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The Decreasing Trend in U.S. Cash Effective Tax Rates:

The Role of Growth in Pre-tax Income

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ABSTRACT: We develop a linear corporate tax function where taxes paid are regressed on pre-tax income and an intercept. We show that if the intercept is positive, cash ETRs are a convex function of pre-tax income. We present large sample evidence consistent with this ETR-convexity. Thus, although firms may have stable linear tax functions (i.e., constant parameters in the linear tax model) representing stable tax avoidance behavior, ETRs can change over time because of growth in pre-tax income. Consequently, simply examining changes (or differences) in cash ETRs is nondiagnostic about whether tax avoidance has changed over time (or differs across firms). We illustrate our argument by showing that all of the observed downward trend in cash ETRs documented by Dyreng et al. (2017) can be explained by growth in pre-tax income. The wholesale concern about increased tax avoidance over time might be overstated.

Keywords: Cash effective tax rate; Corporate tax function; Time trend.
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I. INTRODUCTION

Many studies examine corporate tax avoidance using the cash effective tax rate defined as the ratio of cash taxes paid (*TXPD*) to pre-tax income (*PI*), $Cash\ ETR = TXPD/PI$, which can be also expressed as $TXPD = \beta PI$. Expressing the relation between taxes paid and pre-tax income this way shows that the underlying tax paid model is a proportional model: Each dollar of *PI* is taxed at rate β. The average ETR equals the rate β ($Cash\ ETR = \beta$) and is independent of pre-tax income changes. In the proportional model any increase in tax avoidance is evidenced by a decrease in the cash ETR being β.

We conjecture and show that if a linear tax model $TXPD = \alpha + \beta PI$ is descriptive, the cash ETR will be given by: $Cash\ ETR = \alpha(1/PI) + \beta$ (dividing the linear tax paid model by *PI*). Under this assumption, the cash ETR differs from β and consequently, even in the absence of any differences in tax avoidance behavior (across firms or time), the cash ETR will differ simply due to differences in pre-tax income. Consequently, simply examining variation in cash ETRs is nondiagnostic about whether tax avoidance has changed over time or differs across firms.

We illustrate our arguments by revisiting the results in Dyreng, Hanlon, Maydew, and Thornock (2017) who document a cumulative decline in the cash ETR of U.S. firms of about 10 percentage points over the twenty-five years 1988–2012.[1] We find that almost all of the documented ETR decline is attributable to growth in pre-tax income. Because Dyreng et al. (2017) implicitly assume a proportional underlying tax function, $TXPD = \beta PI$, they and many others (see Wilde and Wilson 2018 for a review) tautologically define tax avoidance as any decrease in cash

[1] While we focus on the Dyreng et al. (2017) paper and the decreasing trend in cash ETRs, as we explain in section 5.2, we want to emphasize that our model and arguments also apply more broadly to any study examining tax avoidance behavior. That is, cash ETRs can differ across firms and/or over time unrelated to a firm's tax planning activities simply because of differences in pre-tax income across firms and/or over time.

taxes paid per dollar of pre-tax income, and consequently interpret the documented decrease in cash ETRs as an increase in firms' tax avoidance behavior over time. However, despite anecdotes and public conjectures as to the source of this decline, they show that changes in firm characteristics, and earnings in foreign jurisdictions with declining statutory tax rates explain only a small portion of the overall decrease in cash ETRs.

While the parsimony of a proportional tax function is potentially appealing, there are many reasons why taxes paid and pre-tax income will not be perfectly proportional – a firm earning at least some non-taxable income, incurring non-deductible expenses that are independent of pre-tax income, or recognizing income or an expense in pre-tax income and taxable income in different periods, aka temporary book-tax differences (BTDs). Our analyses shows that cash ETRs can change over time unrelated to a firm's tax planning activities, simply because of growth in pre-tax income over time. Consequently, before inferences about the time trend in cash ETRs or the contribution of a specific determinant (e.g., specific firm characteristics or earnings in foreign jurisdictions, etc.) to a firm's tax planning level can be drawn, it is necessary to appropriately control for changes in pre-tax income by including *1/PI* as a regressor in the cash ETR model.

The coefficients α and β have the same economic interpretation in both models $TXPD = \alpha + \beta PI$ and $Cash\ ETR = \alpha(1/PI) + \beta$.[2] The coefficient α captures taxes paid that are independent of current period's pre-tax income arising from BTDs, including audit adjustments and tax credits. The coefficient β, as in the proportional model, captures taxes paid that are directly associated with current pre-tax income, i.e., book-tax conforming revenue and expense items. It can be interpreted as the marginal propensity to tax (MPT) because it measures a firm's 'marginal'

[2] Note that empirically in the $TXPD = \alpha + \beta PI$ model, α is the intercept and β is the slope while in the $Cash\ ETR = \alpha(1/PI) + \beta$ model, α is the slope and β is the intercept. However, economically α and β are equivalent in both models – α measuring the dollar amount of taxes paid unrelated to pre-tax income and β the marginal propensity to tax.

tax payment due to an additional dollar of current period pre-tax income.[3] With a linear tax function, an increase in tax avoidance is evidenced by a decrease in α and/or β.

Based on the function *Cash ETR* = α(*1/PI*) + β, we make the following prediction that provides insights regarding the properties of cash ETRs. If α is positive (which we empirically document below) and pre-tax income is positive, cash ETRs will decline in a convex fashion as the level of pre-tax income increases and converge from above towards the MPT (= β). This relation is driven by the fact that with a positive α and increasing income, the positive term α(*1/PI*) in the function will decline and converge towards zero. Figure 1 illustrates this negative convex relation. This decline in cash ETR is independent of any change in tax avoidance because the underlying tax function's parameters, α and β, are constant and the tax function remains unchanged. Thus, ignoring the growth effect of pre-tax income on the magnitudes of cash ETRs can lead to misleading inferences regarding the assessment of firms' tax avoidance behavior.

We begin our empirical analyses using a broad sample of profitable firm-year observations from 1988 through 2016. To illustrate the linear tax model is descriptive and that cash ETRs are a negative convex function of *PI*, we first sort the firm-year observations on *PI* and form 29 *PI* portfolios (labeled *PI*-portfolios).[4] We estimate the model *Cash ETR* = α(*1/PI*) + β using the means of each variable for each *PI*-portfolio. We find that both α and β are positive ($p<0.01$). The significant positive α indicates that cash taxes paid are not simply proportionally related to pre-tax income. We use the estimated α and β and pre-tax income to calculate a fitted mean cash ETR. The

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[3] The economics literature often refers to the slope coefficient, β, as the 'marginal tax rate' where 'marginal' means the incremental current period tax payment induced by an additional dollar of income in the current period. This definition differs from that used in the Scholes-Wolfson framework where the marginal tax rate is a multi-period concept defined as "the effect on the present value of current plus future income taxes to be paid per additional (or marginal) taxable income earned in the current period." (Erickson, Hanlon, Maydew, and Shevlin, 2019, 4-11).

[4] We sort into 29 *PI* portfolios as that is the number of years in our sample. This allows for a direct comparison of results using the 29 *PI*-portfolios with the 29 annual means. Forming 50 or 100 *PI*-portfolios gives very similar results.

fitted ETR indicates how much of the convexity in the actual ETR is related to *PI*. A plot of the actual portfolio mean cash ETRs shows that cash ETRs are negatively convex in *PI* and that the fitted cash ETRs from our model closely mirror the convexity (see Figure 2).

We then turn to analysis of the decreasing trend in cash ETRs documented in Dyreng et al. (2017) using the time-series of 29 annual mean observations. We observe a cumulative decline in the annual mean cash ETR of 12.09 percentage points over our sample period. Further, analyzing the descriptive statistics we find a positive annual mean pre-tax income that is growing through time.[5] We estimate the model $Cash\ ETR = \alpha(1/PI) + \beta$ using the annual means of each variable and note that α and β are both positive and significant ($p<0.01$). We use the estimated α and β, and pre-tax income to calculate fitted annual mean cash ETR. The fitted cash ETR illustrates how much of the actual ETR decline over time is related to growth in *PI*. A plot of the fitted cash ETR shows that our model tracks the annual decline in cash ETR quite closely. Note, in this analysis, we explicitly assume no change in tax avoidance (holding α and β constant) to illustrate that a large part of the decline in cash ETRs *could* simply be due to growth in pre-tax income.

Next, following Dyreng et al. (2017), we add a time trend variable to our cash ETR model, i.e., $Cash\ ETR = \alpha(1/PI) + \beta + \delta TIME$, to test whether there is any increase in tax avoidance over time measured by a significantly negative coefficient δ beyond the growth-induced ETR decline attributable to *1/PI*. The coefficient on the time variable δ is economically close to zero and statistically not significantly different from zero. Our results show that a large portion of the documented declining trend in ETR could be unrelated to firms' tax planning and illustrate why in Dyreng et al. (2017) firm characteristics fail to fully explain the decreasing trend. We thus conclude that if a linear tax function is descriptive, cash ETRs are nondiagnostic about changes over time or

[5] The annual mean of cash taxes paid is also positive and increasing over time

differences across firms in tax avoidance.

In addition to the cash ETR specification, we also estimate a scaled tax function specification, ($TXPD/TA$) = α($1/TA$) + β(PI/TA) using the annual means of total assets (TA) as the scalar with close to identical results. We further compare these two specifications to common specifications used in the literature, such as $Cash\ ETR = c + dROA$, where ROA is pre-tax return on assets or profitability and show that the specifications used in the literature suffer either from an error-in-variable or correlated omitted variable problem, and therefore are not able to capture the documented downward trend in ETRs.

We also estimate our two linear models using a pooled sample of firm-year observations with firm-fixed effects. We note that while the model $Cash\ ETR = \alpha(1/PI) + \beta$ yields similar results and inferences to the 29 annual mean analysis, the model ($TXPD/TA$) = α($1/TA$) + β(PI/TA) with firm fixed effects constitutes a misspecification in pooled regressions and does not explain the ETR trend well. The reason is that the model ($TXPD/TA$) = α($1/TA$) + β(PI/TA) does not have a constant where a firm fixed effect can be incorporated because it is a model with two explanatory variables and no constant. And if a fixed effect is forced, this changes the economic meaning of the linear tax paid model. We conclude that while both models are equivalent when using time-series regressions, such as the 29 annual means, the cash ETR specification is superior in pooled samples with firm-specific tax function parameters.

We conduct several additional analyses. First, we partition our sample into domestic and multinational observations as a widely cited result in Dyreng et al. (2017) is that multinational firms have higher cash ETRs and a less sharp ETR decline than domestic firms, although the opposite is expected given multinational firms' ability to shift income to low tax foreign jurisdictions. We estimate our cash ETR model separately for each group using our pooled dataset to examine whether the model can help to shed light on this result. We find a substantially higher α for the multinational firms but a very similar β for each of the two groups, which helps explain multinationals' higher cash ETRs. Higher income independent taxes possibly arise from differences between consolidated financial reporting but jurisdiction specific tax reporting where taxable income in one jurisdiction cannot be offset by losses in another jurisdiction. We also note that domestic firms' pre-tax income has grown at a significantly higher rate leading to a steeper decline in their cash ETRs.

Second, we illustrate how to test for changes in tax avoidance as reflected in changes of α and β, as well as how to test for hypothesized determinants when either model is used. We add several traditional tax avoidance determinants and their interactions with pre-tax income to the model to examine the changes in α and β. The estimated coefficients are generally consistent with expectations. This analysis allows us to distinguish between two components of cash ETR, ETR changes related to pre-tax income (*PI*-component of cash ETR) and ETR changes related to changes in α and β (tax avoidance-component of cash ETR). Our results show that even when allowing α and β to vary across firms and time as a function of common tax avoidance determinants, growth in pre-tax income continues to explain the documented downward trend in cash ETR. ETR changes attributable to tax avoidance are stationary fluctuating around zero over the sample period.

Our study has four main findings. First, we show that with a linear tax function changes in cash ETRs are related to changes in pre-tax income (*PI*-component of cash ETR). Second, we show that the *PI*-component of cash ETR is a negative convex function of *PI*. Therefore, *1/PI* must be included in ETR-specifications to control for this convex relation. Third, to the extent the tax function's parameters α and β are constant, cash ETRs are nondiagnostic about changes in tax avoidance. Only ETR changes related to changes in α and β are indicative about changes in tax avoidance (tax avoidance-component of cash ETR). Finally, applying our model to Dyreng et al. (2017), we show that growth in pre-tax income is a plausible alternative explanation for the observed decreasing trend in cash ETRs.

We contribute to the literature as follows. First, we develop the implications of the linear tax model for tax avoidance research. Although not common in the current literature, a few papers have noted the importance of controlling for changes in pre-tax income when investigating variation in ETRs (see, Wilkie 1988; Wilkie and Limberg 1990; 1993; Shevlin and Porter 1992; Gupta and Newberry 1997). We show that to the extent BTDs are linearly, versus proportionally, related to pre-tax income, cash taxes paid will also be linearly related to pre-tax income.

Second, we build on the literature examining the association between ETRs and profitability. Related work by Henry and Sansing (2019) examine the relation between the cash ETR and pre-tax ROA (i.e., $CashETR = c + dROA$), motivated by an inconsistent sign on ROA in the *extant* literature. Henry and Sansing model tax paid as $TXPD = \Delta + strPI$, giving an implied cash ETR function: $Cash\ ETR = \Delta(1/PI) + str$, where Δ represents everything that causes tax payments to deviate from *strPI*. They argue that if Δ is positive (negative), increases (decreases) in *PI* will shift the cash ETR downwards (upwards) to the statutory tax rate, thus the sign on ROA when regressed on cash ETR depends on the sign of Δ. In our model, the shift in cash ETR is toward the MPT. However, their study fails to recognize that given their arguments their correct empirical ETR specification should be $Cash\ ETR = \alpha(1/PI) + \beta$, with $\alpha = \Delta$ and $\beta = str$, not cash ETRs on ROA.

