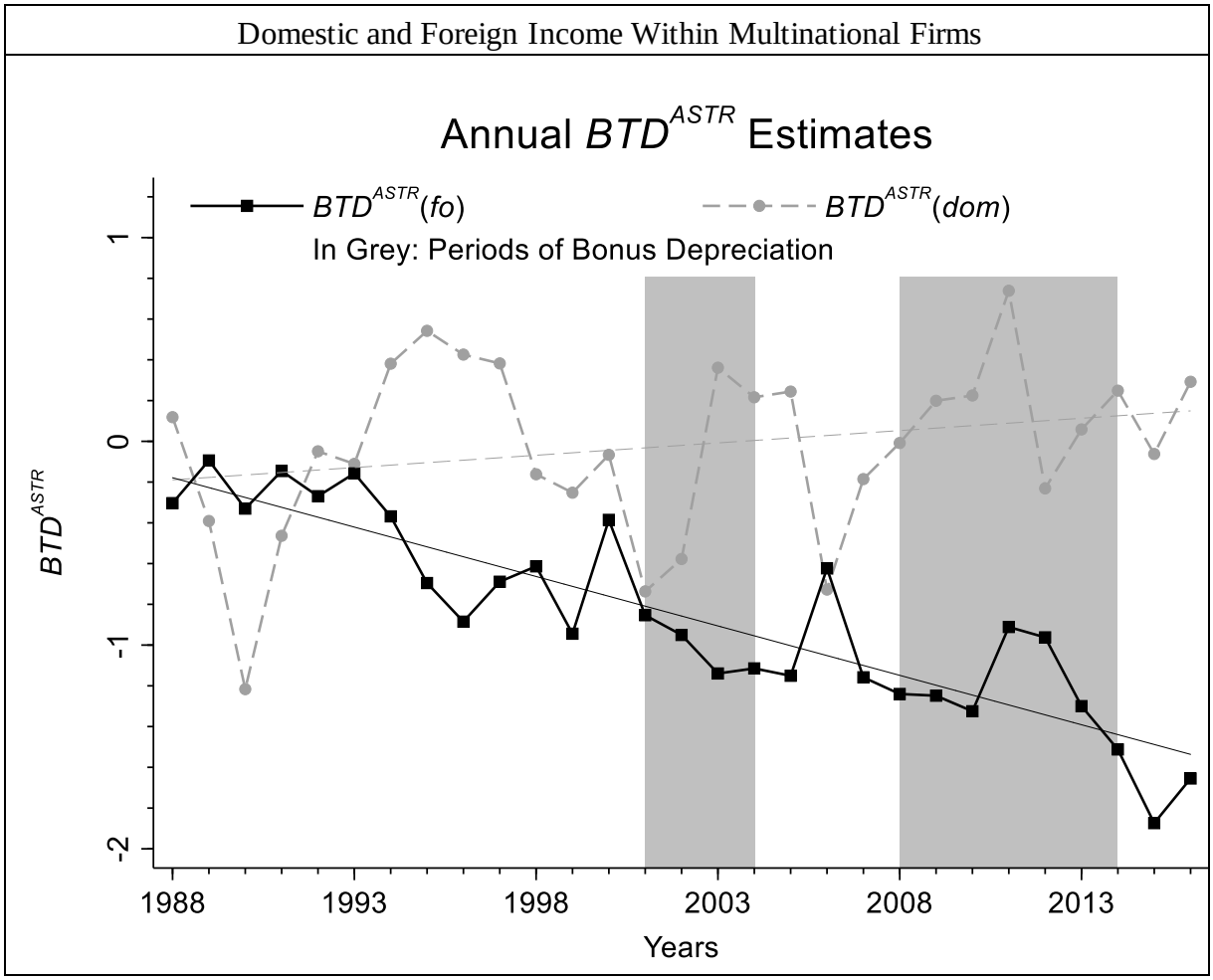

Figure 6: The graph represents estimated mean values of annual book-tax differences (BTD^{ASTR}) for domestic (*dom*) and foreign (*fo*) income within multinational firms for years 1988 to 2016. All variables are multiplied by 100 for readability and defined in Appendix B. Increases in BTD^{ASTR} indicate an increase in tax-base avoidance. Grey shaded areas denote periods of bonus depreciation. For illustrative purposes we include the linear time trends of BTD^{ASTR} values as estimated in Panel B of Table 6.

