The Decreasing Trend in Cash Effective Tax Rates

Alexander Edwards
Rotman School of Management
University of Toronto
alex.edwards@rotman.utoronto.ca

Adrian Kubata
University of Münster, Germany
adrian.kubata@wiwi.uni-muenster.de

Terry Shevlin
The Paul Merage School of Business
University of California at Irvine
tshevlin@uci.edu

January 23, 2018

Abstract

This paper explores the previously documented decreasing trend in ETRs (Dyreng et al. 2017), which has been interpreted as increased tax avoidance by U.S. firms. We develop a linear corporate tax function model, where taxes paid are regressed on pre-tax income. The intercept captures taxes paid effects that are independent of current income and the slope coefficient is the marginal propensity to tax (MPT). We show that to the extent cash taxes paid are not proportionally related to book income, Cash ETRs can change simply because of changes in pre-tax income. Specifically, in the presence of a positive (negative) intercept in the tax function, average ETRs will decline (increase) and converge towards the MPT if pre-tax income is positive and exhibits a growth trend. Thus, although firms may have stable linear tax functions, indicating no systematic changes in their tax avoidance behavior, changes in average ETRs may be observed over time simply because of growth in pre-tax income. We test our model empirically and document a predominantly stable linear tax function for U.S. firms over the past 29 years, in which (i) the intercept is positive and (ii) pre-tax income is positive and growing. Our main results show that under these conditions 69-100% of the observed downward trend in ETRs is driven by the growth in pre-tax income implying that the wholesale concerns regarding increased tax avoidance over time, measured by ETRs, are potentially overstated.

Keywords: Cash effective tax rate; Corporate tax function; Time trend.
JEL Classifications: G39, H20, H25, H26.

We appreciate helpful comments and suggestions from Mark Bagnoli, Scott Dyreng, Michelle Hutchens, Martin Jacob (discussant), Saskia Kohlhase, Wuyang Zhao and seminar participants at Purdue University, Erasmus University Rotterdam, and the EIASM 7th Conference on Current Research in Taxation and 2017 CAAA. We gratefully acknowledge financial support from the Rotman School of Management, the University of Münster, the University of California at Irvine, and the Social Sciences and Humanities Research Council of Canada.

I. Introduction

Although the U.S. statutory corporate tax rate was constant from 1988 to 2017, recent literature documents a cumulative decrease in corporate cash effective tax rates (Cash ETRs = cash taxes paid/pre-tax income) of about 10 percentage points over the past twenty-five years (1988-2012) (Dyreng et al. 2017). Because Dyreng et al. define tax avoidance as a decrease in cash taxes paid per dollar of pretax income, they by definition interpret this decrease in ETRs as an increase in firms' tax avoidance behavior over time. However, despite anecdotes and public conjectures as to the source of this decline, changes in firm characteristics, and earnings in foreign jurisdictions with declining statutory tax rates explain only a little of the overall decrease in ETRs. This study aims to extend the work of Dyreng et al. (2017) and explain this decreasing trend in Cash ETRs based on a simple economic model of a linear corporate tax function and its relation with income growth. In doing so, we offer an alternative non-tautological definition of tax avoidance.

We show that to the extent that cash taxes paid ($TXPD$) are not proportionally related to pre-tax income (PI), that is, $TXPD \neq b\ PI$, Cash ETRs can change simply because of changes in pre-tax income. Thus, if cash taxes paid are not proportionally related to pre-tax income, an economic relation between average Cash ETRs and growth in pre-tax income exists that is unrelated to a firm's tax planning/avoidance activities. Consequently, before inferences about 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.

While not common in the current literature, several papers have highlighted the importance of controlling for changes in firms' pre-tax income levels when investigating variations in effective tax rates (see, Wilkie 1988, Wilkie and Limberg 1990a, 1993, Shevlin and Porter 1992, and Gupta

Newberry 1997). For instance, Wilkie (1988) shows that only if book-tax differences, BTD, are proportionally related to pre-tax income, that is $BTD = \theta PI$, the level of income does not play a role in the determination of the ETR and changes in ETRs are caused solely by changes in book-tax differences (i.e., tax planning). Shevlin and Porter (1992) add that a major problem in using ETRs to assess the impact of tax rule changes is that they can vary across firms and time not only because of changes in tax laws but also because of changes in income if book-tax differences are not proportionally related to book income. In line with this, the authors state that it is an empirical question whether book-tax differences are proportionally related to book income and thus whether or not the level of income influences the ETR. Subsequently, Gupta and Newberry (1997) state that to the extent that book-tax differences are not proportionally related to income, ETRs can change simply because of changes in pre-tax income.