Third, we contribute to the literature on the time trend of ETRs. We reexamine the findings of Dyreng et al. (2017) and show that growth in pre-tax income is a plausible alternative explanation for the observed decreasing trend in cash ETRs. Brock, Clemons, and Nowak (2019) use the linear tax paid model to re-examine the Dyreng et al. (2017) result that U.S. multinationals do not have lower cash ETRs than domestic firms. Brock et al. (2019) focus on the MPT (i.e., β) as a measure of tax avoidance and show that the MPT is lower for U.S. multinationals. However, focusing only on the MPT while ignoring the intercept misstates tax avoidance. In essence, Brock et al. (2019) ignore BTDs that are not proportional to pretax income. Lampenius, Shevlin, and Stenzel (2020) use the linear tax model to estimate the average statutory tax rate that firms face over time, which they refer to as tax rate avoidance. They use this tax rate estimate to estimate an adjusted BTD that they label tax base avoidance. They estimate the linear tax model in annual cross-sections and examine tax rate and tax base avoidance across time comparing U.S. multinationals with domestic firms. They find that multinationals make use of tax rate avoidance while domestic firms make use of tax base avoidance. Drake, Hamilton, and Lusch (2020) examine the trend in ETRs using the reconciling items between statutory and GAAP tax rates from the tax footnote (i.e., permanent BTDs). They find that releases of the valuation allowance can explain the declining time trend in GAAP ETRs, and also cash ETRs, especially for domestic firms. This study provides some specific accounts and transactions that give rise to the linear BTD and tax models that we derive.

Finally, we add to the economics and finance research that oftentimes assumes linear-type tax functions (see for example, Helpman and Sadka 1978; Cooter and Helpman 1974; Romer, 1975; Graham and Smith 1999). Although the economics literature provides strong theoretical foundations as well as empirical evidence on the existence of linear tax functions, finance and accounting research empirically testing the implications of linear corporate tax functions is rare.

II. THEORETICAL BACKGROUND AND MODEL DEVELOPMENT

Development of a linear corporate tax function and its implications for the cash ETR model

In this section we develop a linear corporate tax function and show its implications for the modelling of cash ETR specifications. We start with the assumption that a firm's tax burden –

which we measure as cash taxes paid, *TXPD* – equals its taxable income, *TI*, multiplied by the statutory tax rate, *str*, minus tax credits, *C* (e.g., research and development credits and foreign tax credits) and taxes paid in the current period as a result of audit adjustments, *A*:

$$TXPD_t = A - C + strTI_t \quad (1)$$

Taxable income can be defined as pre-tax income, *PI*, plus or minus total book-tax differences, *BTD*, where book-tax differences are all items (including *NOL*) that receive differential treatment under the tax law as compared to book accounting treatment (as reflected in *PI*) and thus cause taxable income and pre-tax income to diverge:

$$TI_t = PI_t - BTD_t \quad (2)$$

If BTDs are proportionally related to pre-tax income, cash ETRs will not be affected by the level of pre-tax income (Wilkie 1988).[6] If, however, BTDs are linearly related to pre-tax income, cash ETRs will be affected by the level of pre-tax income and any decreasing time trend in cash ETRs could be driven by growth in pre-tax income and not by increased tax avoidance. We therefore model total book-tax differences as a linear function of pre-tax income:

$$BTD_t = \theta_0 + \theta_1 PI_t \quad (3)$$

where θ_0 reflects the portion of total book-tax differences that is unrelated to pre-tax income, and θ_1 the portion of total BTDs that is proportional to pre-tax income. We present examples of these various types of differences in Appendix A and link them to parameters of the linear tax model. Using data on reconciling items from schedule M-3, Gaertner, Laplante, and Lynch (2016) provide descriptive evidence on the major positive and negative permanent and temporary book tax differences of U.S. firms. Economically, θ_0 captures BTDs that are independent of current period's pre-tax income such as audit adjustments, tax credits and book-tax differences unrelated to current

[6] While our analysis is in terms of cash ETRs and role of total book-tax differences, our analysis also applies to GAAP ETRs (total tax expense/pre-tax income) but with permanent differences replacing total book-tax differences.

pre-tax income arising from U.S. GAAP's system of inter-period income tax allocation. Inter-period tax allocation effects arise due to temporary BTDs originating in some past period $t - s$ and reversing in the current period t (tax payments/refunds in t economically related to some prior period $t - s$ including NOLs effects) or due to temporary BTDs originating in period t that will reverse in some future period $t + s$ (tax prepayments such as on unearned revenue). Moreover, θ_0 may also contain permanent BTDs that are unrelated to the magnitude of current pre-tax income. To what extent temporary/permanent book-tax differences are proportionally/linearly related to pre-tax income is an empirical question on which we provide evidence in section IV.

Substituting equation (3) for BTD_t in equation (2), and this modification of equation (2) for TI_t in equation (1), and rearranging terms, yields the following linear corporate tax function:

$$TXPD_t = (A - C - str\theta_0) + str(1 - \theta_1)PI_t \tag{4}$$

Equation (4) shows that to the extent that total book-tax differences in equation (3) are linearly related to pre-tax income, cash taxes paid will also be linearly related to pre-tax income because θ_0 from equation (3) translates to some cash taxes unrelated to pre-tax income ($str\theta_0$) in equation (4), however, with the sign reversed. In addition to equation (3), equation (4) shows that other determinants like adjustments (A) and tax credits (C), which affect current taxes paid dollar for dollar will generate tax effects independent of current period income, which might prevent cash taxes paid being proportionally related to pre-tax income. The tax function's slope coefficient can be interpreted as the marginal propensity to tax (MPT) and is a function of the statutory tax rate and tax conforming components of book revenues and expenses (i.e., $(1 - \theta_1)$)[7].

Denoting $\alpha = (A - C - str\theta_0)$ and $\beta = str(1 - \theta_1)$ simplifies equation (4) to the following

[7] Henry and Sansing (2019) model tax paid as $TXPD = \Delta + strPI$, where Δ represents everything that causes tax payments to deviate from $strPI$. This model can be compared to our model in equation (4): $\Delta = \text{str}\theta_0$ and $\theta_1 = 0$. We model $BTD = \theta_0 + \theta_1 PI$ (equation 3) whereas Henry and Sansing assume $\theta_1 = 0$. We show below in our sample that $\theta_1 > 0$.

linear tax paid model:

$$TXPD_t = \alpha + \beta PI_t \tag{5}$$

Dividing equation (5) by the pre-tax income yields the corresponding cash ETR model:

$$Cash\ ETR_t = \alpha(1/PI_t) + \beta \tag{6}$$

Note the cash ETR model is linear in α and β as well as in (*1/PI*) and thus can be estimated by linear regression. Most importantly, although simple and intuitive, the transformation from equation (5) to (6) has largely been overlooked in prior literature. Instead of regressing cash ETRs on (*1/PI*) to control for changes in pre-tax income, most studies in tax research have regressed cash ETR on pre-tax return on assets (*PI/TA*).

Hypothesis development

We next show that if a linear tax function is descriptive, changes in cash ETRs will be related to changes in pre-tax income. To highlight how the level of the cash ETR is associated with the level of pre-tax income when a linear tax function is descriptive and to formally derive our hypotheses, we proceed in three steps. First, in order to assess the direction of the association between the cash ETR and pre-tax income, we take the first derivative of equation (6) with respect to pre-tax income, i.e., $f'(PI)$:

$$\frac{dCash\ ETR_t}{dPI_t} = -\frac{\alpha}{PI_t^2} \tag{7}$$

The derivative measures the change in the ETR if the level of pre-tax income changes by one unit and shows that holding the tax function constant, if α is positive, the relation between the cash ETR and the level of pre-tax income is negative throughout, meaning that if pre-tax income increases, cash ETR will decrease, i.e., $f'(PI) < 0$.

Second, equation (6) shows that as pre-tax income increases indefinitely, the term α(*1/PI*) approaches zero and the cash ETR approaches the limiting or asymptotic value of β, the marginal propensity to tax (MPT). Therefore, the MPT represents an asymptote or limit value that the dependent variable, cash ETR, will take on when pre-tax income increases indefinitely.

Third, the second derivative of equation (6) is positive, i.e., $f''(PI) > 0$,[8] the negative relation between the cash ETR and *PI* gets less steep as pre-tax income increases – meaning that the level of the cash ETR decreases in a convex fashion as the level of pre-tax income increases. This convexity is illustrated in Figure 1. The three features implied in the linear cash ETR function lead to our first hypothesis:

> *H1: Given a linear tax function, where the intercept and pre-tax income are both positive,* ***the Cash ETR will decline in a convex function of pre-tax income*** *and approach the marginal propensity to tax (MPT) from above.*

In contrast, in a purely proportional tax function where $\alpha = 0$, the level of pre-tax income will not affect the level of the cash ETR. That is, the first derivative will be zero, highlighting that in this case the cash ETR will not change as pre-tax income changes and observed decreases in ETR can be directly interpreted as differences in tax avoidance. This analysis shows that for the traditional definition of tax avoidance to hold, the underlying tax function must be proportional.

For a linear tax function to explain the observed decreasing time trend in cash ETRs requires that in a pooled sample, the average intercept is positive and the average pre-tax income is positive and growing through time. We formally state this as our second hypothesis:

> *H2: Given a linear tax function, where the intercept is positive and pre-tax income is positive and generally increasing through time,* ***the average Cash ETR will decline over time****.*

Extension of the traditional tax avoidance definition

Traditionally tax avoidance is broadly defined as any reduction in cash ETRs (i.e., taxes paid relative to pre-tax income). While this definition is intuitive, it has an embedded assumption that

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[8] The second derivative of $Cash\ ETR = \alpha(1/PI) + \beta$ is given by $d^2Cash\ ETR/dPI^2 = 2\alpha/PI^3$, i.e., $f''(PI) > 0$.

the underlying tax function is proportional (*TXPD* = *βPI*) as, by definition, any change in the ratio of cash taxes paid to pre-tax income (*Cash ETR* = *β*) is a change in tax avoidance. In the proportional model where the ETR is independent of the income level (*dCash ETR/dPI = 0*), the ETR has no *PI*-component but only a tax avoidance-component. This definition is incomplete and misleading if the tax function is not proportional. As already shown, if a linear tax function is descriptive, changes in ETRs will to some extent be related to changes in pre-tax income and, to that extent, will be unrelated to, or nondiagnostic about, tax planning.

We therefore extend the traditional definition of tax avoidance. Given a linear tax function, *TXPD* = *α* + *βPI* that implies an ETR function of the form *Cash ETR* = *α*(*1/PI*) + *β*, only cash ETR decreases that are associated with decreases in *α* – a decrease in taxes paid unrelated to pre-tax income – and/or decreases in *β* – taxes paid as a function of pre-tax income, represent tax avoidance (tax avoidance-component of cash ETR). In contrast, changes in cash ETRs unrelated to changes in *α* and/or *β* are simply due to changes in pre-tax income, and thus, independent of any change in tax avoidance (*PI*-component of cash ETR).

III. DATA AND SAMPLE SELECTION

We include all non-financial and non-utility firm-year observations listed in Compustat with available data and with assets greater than $10 million. We examine the time period 1988–2016 to ensure the longest available period with a constant statutory tax rate after the last major overhaul of the U.S. tax system in 1988 and before the announcement of the 2017 reform.[9] We only include U.S. firms in our analyses and require non-negative values for cash taxes paid and pre-tax income, and non-missing values for total assets. Finally, we require each firm to have at least 5 observations

[9] We acknowledge the top corporate statutory tax rate increased from 34 to 35% in 1993. The Tax Reform Act of 1986 phased in lower statutory corporate tax rates with the new rates fully in effect for 1988 while the Tax Cuts and Jobs Cut (2017) reduced the corporate statutory tax rate to a flat 21%.

of all chosen variables. This requirement leads to a final sample size of 63,407 observations including 5,531 individual firms. A firm appears in the sample for an average of 14.8 years.

Table 1 Panel A reports descriptive statistics where all variables are winsorized at 1% and 99%. We also report descriptive statistics for cash ETRs winsorized (i.e., reset) to 0 if ETR < 0 and reset to 1 if ETR > 1, and trimmed at 0 and 1. We note that cash ETRs winsorized at 1% and 99% have a slightly higher mean compared to ETRs adjusted to range between 0 and 1, but a substantially higher maximum consistent with the fact that resetting to or trimming at 0 and 1 possibly removes an economically useful part of cash ETR-convexity from the sample that might affect α estimates. Overall, our descriptive statistics are consistent with those reported by Dyreng et al. (2017).

To test H1, that cash ETRs are a convex function of pre-tax income when the intercept in the linear tax model is positive, we form 29 portfolios based on pre-tax income, termed *PI*-portfolios. We use 29 portfolios sorted on *PI* for comparison to tests using the 29 annual means of the cash ETR. We use the 29 annual means to test H2, that the decreasing trend in cash ETRs could be explained by growth of *PI* over time even in the absence of any additional tax planning. We note that results of tests of H1 are quantitively similar if we use 50 or 100 (or more portfolios). Descriptive statistics for the *PI*-portfolios are presented in Panel B and for the annual means in Panel C of Table 1. The mean cash ETR for each portfolio is calculated as the mean of *TXPD* divided by the mean of *PI*. Not surprisingly, the minimum and maximum of the means of *TXPD*, *PI*, and cash ETR in the *PI*-portfolios display a larger spread than the 29 annual means. The mean and median of total book-tax differences (*BTD*) and both its components, permanent (*BTDPERM*) and temporary (*BTDTEMP*) differences, are positive in both panels, consistent with pre-tax income being larger than taxable income.

IV. EMPIRICAL RESULTS

Test of H1: ETR is a convex function of pre-tax income

To provide graphical evidence on H1, that cash ETR is a negative convex function of pre-tax income (as illustrated in Figure 1), we present a scatter diagram of cash ETR for the 29 portfolios formed on pre-tax book income in Figure 2 (the solid line is discussed below). The convexity is evident in the plot and provides strong descriptive evidence consistent with our hypothesis.[10] We next provide more formal evidence.

On the theoretical level, we develop our tax function model in the form of levels, that is $TXPD = \alpha + \beta PI$. For empirical estimation, however, we use scaled versions of the level model in order to avoid potential scale bias issues in the estimated coefficients, as well as econometric issues related to heteroscedasticity. We use pre-tax income *PI* and total assets *TA* as deflators. Scaling our model by *PI* yields $Cash\ ETR = \alpha(1/PI) + \beta$ and scaling by *TA*, $(TXPD/TA) = \alpha(1/TA) + \beta(PI/TA)$. Note, because we scale both sides of $TXPD = \alpha + \beta PI$ by the respective scalar, *PI* or *TA*, scaling does not change the economic meaning of our two coefficients of interest, α and β.