Table 1: Sample Composition

Data Criteria	Firms	Firm-Years
All Compustat North America observations between 1988 and 2016 with assets greater than $10 million, non-negative cash taxes paid [*TXPD*] and pretax income [*PI*] greater than zero	15,942	120,198
Require current tax expense [*TXC*] and foreign income taxes [*TXFO*] greater than zero	11,732	82,682
Require at least five observations per firm, 25 observations per industry-year and the existence of all control variables	5,497	55,269

All data are obtained from Compustat North America, Compustat items denoted through square brackets.

Table 2: Descriptive Statistics of Utilized Variables

Panel A: Descriptive Statistics of Variables of Multinational and Domestic-Only Firms

Variables	N	Mean	Std.	25th	Median	75th
TAX	55,269	2.866	2.785	0.807	2.101	4.045
PI	55,269	10.179	7.861	4.775	8.187	13.571
CASH ETR (%)	55,269	29.604	21.507	14.994	27.901	38.347
MNE-DUMMY	55,269	0.488	0.500	0.000	0.000	1.000
LN ASSETS	55,269	6.449	2.008	4.941	6.387	7.842
CHANGE IN SALES	55,269	0.111	0.209	0.009	0.069	0.181
NOL	55,269	0.288	0.453	0.000	0.000	1.000
CHANGE IN NOL	55,269	-0.001	0.047	0.000	0.000	0.000
GROSS PPE	55,269	0.562	0.414	0.219	0.466	0.855
NET PPE/GROSS PPE	55,269	0.537	0.166	0.418	0.537	0.656
CHANGE IN GOODWILL	55,269	0.001	0.014	0.000	0.000	0.000
CHANGE IN GOODWILL AFTER 1993	55,269	0.004	0.027	0.000	0.000	0.000
CHANGE IN GOODWILL AFTER 2001	55,269	0.009	0.037	0.000	0.000	0.000
NON-GOODWILL INTANGIBLES	55,269	0.045	0.088	0.000	0.003	0.048
CHANGE IN POST-RETIREMENT BENEFITS	55,269	-0.000	0.006	0.000	0.000	0.000
TOTAL ASSETS LESS PPE AND INTANGIBLES	55,269	0.552	0.252	0.342	0.563	0.758
CAPEX	55,269	0.058	0.055	0.021	0.042	0.075
ΔTEMP-BTD-CONTROLS	55,269	-0.003	1.901	-0.555	0.000	0.442

Panel B: Comparison of Variables of Multinational and Domestic-Only Firms

	Multinational Firms		Domestic-Only Firms		Mean-Difference (t-Statistic)
Variables	Mean	Std.	Mean	Std.	
CASH ETR (%)	30.083	21.512	29.148	21.493	0.935*** (5.110)
LN ASSETS	6.978	1.919	5.947	1.962	1.031*** (62.424)
CHANGE IN SALES	0.100	0.183	0.121	0.230	-0.021*** (-11.899)
NOL	0.415	0.493	0.167	0.373	0.248*** (67.020)
CHANGE IN NOL	0.001	0.052	-0.002	0.042	0.003*** (7.596)
GROSS PPE	0.453	0.329	0.665	0.457	-0.211*** (-62.143)
NET PPE/GROSS PPE	0.499	0.151	0.573	0.172	-0.074*** (-53.551)
CHANGE IN GOODWILL	0.001	0.014	0.001	0.013	0.000 (1.252)
CHANGE IN GOODWILL AFTER 1993	0.004	0.027	0.004	0.028	-0.000 (-1.346)
CHANGE IN GOODWILL AFTER 2001	0.012	0.043	0.005	0.030	0.007*** (23.724)
NON-GOODWILL INTANGIBLES	0.057	0.088	0.033	0.086	0.024*** (32.705)
CHANGE IN POST-RETIREMENT BENEFITS	-0.001	0.007	-0.000	0.004	-0.000** (-2.052)
TOTAL ASSETS LESS PPE AND INTANGIBLES	0.589	0.214	0.517	0.279	0.072*** (33.933)
CAPEX	0.049	0.044	0.066	0.064	-0.017*** (-35.867)
ΔTEMP-BTD-CONTROLS	0.009	1.883	-0.014	1.918	0.023 (1.426)

Panel A reports descriptive statistics for the overall sample variables, Panel B for the multinational and domestic-only firm samples separately. *TAX*, *CASH ETR*, *PI*, and *ΔTEMP-BTD-CONTROLS* are multiplied by 100 for readability. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses. All variables are defined in Appendix B.