However, none of these studies have applied their arguments to investigate trends in effective tax rates over time and to analyze how much of any observed trend in ETRs is simply related to growth in pre-tax income and therefore is unrelated to tax planning. We build on this prior work to investigate whether the recently documented declining trend in Cash ETRs is related to growth in pre-tax income, and if so, to what extent. Specifically, we investigate how much of the observed declining trend is attributable to growth in pre-tax income and how much is attributable to increased tax avoidance.

We extend the arguments developed in Wilkie (1988), Wilkie and Limberg (1990a), (1993), Shevlin and Porter (1992), and Gupta and Newberry (1997) and show that to the extent that book-tax differences are linearly, as opposed to proportionally, related to pre-tax income, cash taxes paid will also be linearly related to pre-tax income, leading to the following linear tax function $TXPD = a + bPI$. The intercept, a, captures taxes paid effects that are independent of current period's income whereas the product of the slope coefficient and income, bPI, captures tax effects that are directly associated with current pre-tax income. The slope coefficient can be interpreted as the marginal propensity to tax (MPT) since it measures a firm's 'marginal' tax payment due to an additional dollar of current period pre-tax income.[1] Both coefficients, the intercept a and the slope coefficient b, capture to what extent a firm's tax planning is constant over time. Alternatively stated, assuming a linear tax function, an increase in tax avoidance is evidenced by a decrease in a, (i.e., a decrease in taxes paid unrelated to the current period pre-tax income) and/or a decrease in b, (i.e., a decrease in taxes paid as a function of current period income).

Linear tax functions have an inherent 'economic' relation between the average Cash ETR and the marginal propensity to tax (MPT) if pre-tax income is positive and growing over time.[2] To reveal this key economic relation, we divide the linear tax function by pre-tax income leading to the following Cash ETR function: $Cash\ ETR = TXPD/PI = a/PI + b$. Accordingly, average Cash ETR is a function of some constant level of tax planning as indicated by the time invariant coefficients a and b, and the level of pre-tax income, PI. Based on the developed Cash ETR function, we make two predictions that provide insights regarding the time series of Cash ETRs.

First, for firms with tax functions where the intercept a is positive and where pre-tax income is positive and increasing, average Cash ETRs will decline over time and converge from above towards the MPT ($MPT = b$). This relation is driven by the fact that with a positive intercept and growing income, the positive term a/PI in the Cash ETR function will decline and converge towards zero, independent of any change in tax avoidance.

---

[1] Note, in this setting "marginal" is used in the context of the derivative of the tax function which captures the additional amount of current period tax for an additional dollar of pre-tax income. This definition is not to be confused with the similar but different concept of marginal tax rates used in the tax literature (Scholes, et al. 2016) which is the change in the present value of taxes from earning an additional dollar of taxable income in the current period.

[2] Similar economic relations exist also for negative incomes when they exhibit a growth trend. We discuss these cases later on in more detail. In our main analysis, however, we focus on positive incomes and growth.

Second, for firms with tax functions where the intercept a is negative and where the pre-tax income is positive and increasing over time, average Cash ETRs will increase and converge from below towards the MPT ($MPT = b$). This relation is driven by the fact that with a negative intercept and growing income, the negative term $-a/PI$ in the Cash ETR function will increase and converge towards zero.

Our analysis shows that to the extent that the coefficients a and b in the tax function are constant over time, decreases ($a > 0$) or increases ($a < 0$) in the average Cash ETRs will be driven simply by the growth in pre-tax income and thus will be unrelated to firms' increased or decreased tax avoidance activities. Thus, ignoring the growth effect of pre-tax income on the magnitudes of average Cash ETRs can lead to misleading inferences regarding the assessment of firms' tax avoidance behavior.