We present the results of estimating both scaled models based on the 29 *PI*-portfolio means in Table 2: Column (1) presents results for the cash ETR regression and Column (2) for the total asset scaled specification. In both columns α is positive, and approximately 0.57 to 0.60, and significant ($p<0.01$), consistent with firms on average paying a fixed level of tax, regardless of the level of pre-tax accounting income. The significant positive α thus rejects the proportional tax paid

[10] It might appear in Figure 2 that the convexity is driven by the first 3 *PI*-portfolios. However, this is an artefact of the scaling on the y-axis. When these first 3 portfolios are omitted, and the figure redrawn (untabulated), the convexity in the remaining *PI*-portfolios is still clearly evident.

model.[11] The estimated marginal propensity to tax, β, is also positive and significant ($p<0.01$), and approximately 0.27.

The estimated specification in Column (1) directly gives a fitted cash ETR of *Cash ETR* = 0.571(*1/PI*) + 0.272. The estimated coefficients from Column (2), however, can also be used to arrive at a fitted cash ETR of *Cash ETR* = 0.601(*1/PI*) + 0.268. Given the similarity in coefficient estimates, the fitted cash ETRs from both specifications are very similar. The adjusted R-squares are close to 1, which reflects the use of portfolio means rather than firm-year observations (which we report below). We plot the fitted value of the cash ETR model as the solid line in Figure 2. These results are consistent with H1: Given a linear tax function, where the intercept and pre-tax income are both positive, the cash ETR will decline in a convex function of pre-tax income and approach the marginal propensity to tax (MPT) from above if the level of pre-tax income is monotonically increasing.

Test of H2: Cash ETRs decrease over time as pre-tax income increases over time

We calculate the mean annual cash ETR for our sample by dividing the annual mean cash taxes paid by the annual mean pre-tax income. Figure 3A plots the mean cash ETRs for each year from 1988 to 2016 and provides visual evidence of a clear downward trend over the past 29 years,

[11] One way to test whether a proportional or a linear model is more descriptive is to estimate a proportional and a linear tax function and to compare the goodness of fit of the models. Conventional R-square measures as defined in standard econometric textbooks and as reported in the regression output of most statistical software such as STATA are not appropriate for comparisons of the explanatory power between linear and proportional "through-the-origin" models (see e.g. Gujarati and Porter, 2009, p. 150). The reason is that the normal OLS equations and other OLS formulas such as the formula to calculate a regression's slope coefficient or the formula to calculate the R-square differ from each other in regression models with and without an intercept and thus are not comparable (Maddala and Lahiri, 2009, p. 83). In order to evaluate the models "goodness of fit", we use the relative root mean square error: $RMSER = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\left(\widehat{TXPD}_t - TXPD_t\right)/TXPD_t\right)^2}$. Independent of whether the underlying model contains an intercept or not, the relative root mean square errors evaluate a model's goodness of fit and allows comparisons across different models between actual and fitted values. The lower the root mean square error the higher a model's goodness of fit. The relative root mean squared error of the linear model $TXPD = \alpha + \beta PI$ is 0.056 and of the proportional model $TXPD = \beta PI$ is 0.299 when using the 29 *PI*-portfolio observations. The results clearly show that the linear tax paid model has higher goodness of fit and therefore is empirically more descriptive than the proportional model.

consistent with the downtrend trend documented in Dyreng et al. (2017). Figure 3B plots the annual means of cash taxes paid and pre-tax income and shows that both are positive and increasing over time – the over-time increasing *PI* being a necessary condition if H2 is to be descriptive.

We present the results of estimating the ETR specification: *Cash ETR* = α(*1/PI*) + β and the *TA*-scaled taxes paid specification: (*TXPD/TA*) = α(*1/TA*) + β(*PI/TA*) based on the 29 annual means in Panel A of Table 3, Columns (1) and (2). In both columns α is positive, and approximately 16.50, and significant ($p<0.01$), consistent with firms on average paying a fixed level of tax, regardless of the level of pre-tax accounting income. The estimated marginal propensity to tax β is also positive and significant ($p<0.01$), and approximately 0.20. The magnitude of the coefficient estimates differs from those in Table 2 using portfolios formed on *PI*. The explanation for this difference is that the minimum mean *PI* for the 29 *PI*-portfolios is $0.53M compared to $118.86M for the annual means. Similarly, the maximum mean *PI* for the 29 *PI*-portfolios is $5,075M compared to $691M for the annual means. The larger spread in the mean *PI* for the 29 *PI*-portfolios leads to a smaller α and β slope.

We calculate the fitted cash ETRs based on the coefficient estimates in Table 3, Panel A, Column (1) and we plot both the actual cash ETR and the fitted cash ETR over time in Figure 3C, which clearly shows that the fitted cash ETR closely tracks the downward trend in the actual cash ETR. Our results show that growth in pre-tax income explains almost all of the documented ETR decline in Dyreng et al. (2017). Because the estimated coefficients in Table 3 Panel A, Column (2) for the *TA*-scaled tax paid model are almost identical, we do not show these results graphically (both would appear as one line in Figure 3C). Figure 3D shows the estimated residuals from the cash ETR regression in Table 3, Panel A, Column (1). The residuals fluctuate around zero over the sample period, providing further evidence that changes in PI explain the downward ETR-trend and that the level of tax avoidance has not increased over time.

Next, following Dyreng et al. (2017) we add a time trend variable to our ETR specification and an interaction of the time variable and (*PI/TA*)[12] to our *TA*-scaled tax paid model, yielding:

$$Cash\ ETR_t = \alpha(1/PI_t) + \beta + \delta TIME_t \quad (8)$$

$$(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t) + \delta(PI_t/TA_t)TIME_t \quad (9)$$

Our aim is to more formally test whether there is any increase in tax avoidance over time measured by a significantly negative coefficient δ beyond the PI-growth induced ETR decline reported above. Dyreng et al. (2017) find the coefficient on the time trend is negative and statistically significant, concluding that tax avoidance is increasing over time. This result could lead to misleading inferences if the underling tax paid model is linear and the ETR model does not correctly control for growth in pre-tax income (i.e., *1/PI* is not included as a control). Similarly, the *TA*-scaled tax paid model will fail to capture the effect of growth in *PI* if *1/TA* is omitted as a regressor.

Results in Table 3 Panel B, Columns (1) and (2) show an insignificant coefficient δ on the respective time trend variable, which is economically close to zero. Consistent with our prediction in H2, the results show that given a linear tax paid model almost all of the documented ETR-trend is attributable to growth in pre-tax income.

Inability of common tax avoidance specifications to capture the cash ETR's time trend

Probably the most common cash ETR specification used in the literature is a regression of the cash ETR on pre-tax return on assets (*ROA*) (e.g. Gupta and Newberry 1997; Rego 2003; Henry

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[12] Dyreng et. al. (2017), p. 460, footnote 36 implicitly show that if estimating a level specification as $TXPD_t = \alpha + \beta PI_t$ or a deflated level specification as $(TXPD_t/PI_t) = a + b(PI_t/TA_t)$ instead of an ETR specification, one needs to include an interaction term of the time trend variable with the respective explanatory variable instead of simply the time trend variable to obtain consistency between the tax function and the ETR specification. This can be e.g. seen from division of $TXPD_t = \alpha + \beta PI_t + \delta PI_t TIME_t$ by PI_t which gives $Cash\ ETR_t = \alpha(1/PI_t) + \beta + \delta TIME_t$ where the δ coefficient captures the exact same time effect in the respective specifications.

and Sansing 2019):

$$Cash\,ETR_t = c + dROA_t \tag{10}$$

where *ROA* is pre-tax income scaled by total assets. Another common specification is a regression of taxes paid scaled by total assets on pre-tax income scaled by total assets (e.g., Dyreng and Lindsey 2009; Dyreng et al. 2017, footnote 36; Dyreng, Lewellen, and Lindsey 2018):

$$(TXPD_t/TA_t) = a + b(PI_t/TA_t) \tag{11}$$

Another conceivable specification could be given by dividing the profitability model (11) by (*PI*/*TA*) to obtain the corresponding ETR specification:

$$Cash\,ETR_t = a(1/ROA_t) + b \tag{12}$$

In such a specification, the cash ETR is regressed on *1/ROA* as the explanatory variable. The coefficients *c* and *d* in equation (10) are unrelated to our tax function's parameters α and β. Further, the coefficients in equations (11) and (12) are not directly comparable with α and β from our tax paid model. We therefore denote them as a and *b* instead of as α and β.

We present analysis in Appendix C that shows each of the above specifications are misspecified because they contain either an error-in-variable or a correlated omitted variable problem. Both errors will reduce the ability of the respective specification to capture the declining trend in the ETRs. To show that specifications (10) to (12) are misspecified and do not capture the declining trend in the cash ETR, we estimate equations (10) to (12) empirically and compare them to results reported in Table 3 using our linear tax model. In this analysis we continue to use the time-series of 29 annual means. Table 4 Panel A presents the regression results and Figures 4A and 4B illustrate the misspecifications. Across the regressions, only 2 of the 6 estimated coefficients are significant. The R-squares are very low as compared to results in Table 3, indicating that the explanatory variables in equations (10) to (12) do not explain much variation in the dependent variable, as can be seen from the fitted values in Figure 4A. Vuong tests that formally compare the differences in explanatory power between our cash ETR model $Cash\ ETR_t = \alpha(1/PI_t) + \beta$ and models (10) and (12), respectively, as well as our *TA*-scaled tax paid model $(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t)$ and (11) reveals in all cases a highly significant negative Vuong t-statistic (Vuong, 1989).[13] These results are consistent with the fact (i) that *1/PI* explains variation in the mean annual cash ETR better than pre-tax return on assets *PI/TA* or *1/ROA* and (ii) that including *1/TA* helps to improve the explanatory power in models that explain variation of taxes paid scaled by total assets. Figure 4B plots the corresponding residuals from regressions (10) to (12). All three specifications exhibit significant downward trends in the residuals indicating clear model misspecifications. Technically these misspecifications arise from the discussed error-in-variable and omitted correlated variable problems in Appendix C. Economically, these misspecifications reflect the models' inability to adequately control for growth or changes in pre-tax income.

If these traditional specifications do not adequately control for growth in pre-tax income, we expect a time trend variable to be significantly negative. Results in Table 4 Panel B, Columns (1), (2), and (3) all show statistically significant coefficients on the time trend variables. For these models, adding a time trend variable as an additional explanatory variable picks up the misspecification and leads to a significantly negative coefficient on the time trend. These results erroneously show an increase in tax avoidance as measured by the significantly negative δ. The error arises due to the lack of an adequate control variable for growth in pre-tax income. Our

[13] The estimated Vuong t-statistic is −5.31 ($p<0.01$) when comparing $Cash\ ETR_t = \alpha(1/PI_t) + \beta$ and (10), and −5.43 ($p<0.01$) when comparing $Cash\ ETR_t = \alpha(1/PI_t) + \beta$ and (12). Further, the estimated Vuong t-statistic is −5.64 ($p<0.01$) when comparing $(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t)$ and (11).

analysis shows that researchers should be careful in choosing the correct specification when testing for tax avoidance determinants.[14]

Linear tax model results using firm-year (pooled) observations

Use of the Cash ETR Specification to estimate the Tax Paid Model

Typically, cash ETRs are winsorized (reset) at 0 and 1, oftentimes arguing that ETRs below 0 and above 1 lack economic meaning. This argument, however, only applies to a proportional tax function when pre-tax income is positive. Given our theoretical and empirical evidence on a linear tax function, however, this argument no longer applies. With a linear tax paid model, we expect some firms to have *PI* that is small relative to their fixed tax payments (α in the linear tax model). For some of these firms we expect that cash ETRs can be greater than one. Thus, we take the approach that is typically used in the literature on other financial statement-based variables and winsorize cash ETRs at 1 and 99%.

For comparison with the extant ETR literature we also provide results after winsorizing the firm-specific cash ETRs at 0 and 1, and also with trimming the cash ETR at 0 and 1 (i.e., deleting observations outside this range, which removes 2,190 firm-year observations).[15] In addition to winsorizing or trimming the cash ETR, we also identify influential observations using Cook's D where we delete firm-year observations with Cook's D larger than 4/N, where N is the sample size (which removes 80 firm-year observations). We aim to examine whether growth in income explains the cash ETR trend also in the pooled sample and whether the different approaches to adjusting the

[14] For example, in an alternative specification, Dyreng et al. (2017), p. 460 footnote 36, test $(TXPD_t/PI_t) = a + b(PI_t/TA_t) + \delta(PI_t/TA_t)TIME_t$ including controls, and find a significantly negative coefficient of δ. Based on this result, they conclude that tax avoidance has increased over time. In contrast, we show that including (*1/TA*) in this specification as shown in Table 3, Panel B, Column (2) results in an insignificant δ coefficient, which is close to zero. This result indicates that tax avoidance has not increased over time.

[15] Because we restrict our sample to nonnegative *TXPD*, the minimum cash ETR is 0 and thus when we say winsorize to or reset to 0, this is a null set. However, we retain our verbiage (description) to be consistent with extant literature.

ETR for outliers has an impact on the α and β estimates. We also include firm fixed effects as extant literature often includes firm fixed effects when using panel data sets.[16]

The results are presented in Table 5 Panel A. Across the first three approaches, the estimated marginal propensity to tax, β, is approximately 0.26 and significant. However, α declines as we move from winsorizing at 1 and 99%, to winsorizing at 0 and 1, to trimming at 0 and 1, but remains significantly positive in the 3 models. Using Cook's D to remove influential observations in Column (4), we find that both α and β are significant with α approximately the same magnitude as winsorizing cash ETR at 1 and 99% and β is slightly larger at 0.29. Our results show that the two traditional methods to treat ETR-outliers, that is, winsorizing and trimming to 0 and 1, result in substantially lower values of α. The lower α-estimates are caused by the fact that economically meaningful ETR-values above one are eliminated from the empirical ETR convexity.[17]

We again calculate fitted cash ETRs based on the model coefficients and calculate the annual mean (which is an equal weighted mean as we are summing the firm-specific ETRs). The fitted cash ETRs and the actual annual mean cash ETRs are plotted in Figures 5A – 5D using the same winsorizing and trimming rule within each plot. We note that in general the fitted cash ETRs track the downward trend in the actual cash ETRs across all four specifications. This result is consistent with hypothesis 2 that given a linear tax model, growth in pre-tax income explains large parts of the documented declining ETR trend.

In Panel B of Table 5 we again add a time trend. The coefficient on the time trends are not significantly different from 0 in Columns (1) and (2), which use winsorization, but the time trend is significantly negative in Column (3) using trimmed cash ETRs consistent with the lower α

[16] Note that firm fixed effects allow the intercept to vary in regressions. Thus, in the unscaled *TXPD* model, firm fixed effects allows α to vary while in the cash ETR model, firm fixed effects allows β to vary across firms.