Table 3: Comparison of Mean Annual *ASTR* Estimates for Two Estimation Models

	Mean *ASTR*	Mean *ASTR*	Difference (t-Statistic)
ASTR Estimated Using:	*BTD-CONTROLS* (Green & Plesko, 2016)	*ΔTEMP-BTD-CONTROLS*	
	(1)	(2)	(1) - (2)
Panel A: Multinational and Domestic-Only Firms			
Multinational Firms (*mne*)	25.103	24.721	0.383*** (4.575)
Domestic-Only Firms (*do*)	26.752	27.158	-0.406*** (-5.689)
Panel B: Foreign Income and Domestic Income within Multinational Firms			
Foreign Income (*fo*)	21.891	21.839	0.053 (1.280)
Domestic income (*dom*)	32.119	32.472	-0.353*** (-3.643)

This table represents the means of estimated annual average statutory tax rates (*ASTR*) for multinational (*mne*) and domestic-only (*do*) firms (Panel A) and for domestic (*dom*) and foreign (*fo*) income within multinational firms (Panel B). All variables are defined in Appendix B and *ASTR* is multiplied with 100 for readability. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 4: Descriptive Statistics on the mean values for *TAX*, *PI*, *ASTR*, BTD^{ASTR} and BTD^{STRUS}

Panel A: Comparison of Multinational and Domestic-Only Firms

Variables	Multinational Firms	Domestic-Only Firms	Difference (t-Statistic)
	(1)	(2)	(1) - (2)
TAX	2.894	2.840	0.054** (2.286)
PI	10.489	9.884	0.605*** (9.053)
ASTR	24.721	27.158	-2.437*** (-3.107)
BTD^{ASTR}	-1.244	-0.610	-0.635*** (-10.011)
BTD^{STRUS}	2.182	1.710	0.472*** (9.424)

Panel B: Comparison of Foreign Income and Domestic Income within Multinational Firms

Variables	Foreign Income within Multinational Firms	Domestic Income within Multinational Firms	Difference (t-Statistic)
	(1)	(2)	(1) – (2)
TAX	0.926	2.517	-1.591*** (-20.426)
PI	3.461	7.736	-4.276*** (-19.041)
ASTR	21.839	32.472	-10.633*** (-9.197)
BTD^{ASTR}	-0.945	0.010	-0.955*** (-6.351)
BTD^{STRUS}	0.801	0.510	0.291*** (3.035)

This table provides descriptive statistics on the mean values of *TAX*, *PI*, and estimated *ASTR*, BTD^{ASTR} and BTD^{STRUS} values for multinational and domestic-only firms (Panel A) and for the sub-sample of foreign and domestic income within multinational firms (Panel B). All variables are defined in Appendix B and multiplied with 100 for readability. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 5: Multinational and Domestic-Only Firms: Intercept and Slope of the Linear Time Trend of *ASTR* and BTD^{ASTR}

Panel A: Intercept and Slope for *ASTR* Values Related to Multinational and Domestic-Only Firms

Dependent Variable:	Multinational Firms versus Domestic-Only Firms		
Tax-Rate Avoidance (*ASTR*)	*mne*	*do*	*mne - do*
	(1)	(2)	(1) - (2)
δ_0 [Intercept]	26.600***	29.635***	-3.034**
	(26.561)	(36.043)	(-2.342)
δ_1 [Slope]	-0.119**	-0.207***	0.087
	(-2.364)	(-3.427)	(1.114)
N	29	29	
R^2	0.105	0.284	

Panel B: Intercept and Slope for BTD^{ASTR} Values Related to Multinational and Domestic-Only Firms

Dependent Variable:	Multinational Firms versus Domestic-Only Firms		
Tax-Base Avoidance (BTD^{ASTR})	*mne*	*do*	*mne - do*
	(1)	(2)	(1) - (2)
δ_0 [Intercept]	-2.247***	-1.113***	-1.134***
	(-5.833)	(-4.160)	(-3.398)
δ_1 [Slope]	0.063***	0.040*	0.023
	(3.394)	(2.012)	(1.039)
N	26,955	28,314	
R^2	0.005	0.003	