We acknowledge that applying our model to a real world example, we cannot assume that the level of tax planning has remained completely constant over the past quarter-century as implied by the time invariant coefficient a and b. Therefore, we extend our linear tax function model to $TXPD_t = a_t + b_t PI_t$ where $a_t = a + a_t^*$ and $b_t = b + b_t^*$. The coefficients a and b capture the level of tax planning that has remained constant while a_t^* and b_t^* capture changes in firms' tax planning over time. Using this extension we can test to what extent tax planning has remained constant, in order to isolate the impact of income growth on the decrease in Cash ETR by estimating the following tax function: $TXPD = a + bPI + \varepsilon_t$ where ε_t is an empirical residual $= \left((a_t^* + b_t^* PI_t) + u_t\right)$. The estimates of a and b provide inferences about the constant level of tax planning and the empirical residual captures changes in firms' tax planning $(a_t^* + b_t^* PI_t)$ as well as some stochastic noise u_t. Empirically, to the extent a and b are changing over time, indicating changes in firms' tax planning activities, these changes will be captured by ε_t. Separating the two effects allows us to test how much of the observed trend in the Cash ETR is related to growth and how much stems from tax planning. Again, to the extent that cash taxes paid are linearly related to pre-tax income, the trend in Cash ETRs will be solely driven by growth in pre-tax income. Only to the remaining extent that cash taxes paid are not linearly related to pre-tax income, i.e., to the extent ε_t reveals any declining trend, decreases in Cash ETRs can be attributed to firms' increased tax avoidance activities.

We present empirical results that are consistent with our predictions. First, reproducing the sample from Dyreng et al., (2017) and extending it by four years (1988-2016), we document a cumulative decline in the average Cash ETR of 9.92 percentage points (i.e., 0.0992) over the period from 1988 to 2016. Further, analyzing the descriptive statistics we find a positive mean pre-tax income that is growing through time. The mean of cash taxes paid is also positive and increasing over time. Depending on the specification to obtain estimates of a and b, that is, estimating a linear tax function regression of the annual mean level of cash taxes paid on the annual mean level of pre-tax income $TXPD = a + bPI + \varepsilon_t$, or similarly estimating the mean Cash ETR linearly on one over the mean pre-tax income $Cash\ ETR = TXPD/PI = a/PI + b + \varepsilon_t'$, reveals an r-squared of 0.98 (0.74) consistent with 98% (74%) of the variation in cash taxes paid (Cash ETR) being explained by a linear relation with pre-tax income (one over pre-tax income). The estimated intercept a is 7.67 (11.37) and is statistically significant at the 1% level. This result documents that cash taxes paid are not simply proportionally related to pre-tax income. Specifically, relating the magnitude of the intercept to the mean of cash taxes paid of 67.69 shows that, on average, 10% (17%) of cash taxes paid are not proportionally related to pretax income (7.67/67.69=0.10) (11.37/67.69=0.17).

Because the results show that cash taxes paid are related to pretax income in a linear manner, the documented trend in the Cash ETR is, consistent with our prediction, likely to be driven to some extent by the growth in pre-tax income and not solely by increased tax avoidance. Based on the empirical estimates of a and b we are able decompose the cumulative decrease of Cash ETRs into two components, (i) a decrease in the Cash ETR related to growth in pre-tax income and (ii) a decrease in the Cash ETR related to tax avoidance. Our results show that the cumulative decrease attributable to income growth amounts to 6.87 (10.18) percentage points (i.e., 0.0687 (0.1018)). Consequently, out of the documented decline in the Cash ETR of 0.099, 69% (103%) is related to the growth in the pre-tax income (0.69=0.0687/0.099) (0.1018/0.0992) and thus unrelated to tax avoidance. This finding illustrates why in prior research firm characteristics fail to fully explain the decreasing trend. In additional analyses, we explore the role of other firm characteristics in explain the variation in the empirical residual ε_t which is expected to capture changes in firm's tax planning. We find that 75% of the variation in the residual (i.e., changes in a_t^* and b_t^*) can be explained by changes in firm characteristics commonly shown to affect effective tax rates (e.g., being a multinational corporation, property, plant, and equipment, intangibles assets, etc.).

Our results show that a large portion of the declining trend in ETR documented by Dyreng et al. (2017) is unrelated to firms' tax planning. It is important to note that our results do not indicate that the level of tax avoidance is zero. The results rather show that the level of tax avoidance has largely remained constant over time. Our estimated marginal propensity to tax is $b = 0.24$ to $b = 0.22$. Comparing this estimated marginal propensity to tax with the statutory tax rate of 0.35 shows that the average firm in the sample avoids 11 to 13 cents on an additional dollar of pre-tax income, which indicates a significant amount of cash tax savings.