[17] We note the α and β estimates differ in the pooled sample from the annual mean regression results. As noted earlier, these differences are due to the difference in the spread of the variables.

reported in Panel A suggesting that trimming cash ETRs can lead to poor estimates. With Cook's D regression in Column (4), the time trend exhibits a significant positive time trend in cash ETR after allowing for the growth in *PI*. Thus, overall these results from estimating the cash ETR models using pooled data are consistent with our argument that, even in the absence of any change in tax avoidance, we can observe a decline in cash ETRs due to the growth in pre-tax book income.

Book-tax differences in the tax function model

In this section, we test empirically whether BTDs are linearly associated with pre-tax income, and if so, to what extent the temporary and permanent components of BTDs influence the parameters α and β in the tax function.[18]

We calculate permanent BTDs (*BTDPERM*) by subtracting the total GAAP tax expense (*TXT*), grossed up by the statutory tax rate (*str*), from pre-tax income: $BTDPERM_{it} = PI_{it} - TXT_{it}/str$. Temporary BTDs (*BTDTEMP*) are calculated as: $BTDTEMP_{it} = (TXT_{it} - TXPD_{it})/str$. Total BTDs (*BTD*) are given by the sum of permanent and temporary book-tax differences.

We estimate the relation $(BTD_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1$ with the results reported in Column (1) of Table 6, Panel A. Both the intercept and the slope coefficient of the BTD function are statistically significant at p<0.01, and economically meaningful. The estimated intercept is negative, $\theta_0 = -0.985$, indicating that the pre-tax income independent component of total BTDs is negative, consistent with a linear relation between total book-tax differences and pre-tax income.

The estimated total BTDs that are proportionally related to pre-tax income are $\theta_1 = 0.269$,

[18] We use the estimated total temporary and permanent differences due to data limitations. Gaertner et al. (2016) provide descriptive statistics on the main positive and negative temporary and permanent differences as reported in firms' schedule M-3. These data could be used to estimate $(BTD_t/PI_t) = \theta_0(1/PI_t) + \theta_1$ for each individual component to examine which components determine $\alpha = str\theta_0$ and $\beta = str(1 - \theta_1)$ in the linear tax model. We provide examples of BTDs and how we expect they effect the parameters of the linear tax model in Appendix A. For example, we discuss the effect of NOLs as examined by Drake et al. (2020).

meaning that an additional dollar of pre-tax income increases total BTDs by 0.269, or alternatively stated, each dollar of pre-tax income includes 73.1 cents of conforming income reflected in taxable income $(1 - 0.269 = 0.731)$. This relation translates into a marginal propensity to tax of $\beta = str(1 - \theta_1) = 0.35(1 - 0.269) = 0.256$.

In columns (2) and (3) we differentiate between permanent and temporary BTDs to gain further insights into the individual component effects on the tax function's parameters α and β. The intercept θ_0 is significantly negative for both permanent and temporary differences but temporary differences have a more negative coefficient, at nearly 4 times larger. The estimated slope coefficient θ_1 is significantly positive for both permanent and temporary differences, again with temporary differences having a larger coefficient. Taken together, these results are consistent with temporary differences being a large driver of the positive parameters in the tax function regressions.[19]

We also add a time trend to the BTD regressions, reported in Panel B of Table 6. The time trend is negative but not significant, consistent with the positive but not significant time trend in the corresponding cash ETR regression in Column (1) of Table 5, Panel B. The time trend for permanent (temporary) differences is significantly positive (negative) implying permanent (temporary) differences lead to a downward (upward) trend in cash ETRs. However, the two differences cancel out when looking at total *BTDs*.

Our analysis shows that because BTDs are linearly related to pre-tax income, cash taxes paid will also be linearly related to pre-tax income, and consequently, cash ETR changes will be related

[19] We also estimate the BTD regressions using the 29 *PI*-portfolios and 29 annual means. Using the 29 *PI*-portfolios we continue to find that temporary differences are relatively more important. However, when using the 29 annual means, temporary differences appear less important. We conjecture that this arises because in the annual means, a cross-sectional calculation, additions and reversals of temporary differences cancel out across firms. However, we leave further exploration of this result, and further examination to the types of accounts that drive this result, to future research.

to changes in pre-tax income. Temporary differences are relatively more important than permanent differences in explaining the magnitudes of both parameters of the linear tax model. This analysis also indicates that when scaled BTDs are used as a measure of tax avoidance, 1/scalar must be included as an explanatory variable, otherwise the model is miss-specified.

Estimating the Tax Paid Model on Pooled Data

When using firm-level data, the *TXPD* model scaled by total assets is $(TXPD_{it}/TA_{it}) = \alpha(1/TA_{it}) + \beta(PI_{it}/TA_{it})$.[20] If we add firm fixed effects to this model it becomes $(TXPD_{it}/TA_{it}) = (\gamma + \gamma_i) + \alpha(1/TA_{it}) + \beta(PI_{it}/TA_{it})$. Thus, with firm fixed effects, this model is no longer the linear tax model.[21] We report results of this model in Column (1) of Table 7 Panel A. All variables have been winsorized at 1 and 99%. The estimated coefficient on (*1/TA*) is insignificant and negative, with $\alpha = -0.036$ when given our predictions and results obtained so far it is expected to be significantly positive. When a time trend is added to this model, Column (1) of Panel B, the α-coefficient remains negative and the included coefficient on the time trend is significantly negative, indicating that this model does not capture the downward trend. Thus, it is important to note that the use of any scalar other than *PI* in the linear tax paid model will be misspecified if firm fixed effects are added.

We propose a different approach to avoid a potential scale bias in the *TXPD* model. Instead of scaling the model by total assets, we estimate the unscaled tax paid model: $TXPD_{it} = \alpha + \beta PI_{it}$, reported in Column (2) of Table 7. In this regression we remove observations with Cook's D greater

[20] If we estimate the model $(TXPD_{it}/TA_{it}) = a + b(PI_{it}/TA_{it})$ using firm-year observations, this is the misspecified model in Table 4 Column (2). While the slope coefficient, *b*, is similar to the β-estimates in Table 5 for the cash ETR function (at 0.214) the estimated intercept although significant is severely downward biased $a = 0.006$. Further the time trend is significant – this model is unable to explain the downward trend in cash ETRs.

[21] Specifically, re-scaling by multiplying the model by TA_{it} we get: $TXPD_{it} = a + \gamma TA_{it} + \gamma_i TA_{it} + \beta PI_{it}$, which is clearly different from our developed tax paid model in a pooled sample with a firm-fixed effect: $TXPD_{it} = \alpha + \alpha_i + \beta PI_{it}$.

than 4/N (which removes 771 firm-year observations). By using Cook's D to remove influential observations, we can add firm fixed effects to this unscaled *TXPD* model. Column (2) shows that Cook's D regression without scaling by *TA* yields much more consistent results with α = 7.606 and β = 0.235. When a time trend is included in the model in Panel B Column (2), the trend is significant at p<0.01 and positive, δ = 0.001 indicating a very slight decrease in tax avoidance over time after controlling for growth in *PI* (similarly to the cash ETR results using Cook's D in Table 5, Column (4)). The fitted cash ETR from this model tracks the downward trend in the mean actual cash ETR (untabulated).

V. ADDITIONAL ANALYSES

Partitioning sample into U.S. Domestic and U.S Multinational Observations

While our main focus is on the ability of a linear tax model to explain the declining trend in cash ETRs, a second widely cited result from Dyreng et al. (2017) is that multinational firms (MNE) exhibit higher cash ETRs than domestic firms (DOM) and MNEs exhibit a smaller downward trend in cash ETRs when it is expected that MNEs would exhibit a larger downward trend and lower cash ETRs given their ability to shift income to low tax foreign jurisdictions. Because cash ETRs are not diagnostic about tax avoidance one cannot conclude that DOMs are increasing their tax avoidance at a higher rate than MNEs. Thus, we estimate our linear cash ETR model separately for each group using the pooled data.[22] We partition and classify observations as MNEs if they have nonmissing pre-tax foreign income or foreign tax expense; otherwise they are classified as DOM.

In untabulated tests, we first graphically examine the evolution of annual mean cash ETRs for each group and note declining trends for both groups and that MNEs have a higher mean cash

[22] We also replicate Table 2 (*PI*-portfolio analysis) and Table 3 (annual means) for each group with similar inferences to using the pooled data. In addition, we find i) temporary differences are more important than permanent differences for both groups and more important for domestic than multinational firms in explaining α in the linear tax model, and iii) that cash ETR is a convex function of *PI* for both groups.

ETR throughout the sample period. We then regress each ETR on a time trend variable and find that DOMs have a steeper time trend of −0.005 compared to −0.004 for MNEs. These results are consistent with Dyreng et al. (their Table 3 and Figure 3). Because the rate of decline in cash ETRs is a function of the growth in *PI*, we conjecture that the larger decline in DOMs' ETRs could be due to higher growth in pre-tax income. We calculate the average annual growth rate in *PI* for each group over the sample period: DOMs exhibit a significantly higher growth rate of 9.8% compared to 5.2% for MNEs. We report the results of estimating the cash ETR model for each group in Panel A of Table 8. We find that α is significantly positive in both groups but that it is significantly larger (2.3 times larger) for MNEs. The marginal propensity to tax β is also significantly positive in both groups and again larger in the MNE group but not significantly so.[23] Given a roughly similar β, the higher α helps explain the higher average ETR of MNEs. In untabulated plots, we find that the fitted cash ETR tracks the decline in the actual cash ETR for each group, consistent with our conjecture that the higher income growth of DOMs explains the larger decline in the ETR. When we add time trends to our linear model in Table 8 Panel B, the estimated coefficient on the time trend variable is significant at $p<0.1$ and positive for DOMs and positive but not significant for MNEs.

The above findings suggest the following inferences. First, the higher α for the multinational firms helps explain their, on average, higher cash ETRs throughout the sample period. Higher income independent taxes possibly arise from differences between consolidated financial reporting but jurisdiction specific tax reporting where taxable income in one jurisdiction cannot be offset by

[23] Our results are not directly comparable to Brock et al. (2019) as they regress unscaled *TXPD* on *PI* and in their OLS specifications do not adjust for outliers/influential observations. Brock et al. (2019) also use the least absolute deviation (LAD) method to address influential observations. However, LAD estimates, especially for the intercept, are not comparable to OLS estimates (Woolridge (2010), pp. 451-452). Our MPT result might be somewhat surprising given MNEs can shift income to low tax foreign countries but is consistent with Lampenius et al. (2020) who provide reasons for why U.S. domestic firms likely have similar MPT to MNEs. Our results also are not directly comparable to Lampenius et al. (2020). Recall the MPT = $str \times (1-\theta_1)$ and Lampenius et al. (2020) include proxies for book-tax differences to remove the effects $(1-\theta_1)$ so as to isolate the top average statutory tax rate faced by firms which they label as tax rate avoidance.

losses in another jurisdictions.[24] Second, domestic firms' pre-tax income has grown at a significantly higher rate consistent with the steeper decline in cash ETRs. Third, also of note, both groups have similar marginal propensity to tax and thus both groups cash ETRs will converge to roughly the same level as *PI* increases.

Testing for tax avoidance in a linear tax model

To examine how tax avoidance in the linear tax model varies as a function of hypothesized determinants, denoted by vector *X*, we need to control for the mechanical effect of *PI* growth while allowing the parameters α and β to vary as a function of the determinants. Alternatively stated, in a linear model, to test whether some hypothesized determinant is associated with tax avoidance, one has to test whether the parameters, α and β, of the linear tax model vary as a function of the determinants as shown in equation (13):[25]

$$Cash\ ETR_{it} = \alpha(1/PI_{it}) + \sum_{s=1}^{N} \alpha_s (1/PI_{it})({}_sX_{it}/TA_{it}) + \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it}) \qquad (13)$$

We illustrate the application of our model by estimating equation (13), adding some firm characteristics that are hypothesized to influence firms' tax avoidance – variables in the *X*-vector.[26] All continuous variables in the *X*-vector are scaled by total assets (*TA*) and are winsorized at 1 and 99%. We also include firm fixed effects. Results are reported in Table 9 and where significant are

[24] Because MNE firms may have losses in their foreign or domestic operations but overall positive *PI,* which might impact taxes paid independent of *PI*, in untabulated analyses we omit all firm-year observations where either foreign or domestic income of MNEs is negative. Our results are virtually unchanged.

[25] For a detailed derivation of our model (13), see Appendix D. Compare our model (13) with traditional cash ETR specifications based on a proportional tax paid model: $Cash\ ETR_{it} = \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it})$ where to test hypothesized determinants (or to add control variables) the researcher simply linearly adds scaled variables to the cash ETR model. Recall, in a proportional model where the average cash ETR equals the MPT, cash ETRs are independent of pre-tax income changes (*dCash ETR/dPI = 0*) meaning that there is no *PI*-component of cash ETR and thus no need to control for changes in income by including (*1/PI*). Any decrease in the cash ETR (e.g. caused by some determinant X_s) is then evidence of increased tax avoidance (that is, cash ETRs consist solely of a tax avoidance-component). In a linear model, we need to also allow the intercept to vary as a function of hypothesized determinants.

[26] We include total debt scaled by total assets consistent with prior studies but we note that interest is generally a conforming book-tax item so we have no prediction as to how it will effect α and β, if at all.

generally in line with expectations given prior literature. Specifically, we find that α is significantly larger for MNEs consistent with our results in Table 8, is decreasing in *XRD* (as a proxy for the tax benefits associated with intangibles including tax credits), *PPE* (as a proxy for tax benefits associated with investment in tangible assets such as accelerated depreciation), and lower in firms with *NOL cf*. α is also positively associated with the change in *NOL cf* consistent with a decrease in the *NOL* reducing firms' taxes paid with some portion of the reduction being unrelated to the current period *PI* as conjectured in Appendix A.