This table represents the results of linear time trend models fitted to annual values of average statutory tax rates (*ASTR*) (Panel A) and book-tax differences (BTD^{ASTR}) (Panel B) for multinational (*mne*) and domestic-only (*do*) firms for the time period 1988 to 2016. All variables are defined in Appendix B and multiplied with 100 for readability. The intercept and slope are estimated using OLS regression based on Equation (8). To control for earnings management, we include performance matched absolute discretionary accruals (Kothari et al. 2005) when estimating the time trend for BTD^{ASTR}. Standard errors for annual *ASTR* are robust, standard errors for firm-specific BTD^{ASTR} are clustered by firm and year. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 6: Foreign Income and Domestic Income within Multinational Firms: Intercept and Slope of the Linear Time Trend of *ASTR* and BTD^{ASTR}

Panel A: Intercept and Slope for *ASTR* Values Related to Foreign Income and Domestic Income within Multinational Firms

Dependent Variable:	Foreign Income versus Domestic Income within Multinational Firms		
Tax-Rate Avoidance (*ASTR*)	*fo*	*dom*	*fo - dom*
	(1)	(2)	(1) - (2)
δ_0 [Intercept]	32.292***	35.199***	-2.907**
	(41.306)	(43.732)	(-2.317)
δ_1 [Slope]	-0.661***	-0.172***	-0.488***
	(-17.715)	(-4.024)	(-8.274)
N	29	29	
R^2	0.900	0.323	

Panel B: Intercept and Slope for BTD^{ASTR} Values Related to Foreign Income and Domestic Income within Multinational Firms

Dependent Variable:	Foreign Income versus Domestic Income within Multinational Firms		
Tax-Base Avoidance (BTD^{ASTR})	*fo*	*dom*	*fo - dom*
	(1)	(2)	(1) - (2)
δ_0 [Intercept]	-0.178*	-0.189	0.011
	(-1.766)	(-1.002)	(0.047)
δ_1 [Slope]	-0.048***	0.012	-0.061***
	(-6.898)	(1.233)	(-4.806)
N	16,143	16,143	
R^2	0.015	0.001	

This table represents the results of linear time trend models fitted to annual values of average statutory tax rates (*ASTR*) (Panel A) and book-tax differences (BTD^{ASTR}) (Panel B) for domestic (*dom*) and foreign income (*fo*) within multinational firms for the time period 1988 to 2016. All variables are defined in Appendix B and multiplied with 100 for readability. The intercept and slope are estimated using OLS regression based on Equation (8). To control for earnings management, we include performance matched absolute discretionary accruals (Kothari et al. 2005) when estimating the time trend for BTD^{ASTR}. Standard errors for annual *ASTR* are robust, standard errors for firm-specific BTD^{ASTR} are clustered by firm and year. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 7: Examination of BTD^{ASTR} in the Context of Bonus Depreciation

Dependent Variable:	Domestic-Only Firms (*do*)	Domestic Income within Multinational Firms (*dom*)
Tax-Base Avoidance (BTD^{ASTR})	(1)	(2)
δ_0 [Intercept]	-1.010***	-0.121
	(-3.804)	(-0.614)
δ_1 [Slope]	0.029	0.005
	(1.328)	(0.455)
BONUS-DEP-1 × *TIME*	0.926***	0.364***
	(3.954)	(7.204)
BONUS-DEP-2 × *TIME*	0.186	0.003
	(1.118)	(0.089)
BONUS-DEP-1	-13.475***	-5.441***
	(-3.989)	(-7.761)
BONUS-DEP-2	-4.055	0.091
	(-1.101)	(0.110)
N	28,314	16,143
R^2	0.006	0.003

This table represents the results of linear time trend models fitted to estimated book-tax differences (BTD^{ASTR}) for domestic-only (*do*) firms and for domestic income within multinational firms (*dom*) for the time period 1988 to 2016. The intercept and slope of BTD^{ASTR} are estimated using OLS regression based on Equation (9). Dummy variables *BONUS-DEP-1* and *BONUS-DEP-2* take a value of 1 for years 2001 to 2004 and for years 2008 to 2014, respectively, else both are set to zero. To control for earnings management, we include performance matched absolute discretionary accruals (Kothari et al. 2005) when estimating the time trend. All other variables are multiplied with 100 for readability and are defined in Appendix B. Standard errors are clustered by firm and year. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 8: Examination of *ASTR* and BTD^{ASTR} for various Sub-Samples based on Firm Characteristics