We contribute to prior literature by showing that the 'economic' relation that is inherent in linear tax functions is a plausible alternative explanation for the observed decreasing trend in Cash ETRs of U.S. firms and helps to understand why firm characteristics and declining foreign tax rates do not fully explain the trend. Alternatively stated, by defining tax avoidance as a reduction in cash taxes paid per dollar of pre-tax income, Dyreng et al. (2008, 2017), Dyreng and Lindsey (2009), and Hanlon and Heitzman (2010) are implicitly assuming a proportional tax function, that is $TXPD = bPI$, and thus by definition any change in the Cash ETR is attributed to a change in tax avoidance. However, if cash taxes paid are not a proportional but rather are a linear function of pre-tax income this relation provides an explanation for the decreasing trend in Cash ETRs that is not driven by increasing tax avoidance but is primarily related to growth in pre-tax income. Specifically, we show that to the extent that firms' linear tax functions remain unchanged over time, indicating no systematic changes in tax avoidance behavior, changes in average Cash ETRs may be observed simply because of growth in pre-tax income.

Due to the increasing disparity between the statutory tax rate and the continuous decline in ETRs, many have accused firms of not paying their fair share of taxes. The main implication of our findings is that wholesale concerns regarding increasing tax avoidance over time are potentially overstated. Given the empirical evidence of a predominantly stable linear tax function and their inherent economic relation between average Cash ETRs and the MPT in the presence of growth in pre-tax income, for US corporations our results show that 69% up to 100% of the observed Cash ETR decline is unrelated to tax avoidance.

The remainder of this study proceeds as follows. Section 2 provides a background on the theoretical concept of linear tax functions and their empirical estimation; it also develops the hypotheses. Section 3 describes the data, the full sample selection, and the subsample selections. Section 4 presents the results and section 5 concludes.

II. Theoretical background and hypotheses development

2.1 Tax functions in economics literature

Macro and microeconomics-based research oftentimes assumes linear-type tax functions in their models of the form:

$$T_t = a + bY_t \quad (0)$$

where T_t denotes some measure of the tax burden in period t and Y_t some measure of income in period t. The intercept a captures tax payments in time t that are independent of the current period's income if $a > 0$; and tax refunds/reductions in t that are independent of the magnitude of the current period's income if $a < 0$, respectively. The slope coefficient b denotes the marginal propensity to tax (MPT), which is defined as the incremental tax payment in the current period due to an additional dollar of income (Helpman and Sadka, 1978; Cooter and Helpman, 1974; Romer, 1975). The economics literature often refers to the slope coefficient, b, as the 'marginal tax rate.' However, we note that this economics concept of marginal tax rates differs in its definition from the Scholes-Wolfson framework used in accounting-based tax research (Scholes et al., 2016).[3]

Although the economics literature provides strong theoretical foundations as well as empirical evidence on the existence of linear tax functions, accounting research empirically testing the implications of linear corporate tax functions is rare. Evidence on corporate tax functions in accounting-based tax research has already been provided in e.g., Zimmerman (1983), Wilkie (1988), Shevlin and Porter (1991), Dyreng and Lindsey (2009), Hanlon and Slemrod (2009), Desai

[3] In the economics literature, linear tax function of the form: $T = a + bY$ are oftentimes assumed, where the slope coefficient b is defined as the 'marginal tax rate' (e.g., Helpman and Sadka (1978), p. 384). Note that in this context the terminology 'marginal' means the incremental current tax payment induced by an additional dollar of income in the current period and differs from the definition used in the Scholes-Wolfson framework of effective tax planning where the marginal tax rate is a multi-period concept defined as "the effect on the present value of explicit taxes of earning another dollar of taxable income in the current period" (Scholes et al. (2016), pp. 193-195 and 511).

and Dharmapala (2006), and Atwood et al., (2012). The first three studies assume linear tax functions. The next three studies assume 'proportional' tax functions whereas Atwood et al. use a linear multivariate tax function where the current tax expense is regressed on three explanatory variables to estimate the degree of book-tax conformity.[4] None of these studies, however, tests the predicted convergence implications between effective tax rates and the MPT in the presence of pre-tax income growth in order to explain trends in ETRs over time. Therefore, we next provide a theoretical background on linear corporate tax functions and develop the hypotheses.