We find that β is not significantly different for MNEs consistent with Table 8 results and is marginally significantly increasing in *XRD*, and the change in *NOL cf*. The latter is consistent with a decrease in the *NOL* reducing firms' taxes paid with some portion of the reduction being proportional to the current period *PI*. The adjusted R-squared of the model is 0.228 can be compared with the adjusted R-squared of 0.203 reported in Table 5, Panel A, Column (1), which excludes the *X*-vector variables suggesting a marginal increase in explanatory ability of these included variables.[27]

Based on the coefficient estimates in Table 9, we calculate an α and β for each firm in each year based on their *PI* and the other included firm variables: $\alpha_{it} = \alpha + \sum_{s=1}^{N} \alpha_s \times ({}_sX_{it}/TA_{it})$ and $\beta_{it} = \beta + \sum_{s=1}^{N} \beta_s \times ({}_sX_{it}\,/TA_{it})$. We then average these estimates across the firms within each year and plot the resulting annual means in Figure 6 where the mean time-varying α is illustrated on the left-hand side y-axis and the mean time-varying β on the right-hand y-axis. These plots show how tax avoidance has changed over the sample time period. Figure 6 shows that α is increasing

[27] In untabulated analysis, we also multiply each estimated coefficient by its variables' standard deviation to allow direct comparison of the magnitude of the estimated coefficients. Overall, we find the variables that proxy for temporary differences in equation (13), PPE, NOL carryforwards, and change in NOL carryforwards, are generally consistent with the relative importance of temporary differences in the BTD regressions reported in Table 6 and also consistent with the importance of NOLs as documented in Drake et al. (2020).

over time: that is, the average taxes paid independent of *PI* have increased over time which is consistent with decreasing tax avoidance. Figure 6 also shows that β is decreasing over most of the sample period but starts to increase in 2007. A decreasing β is consistent with increasing tax avoidance.[28] We note two offsetting effects of tax avoidance over time.

Results allowing tax avoidance (i.e., α and β) to vary over time

In section 4, we held tax avoidance behavior constant by holding constant the parameters, α and β, when estimating the linear tax model. This approach allowed us to show that cash ETRs are not diagnostic about tax avoidance as the linear tax model, assuming no change in tax avoidance, could fully explain the decrease in cash ETRs documented in Dyreng et al. (2017). As noted during those tests and as we show in the preceding section, tax avoidance behavior did change over time – evidenced by an increasing α and a generally decreasing β. We now partition the decreasing cash ETRs into growth in *PI* effects and change in tax avoidance behavior (i.e., changes in α and β).[29] The *PI*-growth related component in the cash ETR for each firm is estimated as:

$$Cash\ ETR_{it}^{PI} = \alpha_{it-1}(1/PI_{it}) + \beta_{it-1} \quad (14)$$

Because we are using α_{it-1} and β_{it-1} to calculate *Cash ETR*^{PI} in period *t*, we are assuming no change in tax avoidance from $t-1$ to *t*. *Cash ETR*^{PI} thus isolates the effect of any growth in *PI* in period *t* on cash ETRs. We label this the '*PI*-component of cash ETR.' Next, we calculate the cash ETR that is related to tax avoidance, which we label the 'tax avoidance-component of cash ETR' according to (15) where Δ is the difference operator denoting changes in α and β from period $t-1$ to *t*:

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[28] The time-series trend pattern for both α and β are similar if we estimate annual cross-sectional regressions; however, there is more variation around the trend line for each parameter.

[29] While Henry and Sansing (2019) use somewhat similar labels in their paper, we note the definitions differ drastically and should not be confused as they start with a different conceptual model and research question. They define the income effect on cash ETR as *str*×*PI* and the tax avoidance effect as (Δ = cash taxes paid – *PI*×str), which essentially equals the negative of traditionally defined book-tax differences.

$$Cash\ ETR_{it}^{TA} = \Delta\alpha_{it}(1/PI_{it}) + \Delta\beta_{it} \quad (15)$$

Given these components of cash ETR estimates for each firm for each year, we calculate the annual means of each and plot them in Figure 7. So as to not compress the Figure, the left-hand axis is scaled for the actual cash ETR (the solid line) and the *PI*-component of cash ETR (the dashed line) while the right-hand axis is scaled for the tax avoidance-component of cash ETR (the dotted line). The *PI*-component of cash ETR explains the downward trend in cash ETRs and ETR changes related to tax avoidance are stationary fluctuating around zero. The two opposing effects of tax avoidance measured by an increasing α and a decreasing β thus offset each other and lead to an overall stationary level of tax avoidance. Overall, these results extend our earlier results that show cash ETRs are nondiagnostic about tax avoidance in that declining cash ETRs could be explained by growth in *PI* holding constant tax avoidance (by assuming constant α and β in the linear tax model). We show in this section that the declining trend in cash ETRs continues to be largely explained by the growth in pre-tax income (even when allowing α and β to vary) and that tax avoidance behavior largely explains the variance around this trend.[30]

VI. CONCLUSION

A substantial and growing literature examines the determinants of firms' tax avoidance. Many of these studies use the cash effective tax rate (i.e., cash taxes paid (*TXPD*) divided by pre-tax income (*PI*) to proxy for tax avoidance. This measure embeds the assumption that the underlying tax paid model is a proportional model ($TXPD = \beta PI$), i.e., each dollar of *PI* is taxed at

[30] In untabulated analysis we estimate the cash ETR model using annual cross-sectional regressions and then predict the cash ETR in t as α_{t-1} $(1/PI_t) + \beta_{t-1.}$ Basically, given the parameter estimates from $t - 1$, how well does the model predict cash ETR conditional on the realization of *PI* in t: the *PI*-growth related component of cash ETR with no hindsight bias in parameter estimation. The difference between the *PI*-growth related component and actual cash ETR we attribute to tax avoidance. Consistent with the results reported in the text, we find that the *PI*-growth component captures the downward trend in the cash ETRs and tax avoidance behavior largely explains the variation around this trend.

rate β. We hypothesize and show that a linear tax model $TXPD = \alpha + \beta PI$ (or equivalently $Cash\ ETR = \alpha(1/PI) + \beta$) is empirically descriptive and, as a result, the cash ETR will differ across time (or firms) simply due to differences in pre-tax income.

Empirically, using both *PI*-portfolios, annual means and pooled observations, we document that the linear tax model is descriptive and that cash ETRs are a convex function of *PI*. In either specification, we observe positive and significant estimates for the estimated α and β parameters in the linear model ($Cash\ ETR = \alpha(1/PI) + \beta$). The significant positive α indicates that in this sample, cash taxes paid are not simply proportionally related to pre-tax income.

In further tests we use the estimated α and β, and pre-tax income to estimate fitted annual mean cash ETRs. A plot of the fitted cash ETR shows that our model tracks the annual decline in cash ETR quite closely. We then add a time trend variable to our cash ETR model to test whether there is any increase in tax avoidance over time that is beyond the growth-induced ETR decline attributable to *1/PI*. The time variable is close to zero and not statistically significant. Our results show that a large portion of the declining trend in ETR documented by Dyreng et al. (2017) could be unrelated to firms' tax planning. We thus conclude that if a linear tax function is descriptive, cash ETRs are nondiagnostic about changes over time or differences across firms in tax avoidance.

In addition to the cash ETR specification, we also estimate a scaled tax function specification, $(TXPD/TA) = \alpha(1/TA) + \beta(PI/TA)$ using the annual means of total assets (*TA*) and we compare these two specifications to common specifications used in the literature, such as $Cash\ ETR = c + dROA$, and show that the specifications used in the literature suffer either from an error-in-variable or correlated omitted variable problem and therefore are not able to capture the documented downward trend in ETRs.

We also estimate our linear tax model separately for U.S. multinational and domestic firms. We find a substantially higher α for the multinational firms but a very similar β for each of the two groups, which helps explain multinationals' higher cash ETRs documented in Dyreng et al. (2017). We also find that domestic firms' pre-tax income has grown at a significantly higher rate than that of multinational firms, leading to a steeper decline in their cash ETRs.

Our findings should be of interest to academics studying tax avoidance using cash ETRs. Our paper shows that a linear tax function is descriptive, which causes cash ETRs to be a convex function of pre-tax income. Including pre-tax ROA (or ROA, "profitability") as a regressor with cash ETR as the dependent variable, a common model, does not adequately capture this convexity. Thus, in a linear tax model, cash ETR is nondiagnostic about whether tax avoidance differences across firms or decreases over time unless *1/PI* is included as a regressor. Finally, our findings highlight that growth in pre-tax income is a plausible alternative explanation for the observed decreasing trend in cash ETRs of U.S. firms.

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Appendix A: Examples of Inter-period Effects on Tax Payments

In this Appendix we present several examples of transactions that will result in income dependent book-tax difference (i.e., differences captured by θ_1), and income independent book-tax differences (i.e., differences captured by θ_0). These book tax differences directly translate into parameters of the linear tax model: Specifically, from equation (4) $\alpha = str\theta_0$ and $\beta = str(1 - \theta_1)$.

Accounting for intercompany dividends with the dividends received deduction. For firms owning less than 20% of the equity of some other company, dividends received are included 100% in the dividend receiving companies' pre-tax income but only 30%, during our sample period, are included in taxable income. That is, θ_1 = 0.70 and β will be reduced by (1−0.70) = 0.30. If this were the only transaction β = 0.35×0.30 = 0.105. This example illustrates a permanent difference reducing β. Now assume the same firm owns 25% of the stock in another company which requires equity accounting for this investment. The investor company adds 25% of the investee company's income to its own income but not to taxable income. Assuming no contemporaneous dividend, this gives rise to a temporary difference (as tax is accrued on the earnings) on which no tax is actually paid this period by the investor company, which lowers β. When the investor company receives a dividend from the investee company, the dividend, after the dividend received deduction, is included in taxable income but not pre-tax income. This dividend is then an example of an income independent book-tax difference (increasing taxable income relative to pretax income) resulting in a higher α.

Foreign earnings. The foreign earnings of a U.S. multinational subsidiaries are included in pre-tax income when earned but, during our sample period, are only included in taxable income when and if the earnings are repatriated as a dividend. These earnings and any subsequent dividend repatriations are similar to the equity accounting for investments example: In the earnings period, θ_1 is higher resulting in lower β. In the dividend receiving period, θ_0 is lower resulting in a higher α.

Executive compensation. Assume a publicly held corporation pays its CEO a salary of $3 million in period t. The salary is not payable on a commission basis and is not performance-based compensation. The salary payment of $3 million is an expense on the corporation's income statement; however, during our sample period, for tax purposes the corporation may only deduct $1 million as a result of the limitation for certain excessive employee remuneration under I.R.C. §

162(m). The \$2 million difference a (negative) permanent difference, which enters into the computation of the pre-tax income, but never into taxable income. Assuming that this type of salary is pre-tax income independent, this book-tax difference will be reflected in θ_0 (i.e., $\theta_0 = -\$2$ million). Alternatively stated, as operating income rises and falls from year to year, if the CEO is always paid \$3 million the non-deductible portion will not vary with income but will remain stable at \$2 million.

Unearned revenue. Cash received in advance of the provision of the contracted good or service is treated as unearned revenue for book purposes but is taxed immediately for tax purposes. This will give rise to an income independent temporary book-tax difference decreasing θ_0 increasing α. When the good or service is provided the unearned revenue is treated as revenue for book purposes increasing pre-tax income but with no additional taxes, so this increases θ_1 reducing β.

NOL carryforward. When a firm incurs tax losses it can carryback the loss to obtain a tax refund provided it has positive taxable income in the carryback period. As pre-tax income is likely to be negative, such observations are usually omitted from ETR studies. If the loss cannot be carried back, it is carried forward until some future period when it can be deducted against positive taxable income. In the period(s) of deduction, the deduction reduces taxable income and thus taxes paid but not pre-tax income giving rise to a book-tax difference. However, part the deduction will be a function of the magnitude of *PI* to the extent that *TI* and *PI* are related (the conforming component of tax and book income), as the deduction is limited based on the level of *TI* in the period. When this book-tax difference is regressed on *PI* (as in equation 3) some will show up as a book-tax difference independent of *PI* and some proportional to *PI*: accordingly, the NOL carryforward when used will therefore be reflected in θ_0 and θ_1, and thus α and β in the linear tax model.[31]

[31] With respect to the accounting for NOL carryforwards, see Drake, Hamilton, and Lusch (2020). See also Erickson, Hanlon, Maydew, and Shevlin (2019, Chapter 7) for examples of temporary and permanent differences.

Appendix B: Variable Definitions

PI	*PI* denotes pre-tax income.
TXPD	*TXPD* denotes cash taxes paid.
Cash ETR	The ratio of cash taxes paid to pre-tax income.
BTD	Total book-tax differences calculated as the sum of permanent (*BTDPERM*) and temporary book-tax differences (*BTDTEMP*).
BTDPERM	Permanent book-tax differences calculated by subtracting the total tax expense (*TXT*) grossed up by the statutory tax rate from pre-tax income.
BTDTEMP	Temporary book-tax differences calculated as: *BTDTEMP*=(*TXT*-*TXPD*)/*str* where *TXT* is total tax expense.
MNE	An indicator variable for multinational firm-years and is equal to one if the current-year pre-tax foreign income (*PIFO*) is greater than zero or if the absolute value of the foreign tax expense (*TXFO*) is greater than zero.
TA	*TA* denotes total assets.
XRD	*XRD* denotes research and development expense; if missing, it is set to zero.
PPE	*PPE* denotes property, plant, and equipment.
TDEBT	*TDEBT* denotes total debt.
NOL	An indicator variable equal to one if Compustat reports a tax-loss carryforward (*TLCF*) at the end of the previous year, and zero otherwise.
Δ*NOL*	Δ*NOL* denotes the change in net operating losses.

Appendix C: Misspecification in traditional Cash ETR or tax paid models

In the text we present three traditional models (10) to (12), denoted C1, C2 and C3 here

$$Cash\ ETR_t = c + dROA_t \quad \text{(C1)}$$

$$(TXPD_t/TA_t) = a + b(PI_t/TA_t) \quad \text{(C2)}$$

$$Cash\ ETR_t = a(1/ROA_t) + b \quad \text{(C3)}$$

If a tax function of the form, $TXPD = \alpha + \beta PI$ or its equivalent transformation of the form $Cash\ ETR = \alpha(1/PI) + \beta$ is theoretically and empirically descriptive, equations (C1) and (C3) will suffer from an error-in-variables problem and equation (C2) will suffer from an omitted correlated variable problem.

Specifically, in equation (C1) the error in the explanatory variable is multiplicative and amounts to TA/PI^2. Accounting for this error gives: $Cash\ ETR = c + d(ROA \times TA/PI^2)$ and leads to our ETR specification of $Cash\ ETR = \alpha(1/PI) + \beta$ where $d = \alpha$ and $c = \beta$. Equation (C2) suffers from an omitted correlated variable problem because the tax function has not been scaled correctly. If the underlying economic model is given by: $TXPD = \alpha + \beta PI$ and if the deflation factor is chosen to be total assets, TA, then standard econometric procedure requires inclusion of the reciprocal of the deflator $1/TA$ as an extra explanatory variable and estimating the transformed model omitting the constant term (Maddala and Lahiri, 2009, p. 224):

$$(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t) \quad \text{(C4)}$$

Scaling the tax function by a variable other than the explanatory variable PI thus leads to a two explanatory variable model with no intercept. Comparing specification (C4) with specification (C2) reveals that the omitted correlated variable in (C2) is $1/TA$. Consequently, the estimated coefficients from (C2) are likely to be biased and such a specification will not be able to capture the observed declining trend in ETRs. Notice, if dividing $(TXPD/TA) = a(1/TA) + b(PI/TA)$

by (*PI/TA*) to get an ETR version of this specification, we obtain back our specification *Cash ETR* = α(*1/PI*) + β, indicating the correctness of the scaling method.