Variable Used to Split the Sample	*Size (LN ASSETS)*		*CAPEX*		*R&D EXPENSE*		*UTB*		*PREDICTED UTB*	
Evaluated Concept For Sub-Sample	*ASTR mne*	BTD^{ASTR} *do*	*ASTR mne*	BTD^{ASTR} *do*	*ASTR mne*	BTD^{ASTR} *do*	*ASTR mne*	BTD^{ASTR} *do*	*ASTR mne*	BTD^{ASTR} *do*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	24.78***	-1.110***	23.77***	-1.009***	27.71***	-0.887***	27.164***	-0.331	27.630***	-0.520
	(0.589)	(-4.054)	(0.567)	(-3.939)	(0.560)	(-4.593)	(59.806)	(-0.825)	(39.921)	(-0.993)
HIGH-GROUP-DUMMY	-0.204	0.984***	1.802**	0.752**	-6.056***	1.029***	-3.492***	0.036	-6.360***	0.320
	(0.804)	(3.200)	(0.826)	(2.433)	(0.892)	(3.099)	(-5.096)	(0.053)	(-7.455)	(0.623)
N	58	28,314	58	28,314	58	28,314	22	4,709	22	7,358
R^2	0.001	0.005	0.073	0.005	0.442	0.004	0.571	0.001	0.751	0.002

This table represents the results for samples split based on firm characteristics and annually estimated *ASTR* and firm-specific BTD^{ASTR} for multinational (*mne*) and domestic-only (*do*) firms. Sub-samples are identified based on median of firm characteristics *SIZE*, *CAPEX*, *R&D EXPENSE*, *UTB*, or *PREDICTED UTB*, where *HIGH-GROUP-DUMMY* is one for firms within variables above the median value, else zero. All variables are multiplied with 100 for readability and are defined in Appendix B. We include performance matched absolute discretionary accruals (Kothari et al. 2005) to control for earnings management when examining BTD^{ASTR} values. Standard errors for annual *ASTR* per group are robust, standard errors for firm-specific BTD^{ASTR} are clustered by firm and year. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 9: Tax-Rate and Tax-Base Avoidance across Industries

Dependent Variable	Tax-Rate Avoidance (*ASTR*) Multinational Firms (*mne*)	Tax-Base Avoidance (BTD^{ASTR}) Domestic-Only Firms (*do*)
Industries	(1)	(2)
MANUFACTURING (Main Effect)	25.758***	-0.274
	(41.154)	(-0.821)
MINING	4.501	36.507
	(1.608)	(1.166)
WHOLESALE & RETAIL TRADE	6.804***	0.158
	(7.834)	(0.391)
TRANSPORTATION	19.050***	2.147***
	(7.686)	(3.544)
INFORMATION	-7.038***	-1.677*
	(-5.657)	(-1.788)
FINANCE	3.025**	-5.144***
	(2.549)	(-3.090)
REAL ESTATE	-43.134	7.504***
	(-1.192)	(4.426)
PROFESSIONAL	0.282	-0.694
	(0.205)	(-0.817)
OTHER	1.335	-0.251
	(1.174)	(-0.471)
N	174	16,035
R^2	0.333	0.059

This table represents the results of a regression of either tax-rate avoidance (*ASTR* estimated separately for industry-years) (column 1) or tax-base avoidance (BTD^{ASTR} calculated based on *ASTR* estimated separately for industry-years) (column 2). We use the two-digit North American Industry Classification (NAICS) to identify industry affiliation and require at least 10 consecutive years with identical NAICS classification observations per firm for multinational (*mne*) and domestic-only (*do*) firms covering a time period of 1988 to 2016. All firms with non-identical historical NAICS and current NAICS code are removed. We define manufacturing (*MANUFACTURING*) as the base industry against which all other industries are compared. We include performance matched absolute discretionary accruals (Kothari et al. 2005) to control for earnings management when examining BTD^{ASTR} values. All variables are multiplied with 100 for readability and are defined in Appendix B. Standard errors for industry-year *ASTR* are robust, standard errors for firm-specific BTD^{ASTR} are clustered by firm and year. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Table 10: Examination of *ASTR* for Tax Haven Firms