Finally, it can be shown that (C3), i.e., $Cash\ ETR_t = a(1/ROA_t) + b$, also suffers from an error-in-variable problem. Rewriting this specification gives: $Cash\ ETR_t = a(TA/PI) + b$. From a theoretical standpoint it is unclear why the ratio of total assets to pre-tax income TA/PI should be the primary explanatory variable to explain variation in cash ETRs. In equation (C3) the error in the explanatory variable is multiplicative and amounts to $1/TA$, the omitted variable from equation (C2). Accounting for this error gives: $Cash\ ETR = a(TA/PI \times 1/TA) + b$ and leads again back to our ETR specification of *Cash ETR* = α(*1/PI*) + β.

Appendix D: Deriving the linear model for testing determinants of corporate tax avoidance

Starting with our equation (5) but adding firm and time subscripts

$$TXPD_{it} = \alpha_{it} + \beta_{it} PI_{it} \tag{D1}$$

we can model tax avoidance as varying both the parameter α (taxes paid unrelated to the level of PI) and the parameter β (the marginal propensity to tax) as a function of hypothesized determinants denoted by X with s columns (for s determinants):

$$\alpha_{it} = \alpha + \sum_{s=1}^{N} \alpha_s \times {}_sX_{it} \tag{D2}$$

and

$$\beta_{it} = \beta + \sum_{s=1}^{N} \beta_s \times {}_sX_{it} \tag{D3}$$

Substituting (D2) for α_{it} and (D3) for β_{it} in (D1) gives equation (D4)

$$TXPD_{it} = \alpha + \sum_{s=1}^{N} \alpha_s \times {}_sX_{it} + \beta PI_{it} + \sum_{s=1}^{N} \beta_s \times {}_sX_{it} PI_{it} \tag{D4}$$

Scaling (D4) by PI_{it} and each respective X-control variable by total assets (TA) gives a cash ETR function that controls for the growth in PI-effect (PI-component of cash ETR) and picks up changes in α and β as a function of ${}_sX_{it}$ variables (control variables and/or hypothesized new determinants) (tax avoidance-component of cash ETR) which is equation (13) in the text.

$$Cash\ ETR_{it} = \alpha(1/PI_{it}) + \sum_{s=1}^{N} \alpha_s (1/PI_{it})({}_sX_{it}/TA_{it}) + \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it}) \tag{D5}$$

Alternatively, tax avoidance can be examined using the tax function in (D4) scaled by TA_{it}:

$$\left(\frac{TXPD_{it}}{TA_{it}}\right) = \alpha\left(\frac{1}{TA_{it}}\right) + \sum_{s=1}^{N} \alpha_s \times \left(\frac{1}{TA_{it}}\right) {}_sX_{it} + \beta\left(\frac{PI_{it}}{TA_{it}}\right) + \sum_{s=1}^{N} \beta_s \times {}_sX_{it} \left(\frac{PI_{it}}{TA_{it}}\right) \tag{D6}$$

Note that in either of the models (D4), (D5), and (D6), we need the ${}_sX_{it}$-vector itself and the ${}_sX_{it}$-

vector interactions with either PI_{it} in (D4), $(1/PI_{it})$ in (D5), or (PI_{it}/TA_{it}) in (D6) to capture changes in α and β that are tax avoidance. Further, while the specification in (D5) exhibits a constant term, β, the specification in (D6) does not exhibit a constant. Therefore, if the research design and/or research question requires the inclusion of a fixed effect, then specification (D5) should be preferred over specification (D6) in pooled panel data samples.[32]

[32] Based on the results in Table 7 for the *TXPD* model scaled by *TA* we do not recommend the (*TXPD/TA*) model for empirical work in pooled (panel) data sets with heterogenous intercepts. The model (D6), however, might be useful in pooled data sets with homogenous intercepts where no fixed-effects are necessary or in time-series regressions.

Table 1: Descriptive Statistics

Panel A: Pooled Sample

VARIABLES	N	mean	sd	min	p25	p50	p75	max
TXPD	63,407	86.98	268.53	0.00	1.32	7.92	40.90	1,962
PI	63,407	341.13	1,020	0.29	9.23	39.26	177.00	7,442
Cash ETR (*winsor.*)	63,407	0.31	0.39	0.00	0.11	0.26	0.38	2.94
Cash ETR [0;1] (*reset*)	63,407	0.28	0.23	0.00	0.11	0.26	0.38	1.00
Cash ETR [0;1] (*trunc.*)	61,217	0.25	0.19	0.00	0.10	0.25	0.36	1.00
BTD	63,407	86.50	360.62	-623.14	-1.07	4.86	41.22	2,573
BTDPERM	63,407	49.96	250.61	-407.29	-3.69	0.02	12.36	1,843
BTDTEMP	63,407	36.52	242.45	-840.00	-2.45	2.17	24.77	1,552
TA	63,407	4,003	11,514	14.52	126.81	502.69	2,207	84,821

Panel B: Mean PI-Portfolio Sample

VARIABLES	N	mean	sd	min	p25	p50	p75	max
TXPD	29	86.99	235.68	0.73	3.46	11.60	46.70	1,217
PI	29	341.18	972.66	0.53	9.80	39.34	167.47	5,075
Cash ETR (*weighted*)	29	0.36	0.21	0.24	0.27	0.29	0.35	1.38
Cash ETR (*eq. weighted*)	29	0.31	0.10	0.26	0.27	0.29	0.31	0.77
BTD	29	92.64	300.72	-1.57	-0.10	6.18	34.04	1,595
BTDPERM	29	52.87	185.58	-0.22	0.47	2.80	17.95	989.39
BTDTEMP	29	39.77	115.58	-1.48	-0.58	4.53	16.09	606.53
TA	29	4,003	9,721	94.30	261.60	725.25	2,574	49,722

Panel C: Mean Annual Sample

VARIABLES	N	mean	sd	min	p25	p50	p75	max
TXPD	29	85.27	43.51	39.90	51.87	64.05	112.38	170.85
PI	29	331.00	194.50	118.86	162.84	257.25	463.74	691.50
Cash ETR (*weighted*)	29	0.27	0.04	0.22	0.25	0.25	0.30	0.37
Cash ETR (*eq. weighted*)	29	0.32	0.04	0.24	0.29	0.32	0.34	0.42
BTD	29	87.38	73.08	-8.10	18.83	72.83	136.63	224.31
BTDPERM	29	50.39	59.27	-1.93	0.93	16.03	90.88	175.88
BTDTEMP	29	36.98	22.79	-8.08	18.16	43.21	52.02	83.09
TA	29	3,914	2,394	1,550	1,876	3,107	5,023	9,292

All variables are defined in Appendix B. All variables in Panel A are winsorized at 1 and 99% except for *Cash ETR* [0;1] (*reset*) which resets *Cash ETR* to 0 and 1 for values < 0 and > 1, and *Cash ETR* [0;1] (*trunc.*) which deletes *Cash ETR* values < 0 and >1 (for comparison to prior literature). In Panel B, the *PI*-portfolios are based on sorting firm-year observations on *PI* into 29 groups and the means of each variable are calculated on the winsorized data in Panel A. In Panel C, the annual means are also calculated on the winsorized data in Panel A. In Panels B and C, *Cash ETR* (*weighted*) is calculated as *Cash ETR* = (*1/N ΣTXPD*)/(*1/N ΣPI*). *Cash ETR* (*eq. weighted*) is an equally weighted *Cash ETR = 1/N ΣCash ETR* where *Cash ETR* is the firm-specific *Cash ETR*, winsorized at 1/99%.

Table 2: Results on Tax Function Estimation Using 29 PI-Portfolios

MODELS			
Column (1): $Cash\ ETR_t = \alpha(1/PI_t) + \beta$			
Column (2): $(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t)$			
		(1)	(2)
VARIABLES	Predicted Sign	$Cash\ ETR_t$	$(TXPD_t/TA_t)$
α	(+)	0.571***	0.601***
		(26.61)	(14.11)
β	(+)	0.272***	0.268***
		(79.19)	(64.05)
Observations		29	29
Adjusted R-squared		0.992	0.997

All variables are defined in Appendix B. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Result on Cash ETR and Tax Function Estimation Using 29 Annual Obs.

Panel A: Results on Cash ETR and TA-Scaled Tax Function Estimation

MODELS

Column (1): $Cash\ ETR_t = \alpha(1/PI_t) + \beta$

Column (2): $(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t)$

VARIABLES	Predicted Sign	(1) $Cash\ ETR_t$	(2) $(TXPD_t/TA_t)$
α	(+)	16.545***	16.434***
		(11.46)	(12.02)
β	(+)	0.205***	0.206***
		(29.43)	(31.10)
Observations		29	29
Adjusted R-squared		0.819	0.996

Panel B: Results on Cash ETR and TA-Scaled Tax Function Estimation including a Time Trend

MODELS

Column (1): $Cash\ ETR_t = \alpha(1/PI_t) + \beta + \delta TIME_t$

Column (2): $(TXPD_t/TA_t) = \alpha(1/TA_t) + \beta(PI_t/TA_t) + \delta(PI_t/TA_t)TIME_t$

VARIABLES	Predicted Sign	(1) $Cash\ ETR_t$	(2) $(TXPD_t/TA_t)$
α	(+)	17.474***	16.316***
		(3.84)	(12.02)
β	(+)	0.197***	0.207***
		(5.12)	(31.10)
δ	(±0)	<0.001	>-0.001
		(0.21)	(-0.03)
Observations		29	29
Adjusted R-squared		0.820	0.996

All variables are defined in Appendix B. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Results on Tax Function Estimation Using 29 Annual Observation

Panel A: Coefficient Estimates from Traditional Models

MODELS

Column (1): $Cash\ ETR_t = c + dROA_t$

Column (2): $(TXPD_t/TA_t) = a + b(PI_t/TA_t)$

Column (3): $Cash\ ETR_t = a(1/ROA_t) + b$

VARIABLES	Predicted Sign	(1) $Cash\ ETR_t$	(2) $(TXPD_t/AT_t)$	(3) $Cash\ ETR_t$
a	(+)		0.010	0.012
			(1.57)	(1.52)
b	(+)		0.152*	0.138
			(2.02)	(1.58)
c	(?)	0.402***		
		(4.57)		
d	(?)	-1.504		
		(-1.51)		
Observations		29	29	29
Adjusted R-squared		0.042	0.080	0.053

Panel B: Results from Misspecification including Time Trend Variables

MODELS

Column (1): $Cash\ ETR_t = c + dROA_t + \delta TIME_t$

Column (2): $(TXPD_t/TA_t) = a + b(PI_t/TA_t) + \delta(PI_t/TA_t)TIME_t$

Column (3): $Cash\ ETR_t = a(1/ROA_t) + b + \delta TIME_t$

VARIABLES	Predicted Sign	(1) $Cash\ ETR_t$	(2) $(TXPD_t/AT_t)$	(3) $Cash\ ETR_t$
a	(+)		0.007*	0.008**
			(1.95)	(2.15)
b	(+)		0.250***	0.236***
			(6.00)	(5.31)
δ	(−)		-0.004***	-0.004***
			(-11.72)	(-11.33)
c	(?)	0.427***		
		(8.71)		
d	(?)	-1.075*		
		(-1.98)		
δ	(−)	-0.004***		
		(-10.91)		
Observations		29	29	29
Adjusted R-squared		0.736	0.753	0.744

All variables are defined in Appendix B. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Result on Cash ETR Function Estimation Using Pooled Regressions

Panel A: Results on Cash ETR Functions

MODELS

Column (1): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$; $Cash\ ETR_{it}$ winsorized at 1/99%
Column (2): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$; $Cash\ ETR_{it}$ winsorized at (reset to) [0;1]
Column (3): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$; $Cash\ ETR_{it}$ truncated at [0;1]
Column (4): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$; Observations truncated *Cook's D > 4/N*

VARIABLES	Predicted Sign	(1) $Cash\ ETR_{it}$	(2) $Cash\ ETR_{it}$	(3) $Cash\ ETR_{it}$	(4) $Cash\ ETR_{it}$
α	(+)	0.345***	0.120***	0.0841***	0.308***
		(23.62)	(20.42)	(12.92)	(16.09)
β	(+)	0.256***	0.260***	0.244***	0.291***
		(54.24)	(64.00)	(62.30)	(41.29)
Observations		63,407	63,407	61,217	63,327
Adjusted R-squared		0.203	0.236	0.274	0.129
Firm Fixed Effects		YES	YES	YES	YES

Panel B: Results on Cash ETR Functions including a Time Trend Variable

MODELS

Column (1): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$; $Cash\ ETR_{it}$ winsorized at 1/99%
Column (2): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$; $Cash\ ETR_{it}$ winsorized at (reset to) [0;1]
Column (3): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$; $Cash\ ETR_{it}$ truncated at [0;1]
Column (4): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$; Observations truncated *Cook's D > 4/N*

VARIABLES	Predicted Sign	(1) $Cash\ ETR_{it}$	(2) $Cash\ ETR_{it}$	(3) $Cash\ ETR_{it}$	(4) $Cash\ ETR_{it}$
α	(+)	0.346***	0.119***	0.0817***	0.308***
		(23.35)	(19.60)	(12.07)	(16.10)
β	(+)	0.246***	0.265***	0.254***	0.269***
		(34.33)	(44.37)	(46.14)	(24.44)
δ	(±0)	0.001	>-0.001	-0.001**	0.003**
		(1.65)	(-1.23)	(-2.64)	(2.71)
Observations		63,407	63,407	61,217	63,327
Adjusted R-squared		0.203	0.237	0.275	0.129
Firm Fixed Effects		YES	YES	YES	YES

All variables are defined in Appendix B. Standard errors clustered by firm and year. Corresponding t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Result on Book-Tax Differences Estimation Using Pooled Regressions