Variable Used to Split the Sample	*TAX-HAVEN-YEAR-DUMMY*	*TAX-HAVEN-DUMMY*
	(1)	(2)
Intercept	24.251***	24.239***
	(27.039)	(16.019)
GROUP-SPLIT-DUMMY	-4.449***	-3.460*
	(-3.593)	(-1.987)
N	44	44
R^2	0.189	0.063

This table represents the differences in annual *ASTR* values estimated separately for foreign income within multinational firms for firms active and not active in tax haven countries covering a time period of 1993 to 2014. Dummy variables *TAX-HAVEN-YEAR-DUMMY* and *TAX-HAVEN-DUMMY* are set to one for tax haven firms and zero for non-tax haven firms. All variables are multiplied with 100 for readability and are defined in Appendix B. Standard errors for annual *ASTR* are robust. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively, with t-statistics in parentheses.

Appendix A

Numerical Example to illustrate tax-rate and tax-base avoidance

To motivate our research, it is useful to illustrate tax-rate and tax-base avoidance strategies in a simple numerical example of a U.S. based firm that has the opportunity to engage in tax avoidance. As base scenario (S0) we assume a U.S. domestic-only firm that is exposed to an overall statutory tax rate (*STR*, here federal taxes plus state and county/city taxes) of 40 percent in the U.S. and that has a pretax book income (*PI*) of 150 units. The domestic-only firm is not engaging in base erosion and profit shifting (BEPS), however, by making use of book-tax differences (*BTD*) in the U.S., the firm is able to lower its taxable income (*TI*) by 75 units to a *TI* in the U.S. of 75.

Now we assume three different tax avoidance scenarios (S1 to S3) where the firm engages in BEPS using a subsidiary in a foreign country and is able to shift 50 units of *PI* to the foreign subsidiary, earning the same combined *PI* as in S0. For scenario one (S1), we assume that when shifting income to the foreign subsidiary some of the *BTD* have to be shifted to the foreign subsidiary, and are recognized under the foreign tax regime, resulting in *BTD* of 45 units in the U.S. and *BTD* of 30 units in the foreign subsidiary. In addition, we assume that the statutory tax rate of the foreign country is equal to the U.S. *STR* from the base scenario S0. In scenario two (S2), we assume that the shifted *BTD* are not recognized in the foreign country and that the statutory tax rate of the foreign country amounts to 16 percent. In scenario three (S3), we assume that only some of the shifted *BTD* are recognized under the foreign tax regime and that the statutory tax rate of the foreign country amounts to 20 percent. The four scenarios are illustrated in Table A1 and include the respective *BTD*, *TI*, and *TAX*, cash taxes paid in the example, and the derived average statutory tax rate (*ASTR*) and cash effective tax rate ($CASH\,ETR = TAX / PI$). Bold figures indicate

information, which is publicly available in the financial statements while grey highlighted cells of *BTD* and *ASTR* figures indicate the particular tax avoidance strategies and their extent.

Table A1: Numerical Examples of Tax-Base and Tax-Rate Avoidance with and without BEPS

		S0: U.S. Domestic-only (Tax-Base Avoidance)			S1: BEPS Tax-Base Avoidance			S2: BEPS Tax-Rate Avoidance			S3: BEPS Tax-Rate and Tax-Base Avoidance		
		US-Firm (I)	Foreign-Subsidiary (II)	10-K = (I) + (II)	US-Firm (I)	Foreign-Subsidiary (II)	10-K = (I) + (II)	US-Firm (I)	Foreign-Subsidiary (II)	10-K = (I) + (II)	US-Firm (I)	Foreign-Subsidiary (II)	10-K = (I) + (II)
PI	**(1)**	**150**	**-**	**150**	**100**	**50**	**150**	**100**	**50**	**150**	**100**	**50**	**150**
BTD	(2)	75	-	75	45	30	75	45	0	45	45	10	55
TI	(3) = (1) - (2)	75	-	75	55	20	75	55	50	105	55	40	95
STR	(4)	40%	-		40%	40%		40%	16%		40%	20%	
TAX	**(5) = (3) · (4)**	**30**	**-**	**30**	**22**	**8**	**30**	**22**	**8**	**30**	**22**	**8**	**30**
ASTR	(6) = (5) / (3)			40%			40%			28.57%			31.58%
CASH ETR	**(7) = (5) / (1)**			**20%**			**20%**			**20%**			**20%**