Panel A: Results on BTD Function

MODELS

Column (1): $(BTD_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1$

Column (2): $(BTDPERM_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1$

Column (3): $(BTDTEMP_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1$

VARIABLES	Predicted Sign	(1) (BTD_{it}/PI_{it})	(2) $(BTDPERM_{it}/PI_{it})$	(3) $(BTDTEMP_{it}/PI_{it})$
θ_0	(−)	-0.985***	-0.210***	-0.775***
		(-23.62)	(-8.88)	(-21.76)
θ_1	(+)	0.269***	0.099***	0.170***
		(19.95)	(10.41)	(14.77)
Observations		63,407	63,407	63,407
Adjusted R-squared		0.203	0.223	0.141
Firm Fixed Effects		YES	YES	YES

Panel B: Results on BTD Function including a Time Trend Variable

MODELS

Column (1): $(BTD_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1 + \delta TIME_{it}$

Column (2): $(BTDPERM_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1 + \delta TIME_{it}$

Column (3): $(BTDTEMP_{it}/PI_{it}) = \theta_0(1/PI_{it}) + \theta_1 + \delta TIME_{it}$

VARIABLES	Predicted Sign	(1) (BTD_{it}/PI_{it})	(2) $(BTDPERM_{it}/PI_{it})$	(3) $(BTDTEMP_{it}/PI_{it})$
θ_0	(−)	-0.989***	-0.204***	-0.785***
		(-23.35)	(-8.62)	(-21.68)
θ_1	(+)	0.296***	0.058***	0.238***
		(14.42)	(5.73)	(12.87)
δ	(±0)	-0.003	0.005***	-0.008***
		(-1.65)	(6.93)	(-4.58)
Observations		63,407	63,407	63,407
Adjusted R-squared		0.203	0.225	0.142
Firm Fixed Effects		YES	YES	YES

All variables are defined in Appendix B. All variables are winsorized at 1 and 99%. Standard errors clustered by firm and year. Corresponding t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Results on TXPD Function Estimation Using Pooled Regressions

Panel A: Coefficient Estimates

MODELS

Column (1): $(TXPD_{it}/TA_{it}) = \gamma + \alpha(1/TA_{it}) + \beta(PI_{it}/TA_{it})$

Column (2): $TXPD_{it} = \alpha + \beta PI_{it}$; Observations truncated using *Cook's D > 4/N*

VARIABLES	Predicted Sign	(1) $(TXPD_{it}/TA_{it})$	(2) $TXPD_{it}$
γ	(?)	0.006***	
		(10.50)	
α	(+)	-0.0361	7.606***
		(-1.23)	(6.27)
β	(+)	0.214***	0.235***
		(37.96)	(57.89)
Observations		63,407	62,636
Adjusted R-squared		0.653	0.899
Firm Fixed Effect		YES	YES

Panel B: Results from including Time Trend Variables

MODELS

Column (1): $(TXPD_{it}/TA_{it}) = \gamma + \alpha(1/TA_{it}) + \beta(PI_{it}/TA_{it}) + \delta(PI_{it}/TA_{it})TIME_{it}$

Column (2): $TXPD_{it} = \alpha + \beta PI_{it} + \delta PI_{it}TIME_{it}$; Observations truncated using *Cook's D > 4/N*

VARIABLES	Predicted Sign	(1) $(TXPD_{it}/TA_{it})$	(2) $TXPD_{it}$
γ	(?)	0.006***	
		(13.27)	
α	(+)	-0.091***	9.790***
		(-3.47)	(6.73)
β	(+)	0.224***	0.210***
		(28.75)	(26.09)
δ	(±0)	-0.001***	0.001***
		(-2.91)	(3.83)
Observations		63,407	62,636
Adjusted R-squared		0.654	0.900
Firm Fixed Effect		YES	YES

All variables are defined in Appendix B. Columns (1) variables winsorized at 1 and 99%. Standard errors clustered by firm and year. Corresponding t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Note, estimating the *TA*-scaled tax function in Columns (1) and (2) and including a firm fixed effect yields actually the regression: $(TXPD_{it}/TA_{it}) = (\gamma + \gamma_i) + \alpha(1/TA_{it}) + \beta(PI_{it}/TA_{it})$ where γ is the estimated mean intercept and γ_i is a vector of estimated firm-specific incremental effects. The results above only report the mean effect of γ and the 5,531 firm-specific incremental effects γ_i have been omitted for reasons of clarity.

Table 8: Results on Cash ETR Function Using Pooled Regressions Partitioned into U.S. Domestic and U.S. Multinational Firms: Cash ETRs winsorized at 1 and 99%

Panel A: Results on Cash ETR Function

MODELS

Column (1): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$ (Domestic Sample)

Column (2): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta$ (Multinational Sample)

VARIABLES	Predicted Sign	(1) $Cash\ ETR_{it}$	(2) $Cash\ ETR_{it}$
α	(+)	0.254***	0.584***
		(20.45)	(20.93)
β	(+)	0.238***	0.270***
		(51.55)	(52.48)
Observations		30,619	32,390
Adjusted R-squared		0.213	0.242
Firm Fixed Effects		YES	YES

Panel B: Results on Cash ETR Functions including a Time Trend Variable

MODELS

Column (1): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$ (Domestic Sample)

Column (2): $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \beta + \delta TIME_{it}$ (Multinational Sample)

VARIABLES	Predicted Sign	(1) $Cash\ ETR_{it}$	(2) $Cash\ ETR_{it}$
α	(+)	0.256***	0.584***
		(20.15)	(21.00)
β	(+)	0.226***	0.268***
		(30.42)	(30.29)
δ	(±0)	0.002*	<0.001
		(1.93)	(0.28)
Observations		30,619	32,390
Adjusted R-squared		0.213	0.242
Firm Fixed Effects		YES	YES

All variables are defined in Appendix B. Firms are classified based on firm-years with the result some firms only have 1 firm-year observation in that partition. These observations are omitted (but results are similar if retained). Standard errors are clustered by firm and year. Corresponding t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Results using Pooled Regression Allowing Parameters of Linear Tax Function to Vary as Function for Firm characteristics

MODEL			
$Cash\ ETR_{it} = \alpha(1/PI_{it}) + \sum_{s=1}^{N} \alpha_s (1/PI_{it})({}_sX_{it}/TA_{it}) + \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it})$			
VARIABLES	Predicted Sign		(1) $Cash\ ETR_{it}$
$(1/PI_{it})$	(+)	α	0.286*** (11.01)
$(1/PI_{it})MNE_{it}$		α_1	0.312*** (10.57)
$(1/PI_{it})(XRD_{it}/TA_{it})$		α_2	-0.505** (-1.98)
$(1/PI_{it})(PPE_{it}/TA_{it})$		α_3	-0.122** (-2.29)
$(1/PI_{it})(TDEBT_{it}/TA_{it})$		α_4	0.244*** (3.77)
$(1/PI_{it})NOL_{it}$		α_5	-0.079*** (-3.73)
$(1/PI_{it})(\Delta NOL_{it}/TA_{it})$		α_6	0.231* (1.71)
MPT	(+)	β	0.253*** (24.55)
MNE_{it}		β_1	-0.001 (-0.17)
(XRD_{it}/TA_{it})		β_2	0.286* (1.92)
(PPE_{it}/TA_{it})		β_3	-0.011 (-0.43)
$(TDEBT_{it}/TA_{it})$		β_4	0.050*** (2.69)
NOL_{it}		β_5	-0.026*** (-4.85)
$(\Delta NOL_{it}/TA_{it})$		β_6	0.195*** (4.63)
Observations			
Adjusted R-squared			0.228
Firm Fixed Effects			YES

All variables are defined in Appendix B. All variables winsorized at 1 and 99%. Standard errors clustered by firm and year. Corresponding t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Theoretical Predictions between the Cash ETR, MPT and Pre-tax Income

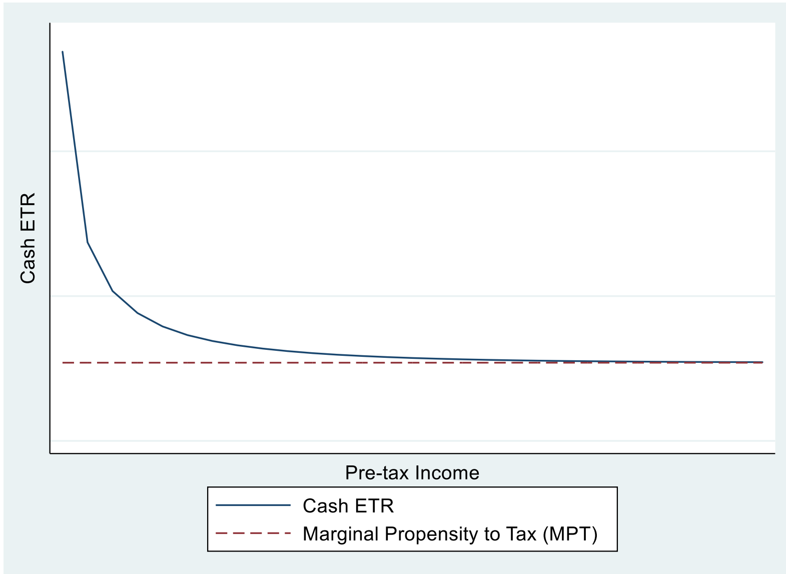


Figure 1 illustrates the theoretical predictions contained in Hypothesis 1. Given a linear tax function where cash taxes paid are linearly related to pre-tax income: $TXPD = \alpha + \beta PI$ the cash ETR function is given by: $Cash\ ETR = \alpha(1/PI) + \beta$. If $\alpha > 0$, $\beta > 0$, $PI > 0$ and if the level of PI is increasing the cash ETR will decline in a convex fashion and converge from above towards the marginal propensity to tax (MPT = β).

Figure 2: Results on Cash ETR Convexity based on 29 PI-Portfolios

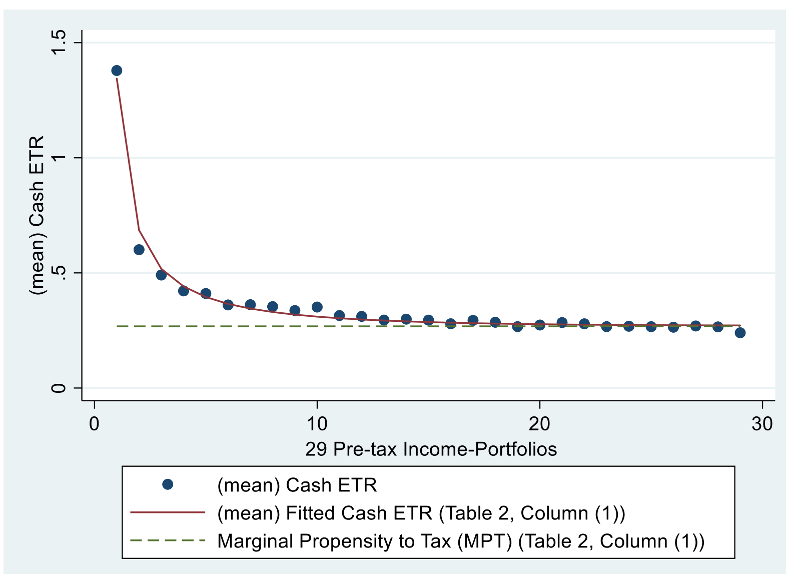
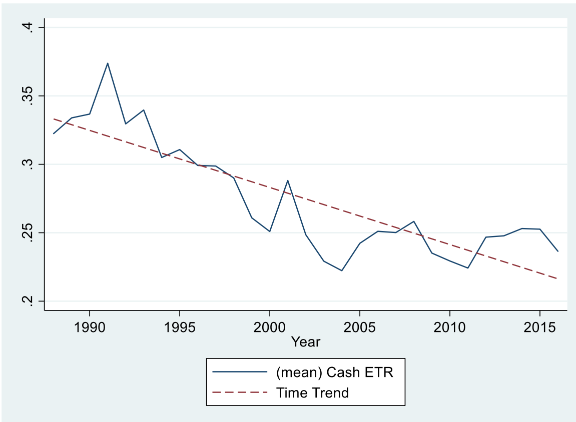


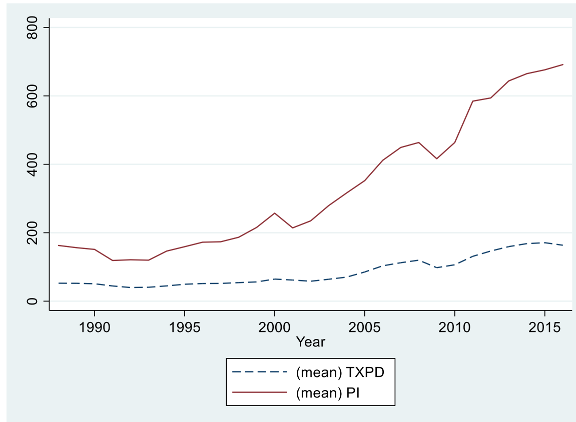
Figure 2 illustrates empirical results on the predicted cash ETR convexity (H1). We collapse cash ETRs from the pooled sample of 63,407 firm-year obs. into 29 *PI*-portfolios and calculate the mean cash ETR for each portfolio. Using these 29 observations, we estimate the cash ETR model: $Cash\ \ ETR = \alpha(1/PI) + \beta$. The results (reported in Table 2, Column (1)) are: $\alpha = 0.571$ (p<0.01) and $\beta = 0.272$ (p<0.01). Accordingly, the fitted cash ETR is calculated as: $Cash\ ETR = 0.571(1/PI) + 0.272$.

Figure 3: Results on 29 Annual Mean Observations

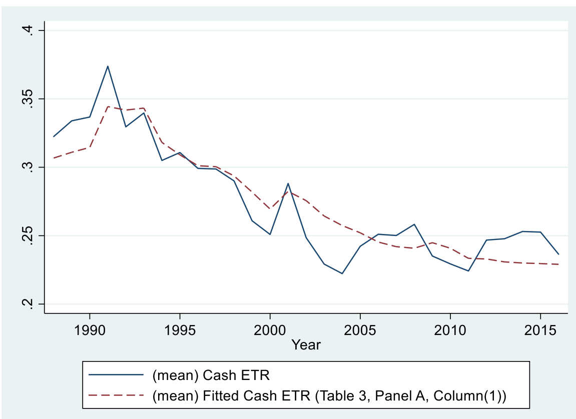
Panel A: Decreasing Trend in Cash ETR



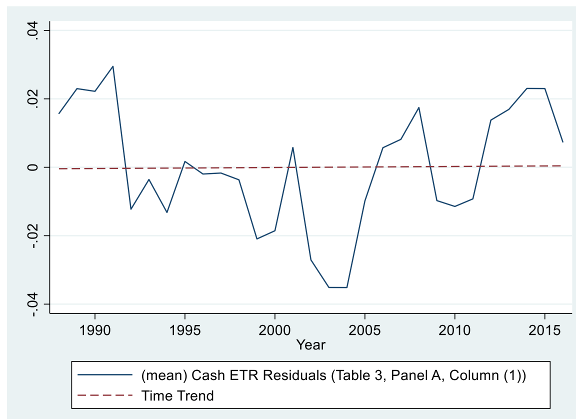
Panel B: Evolution of TXPD and PI



Panel C: Evolution of the Actual and the Fitted Cash ETR over Time



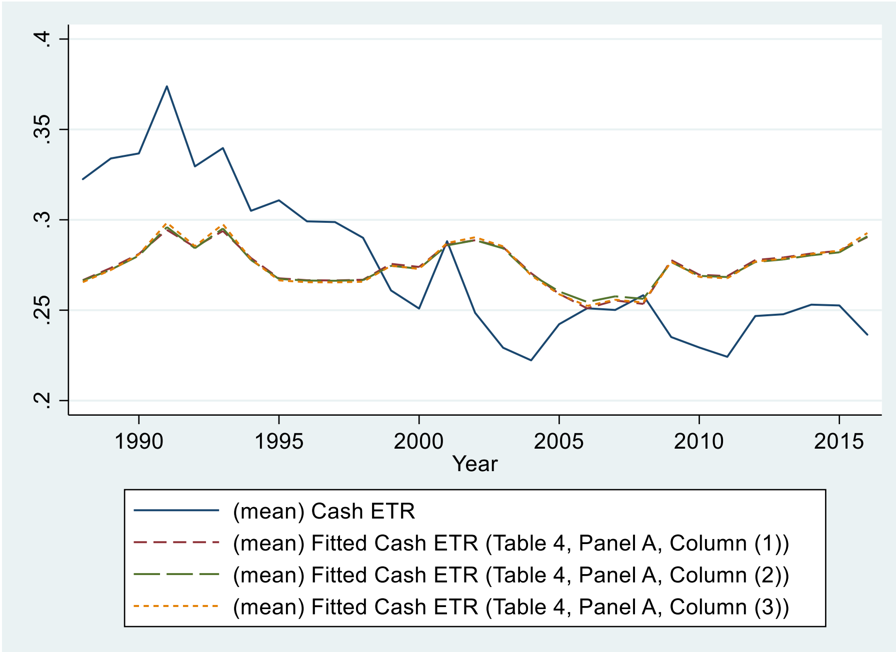
Panel D: Residuals from the Cash ETR Function: *Cash ETR* =*α*(*1/PI*) + *β*



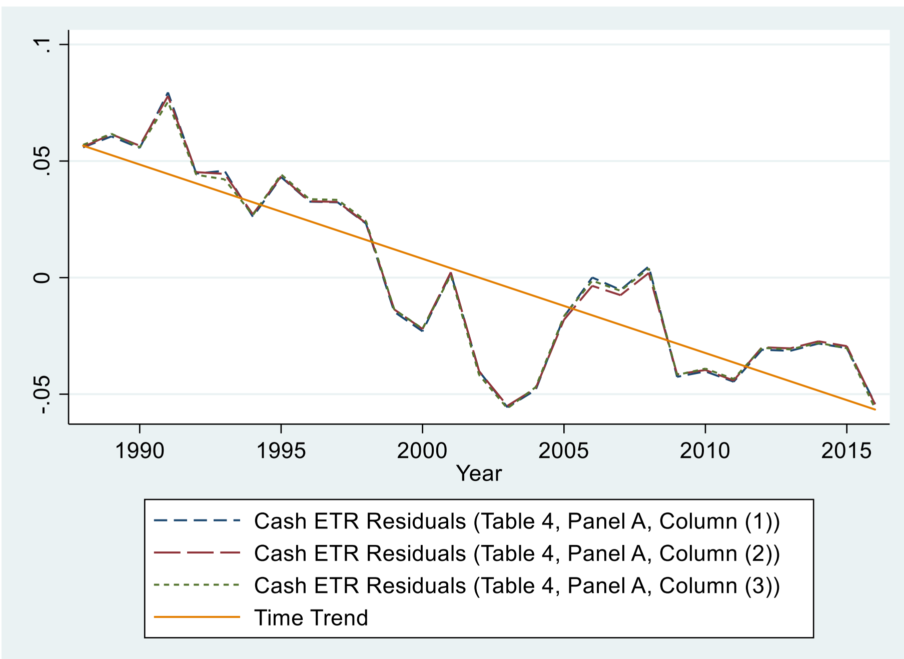
In an untabulated regression, we estimate this cash ETR on a time trend variable (*TIME*): $Cash\ ETR_t = \lambda_0 + \lambda_1 TIME_t$ where $TIME_t$ has the values 1, 2, ..., 29 representing the years of the sample period (1988−2016). We find a significant ($p<0.01$) negative coefficient on the time trend variable of $-\lambda_1 = -0.00417$ indicating a cumulative ETR decline of 12.09 (=29×0.00417) percentage points from 1988 to 2016.

Figure 4: Results on Cash ETR Misspecifications

Panel A: Evolution of Actual and Fitted Cash ETRs over time



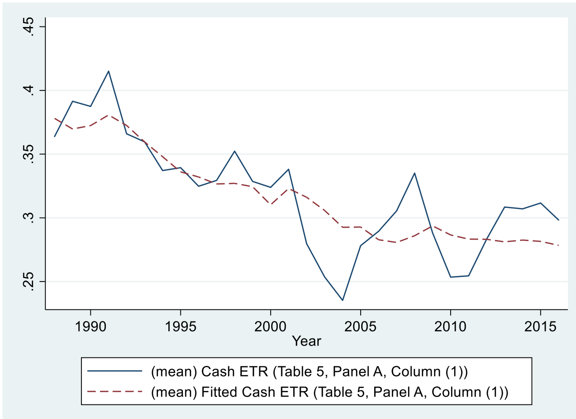
Panel B: Evolution of Residuals Over Time



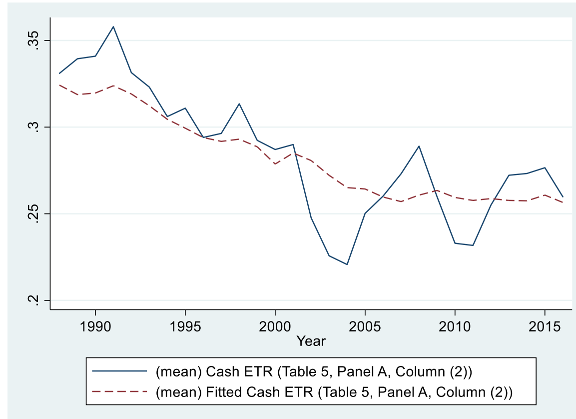
Panel A of Figure 4 illustrates fitted cash ETRs from three misspecified models, equation (10): $Cash\ ETR_t = c + dROA_t$, equation (11): $(TXPD_t/TA_t) = a + b(PI_t/TA_t)$, and equation (12): $Cash\ ETR_t = a(1/ROA_t) + b$, which are reported in Table 4, Panel A, Columns (1) to (3). Panel B of Figure 4 illustrates the evolution of the corresponding residuals over time, all of which exhibit a significant downward trend. Note, the three fitted Cash ETR lines, and the three Cash ETR residuals lines, each follow similar plots and closely overlap.

Figure 5: Results on Cash ETR Specification Using the Pooled Sample

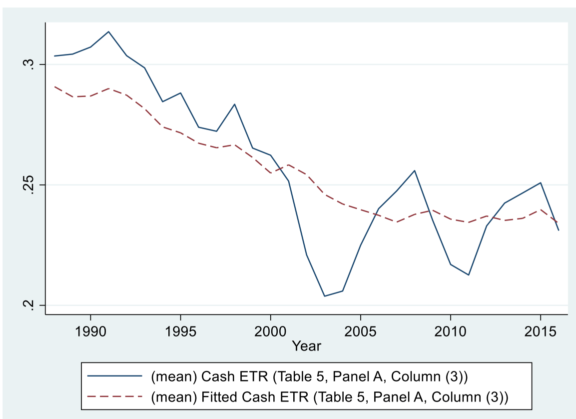
Panel A: Actual and Fitted Cash ETRs: Cash ETRs winsorized at 1 and 99%



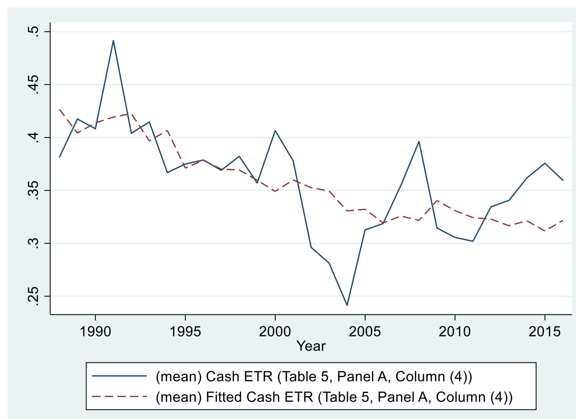
Panel B: Actual and Fitted Cash ETRs: Cash ETRs winsorized at 0,1



Panel C: Actual and Fitted Cash ETRs: Cash ETRs trimmed at 0,1

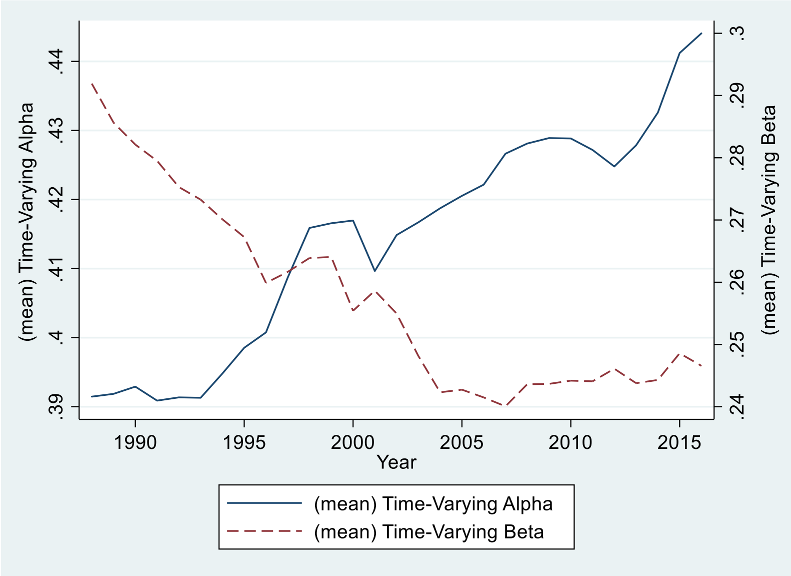


Panel D: Actual and Fitted Cash ETRs: Obs. truncated using Cook's D > 4/N



This Figure shows the evolution of actual cash ETRs and fitted cash ETRs (the *PI*-component of the cash ETR), which is indicative of how much of the ETR decline is related to growth.

Figure 6: Plot of Estimated α and β over time



Left y-axis illustrates the mean time-varying α and right y-axis the mean time-varying β calculated as $\alpha_{it} = \alpha + \sum_{s=1}^{N} \alpha_s \times ({}_sX_{it}/TA_{it})$ and $\beta_{it} = \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it})$ based on the estimates of equation (13) in the text: $Cash\ ETR_{it} = \alpha(1/PI_{it}) + \sum_{s=1}^{N} \alpha_s \times (1/PI_{it})({}_sX_{it}/TA_{it}) + \beta + \sum_{s=1}^{N} \beta_s ({}_sX_{it}/TA_{it})$, which are reported in Table 9. After calculation of α_{it} and β_{it} in the pooled sample (N=63,407), the annual mean time-varying α_t and β_t are obtained by averaging α_{it} and β_{it} to obtain 29 annual means.

Figure 7: Plot of Actual and Predicted Cash ETR

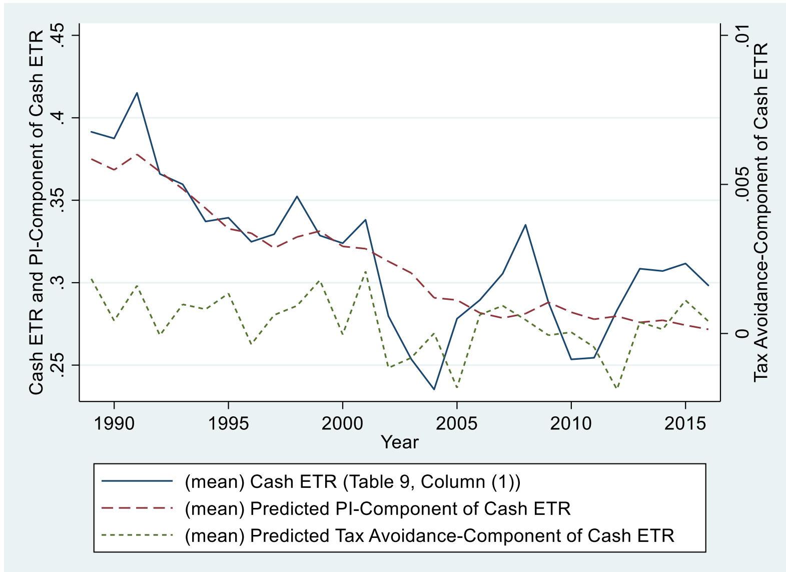


Figure 7 illustrates the decomposition of the cash ETR into two components, the 'PI-component of cash ETR' and the 'tax avoidance-component of cash ETR.' Time-varying estimates of α and β are obtained from pooled regression (13) and calculated as $\alpha_{it} = \alpha + \sum_{s=1}^{N} \alpha_s \times ({}_sX_{it}/TA_{it})$ and $\beta_{it} = \beta + \sum_{s=1}^{N} \beta_s\big({}_sX_{it}/TA_{it}\big)$. Based on these α_{it} and β_{it} estimates the PI-Component of cash ETR is calculated as in (14): $Cash\,ETR_{it}^{PI} = \alpha_{it-1}(1/PI_{it}) + \beta_{it-1}$ and the Tax Avoidance Component of cash ETR is calculated as in (15): $Cash\,ETR_{it}^{TA} = \Delta\alpha_{it}(1/PI_{it}) + \Delta\beta_{it}$ using the pooled sample of N=63,407 firm-year obs. before being collapsed to annual means.