This table numerically illustrates tax-base avoidance and tax-rate avoidance. Bold figures indicate information which is publicly available in the financial statements while grey highlighted figures indicate the particular tax avoidance strategies and their extent for each scenario. The BEPS examples show that 1) our tax-rate avoidance measure captures the effects of tax avoidance arising from base erosion profit shifting into lower tax jurisdictions and 2) that our tax-base avoidance measure captures tax avoidance that relates to a decrease in taxable income, i.e., complements the efforts to reduce overall tax rates, i.e., the effects of base erosion and income shifting.

Evaluating the numerical results, it seems noteworthy that the domestic-only firm already engages in tax avoidance by recognizing *BTD* in the U.S., since its S0 *CASH ETR* is below *STR*. Here tax avoidance is possible through tax-base avoidance in the U.S. without engaging in BEPS activities. When including BEPS, scenarios S1 to S3 illustrate tax avoidance that results from income shifting and tax-base avoidance in a foreign country, here S1; from income shifting and tax-rate avoidance in a foreign country, here S2; or from income shifting and a combination of tax-rate and tax-base avoidance, here S3.[21]

It should be noted that the *CASH ETR* is identical for all four scenarios, thus, *CASH ETR* does not allow for a separate examination of tax-rate and tax-base avoidance strategies. However, regulators, researchers, or investors might be interested in a separate examination of tax-rate and tax-base avoidance when discussing the economic effects of BEPS or when evaluating the impact

[21] All BEPS scenarios (S1 to S3) also illustrate tax-base avoidance resulting from the *BTD* recognized in the U.S. firm, here always 45 units of *BTD* in the U.S.

of tax policy changes. Further, the scenarios illustrate that *ASTR* considers a weighting scheme that represents the weights as induced by the publicly unobservable taxable income related to the different statutory tax rates a firm is exposed to. The scenarios illustrate that *ASTR* captures tax-rate avoidance and that *BTD* captures tax-base avoidance. The examples also illustrates how *CASH ETR* relates to *ASTR* and *BTD* according to $CASH\ ETR = ASTR - ASTR \cdot BTD / PI$. For example, in S3, $ETR = 31.58\% - 31.58\% \cdot 55 / 150 = 20\%$.

Appendix B

Definition of Variables

Variable	Definition
ASTR	Average statutory tax rate, defined in Equation (2) ($ASTR_{it} = \sum_{j=1}^{N} \frac{TI_{ijt}}{\sum TI_{ijt}} \cdot STR_{jt}$) and estimated as the β_1 coefficient according to the regression model of Equation (6) ($TAX_{it} = \beta_0 + \beta_1 \cdot PI_{it} + \sum \beta_j \cdot BTD\text{-}CONTROLS_{it} + \epsilon_{it}$).
BONUS-DEP-1	Dummy variable set to 1 for years 2001 to 2004, else zero.
BONUS-DEP-2	Dummy variable set to 1 for years 2008 to 2014, else zero.
BTD^{ASTR}	Book-tax differences using year-specific estimated *ASTR* as defined in Equation (7) ($BTD_{it}^{ASTR} = PI_{it} - TAX_{it}/ASTR_{it}$). BTD^{ASTR} values are not winsorized given that their input variables are already winsorized.
BTD^{STRUS}	Book-tax differences defined as $BTD^{STRUS} = PI - TAX / STR_{US}$ using year-specific STR_{US}. BTD^{STRUS} values are not winsorized given that their input variables are already winsorized.
CAPEX [b]	Capital expenditures [*CAPX*] divided by total assets [*AT*].
CASH ETR	Cash effective tax rate, calculated as cash taxes paid [*TXPD*] over pretax income [*PI*], winsorized at 0 and 1. Here, *TXPD* and *PI* are not winsorized.
CHANGE IN GOODWILL [a, b]	Change in goodwill [*GDWL*] up to 1992 divided by total assets [*AT*], where missing values are set to zero.
CHANGE IN GODWILL AFTER 1993 [a, b]	The difference between reported goodwill [*GDWL*] and goodwill reported in 1993 up to 2000 scaled by total assets [*AT*], where missing values are set to zero.
CHANGE IN GODWILL AFTER 2001 [a, b]	The difference between reported goodwill [*GDWL*] and goodwill reported from 2001 and later scaled by total assets [*AT*], where missing values are set to zero.
CHANGE IN NOL [a, b]	Change in tax-loss carryforward [*TLCF*] scaled by lagged total assets [*AT*].
CHANGE IN SALES [a, b]	Change in sales [*SALE*] scaled by total assets [*AT*].
CHANGE IN POST-RETIREMENT BENEFITS [a, b]	Change post-retirement benefits [*PRBA*] scaled by total assets [*AT*], where missing values are set to zero.
CURRENT ETR	Current effective tax rate, calculated as current taxes [*TXC*] over pretax income [*PI*], winsorized at 0 and 1. Here, *TXC* and *PI* are not winsorized.
GROSS PPE [a, b]	Gross property, plant, and equipment [*PPEGT*] scaled by total assets [*AT*].
LN ASSETS [a, b]	Natural logarithm of total assets [*AT*].
NET PPE/GROSS PPE [a, b]	Net property, plant, and equipment [*PPENT*] divided by gross property, plant, and equipment [*PPEGT*].
NOL [a, b]	Indicator variable equal to one if firm reports a tax-loss carryforward [*TLCF*] at the end of the previous year.
NON-GOODWILL INTANGIBLES [a, b]	Intangible assets [*INTAN*] less goodwill [*GDWL*] divided by total assets, where missing values for *GDWL* are set to zero.
PI [b]	Pretax income, where we use either pretax income [*PI*] when evaluating domestic-only and multinational firms or foreign pretax income [*PIFO*] and domestic pretax income [*PIDOM*] when estimating variables for foreign and domestic income within multinational firms, all scaled by total assets [*AT*].
PREDICTED UTB [b]	Predicted unrecognized tax benefits based on Rego and Wilson (2012).
R&D EXPENSE [b]	R&D Expenses [*XRD*] divided by lagged total assets [*AT*], where missing values are set to zero.
STR	Corporate statutory tax rate, where we add US as a subscript (STR_{US}) when we refer to the top federal U.S. statutory tax rate.
TAX [b]	Corporate income taxes, where we use either cash taxes paid [*TXPD*] when evaluating domestic-only and multinational firms or foreign tax expense [*TXFO*] and domestic tax expense, calculated as current tax expense [*TXC*] minus foreign tax expense [*TXFO*], for foreign and domestic income within multinational firms, all scaled by total assets [*AT*].

TAX-HAVEN-DUMMY	Dummy variable that classifies firms as tax haven firms if they report a subsidiary in a tax haven country in Exhibit 21 in any year of our sample period.
TAX-HAVEN-YEAR-DUMMY	Dummy variable that classifies tax haven firm-years if firms report a subsidiary in a tax haven country in Exhibit 21 in a particular year.
ΔTEMP-BTD-CONTROLS [b]	Change in temporary book-tax differences defined as the change in the sum of short- and long-term deferred tax assets [*TXDBCA* + *TXDBA*] minus short- and long-term deferred tax liabilities [*TXDBCL* + *TXDB*] scaled by total assets [*AT*], where missing values are replaced with zeros.
TIME	Integer variable that is set to zero for the first sample year and incremented each year.
TOTAL ASSETS LESS PPE AND INTANGIBLES [a,b]	Total assets [*AT*] less net property, plant, and equipment [*PPENT*] and intangibles [*INTAN*] divided by total assets [*AT*].
UTB [b]	Unrecognized tax benefit, defined as ending balance unrecognized tax benefit [*UTB*] balance divided by total assets [*AT*].

This table contains the definitions of all variables used. Compustat annual data items are denoted using square brackets. Variables marked with [a] are included in Equation (6) as *BTD-CONTROLS* when using the control variables identified by Green and Plesko (2016). All variables marked with [b] are winsorized at the 1st and 99th percentile per year and for multinational and domestic-only firms separately after scaling by total assets (*AT*).