2.2 Linear corporate tax functions

Based on Wilkie (1988), Wilkie and Limberg (1990a, 1993), Shevlin and Porter (1992), and Gupta Newberry (1997), 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:

$$TXPD_t = A_t - C_t + strTI_t \tag{1}$$

Taxable income is defined as pre-tax income, PI, plus or minus total book-tax differences, BTD, where book-tax differences are all items (including $NOLs$) 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:

$$TI_t = PI_t - BTD_t \tag{2}$$

---

[4] Note that in 'proportional' tax functions of the form: $T = bY$, that is, where an intercept is missing, the average ETR (T/Y) equals the marginal propensity to tax ($dT/dY = b$). Further, all studies which estimate the unobservable taxable income (TI) by grossing up the current tax expense (TXC) by the statutory tax rate (str), i.e., $TI = TXC/str$, imply a 'proportional' tax function of the type: $TXC = strTI$. Dyreng and Lindsey (2009) include an intercept but essentially assume a proportional tax function as they do not focus on the role of the intercept. Atwood et al. (2012) estimate the following linear multivariate tax function: $CTE_t = \theta_0 + \theta_1 PTBI_t + \theta_2 ForPTBI_t + \theta_3 DIV_t + e_t$, where CTE is current tax expense, $PTBI$ is pre-tax book income, $ForPTBI$ is foreign pre-tax book income, and DIV is total dividends. The residual e_t is aimed to measure the variation of book-tax conformity.

According to Shevlin and Porter (1992), the key assumption to test empirically in order to answer the question whether ETRs are influenced by the level of pre-tax income is: to what extent are total book-tax differences proportionally/linearly related to pre-tax income? If book-tax differences are proportionally related to pre-tax income, ETRs will not be affected by the level of pre-tax income. If however, book-tax differences are linearly related to pre-tax income, ETRs will be affected by the level of pre-tax income. To the extent book-tax differences are linearly related to pre-tax income, the trend in ETRs over time could be driven solely by growth in pre-tax income and not by tax avoidance. We therefore model total book-tax differences as a linear function of pre-tax income:[5]

$$BTD_t = \theta_{0t} + \theta_{1t} PI_t \qquad (3)$$

where θ_{0t} captures the portion of total book-tax differences that is unrelated to pre-tax income, and where $\theta_{1t} PI_t$ captures the portion of total book-tax differences that is proportional to pre-tax income.[6,7] Equation (3) can be estimated empirically in order to assess to what extent book-tax differences are proportionally/linearly related to pre-tax income and thus to determine whether trends in ETRs are driven by the level of pre-tax income.

Economically, the coefficient θ_0 captures US GAAP's system of interperiod income tax allocation. 'Interperiod tax allocation effects' arise mainly due to temporary book-tax differences originated 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 book-tax differences originating in period t that will reverse in some future period e.g., in $t + 1$ (tax prepayments such as unearned revenue).

---

[5] Appendix A shows formally when ETRs are influenced by the level of pre-tax income depending on different specifications of the relation between total book-tax differences and pre-tax income.
[6] We present examples of these various types of differences in Appendix B.
[7] Note, both $\theta_{0t} < 0$ and $\theta_{1t} > 0$ imply $PI_t > TI_t$ whereas both $\theta_{0t} > 0$ and $\theta_{1t} < 0$ imply $PI_t < TI_t$.

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:

$$TXPD_t = \left(A_t - C_t - str\theta_{0t}\right) + str(1 - \theta_{1t})PI_t \tag{4}$$

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 the coefficient θ_{0t} from equation (3) translates to some cash taxes unrelated to pre-tax income ($str\theta_{0t}$) in equation (4). In addition to equation (3), equation (4) shows that also 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.

Dividing the tax function provided in equation (4) by the pre-tax income yields the Cash ETR function:

$$Cash\ ETR_t = \frac{TXPD_t}{PI_t} = \frac{(A_t - C_t - str\theta_{0t})}{PI_t} + str(1 - \theta_{1t}) \tag{5}$$

Denoting $a_t = (A_t - C_t - str\theta_{0t})$ and $b_t = str(1 - \theta_{1t})$ equation (4) reduces to:

$$TXPD_t = a_t + b_t PI_t, \tag{6}$$

and equation (5) reduces to:

$$Cash\ ETR_t = \frac{TXPD_t}{PI_t} = \frac{a_t}{PI_t} + b_t \tag{7}$$

Equations (4) and (5) reveal the determinants of the tax function's intercept and the slope coefficient. Specifically, if an accounting system allows for interperiod tax allocation effects, as is the case under US GAAP because of the existence of timing differences between the two sets of books (i.e., temporary book-tax differences), the tax function will exhibit tax payments unrelated to the current period and thus an intercept. Moreover, if a tax system allows tax credits (e.g., research and development and foreign tax credits), which are deductible from gross taxes, this will also be reflected in the intercept. Thus, different types of originating/reversing temporary book-tax differences will be the primary cause of the intercept. However, the intercept may also contain permanent book-tax differences that are unrelated to the magnitude of pre-tax income. The slope coefficient of the tax function can be interpreted as the MPT and is given by the product of the statutory tax rate and one minus the pre-tax income proportional book-tax differences (both temporary and permanent). To what extent temporary/permanent book-tax differences are proportionally/linearly related to pre-tax income is an empirical question. Because most accounting systems allow for the described effects, assuming proportional tax functions of the form: $TXPD_t = bPI_t$ where an intercept a is missing, appears incomplete and can affect inferences drawn from ETRs about corporate tax planning.

2.3 The relation between ETR and the level of pre-tax income

To highlight how cash ETR changes with pretax income, we next take the derivative of equation (7):

$$\frac{dCash\ ETR_t}{dPI_t} = -\frac{a}{PI_t^2} \tag{8}$$

Recall, in a purely proportional tax function the intercept a will not play a role (i.e., $a = 0$). Substituting zero for a into equation (8) yields a first derivative of 0 and highlights that cash ETR will not change as pretax income changes. This association is also illustrated in Figures 1(A) and 1(B).

When allowing for a non-zero intercept a, the corresponding change in cash ETR, when there is a change in pretax income, is the negative value of the intercept divided by pretax income squared. Alternatively stated, in a linear tax function, changes in pretax income will yield a change in cash ETR with the direction of change depending on the sign of the intercept term. This association is also illustrated in Figures 1(C) and 1(D). Figure 1(C) shows that given a linear tax function, changes in the level of the Cash ETR will arise simply because of increases (changes) of the level of pre-tax income. Thus, given a linear tax function, the level of the Cash ETR is not independent of the level of pre-tax income. Consequently, if linear tax functions are descriptive, it is necessary first to control for changes in pre-tax income before inferences about the contribution of a specific determinant to a firm's tax planning level can be drawn.

2.4 Hypotheses Development

The main prediction for our model is that to the extent book-tax differences (and cash taxes paid) are linearly related to pre-tax income in a fixed relation, Cash ETRs will be affected by the growth of pre-tax income. Consequently, such changes in Cash ETR will not be related to changes in a firm's tax planning level. Equation (5-7) and equation (8) from the prior section provides the basis for our two main hypotheses. Equations (5-7) and (8) reveal 4 main predictions about the relation between average Cash ETRs and the marginal propensity to tax (MPT), as well as about the trend inherent in Cash ETRs depending on the sign of the intercept (positive or negative), the sign of pre-tax income (positive or negative) and its evolution over time (increasing/decreasing). Figure 2 illustrates the four cases while assuming a MPT of 0.30.[8] However, we focus on profitable firms and ignore investigating trends in Cash ETRs of loss firms. In doing so, we only differentiate between two types of tax functions. Tax function type I describes firms with a positive intercept, $a > 0$, and a positive and growing pre-tax income. Tax function type II describes firms with a

[8] For this example, we arbitrarily assume a marginal propensity to tax (MPT) of 0.30 to outline the associations between average Cash ETRs and the MPT in Figure 2. The outlined associations remain basically the same if a different MPT is assumed, e.g., $MPT = 0.2$. The only thing that changes if a different level of MPT is assumed is the level to which the average Cash ETRs converges if pre-tax income increases. Assuming a MPT of 0.30 roughly implies a mean relative book-tax differences level of 0.15, i.e., $MPT \approx 0.30 \approx str(1 - 0.15)$ where $str = 0.35$. Further, the outlined associations in Figure 2 assume that the tax function has the same marginal propensity to tax for both loss firm-year observations and for firm-year observations with a positive pre-tax income. However, it is reasonable to assume that the marginal propensity to tax for loss-tax functions will be flatter than for tax functions with a positive pre-tax income, i.e., will have a lower marginal propensity to tax.

negative intercept, $a < 0$, and a positive and growing pre-tax income.

Tax function type I: $PI_t > 0$, $a > 0$

The first type of corporate tax function describes a linear relation between the level of cash taxes paid and the level of pre-tax income with both a positive intercept and a positive and increasing current pre-tax income. The positive intercept, $a > 0$, reflects the component of cash taxes paid that is independent of current period's pre-tax income, e.g., reversing temporary book-tax differences in period t that cause cash tax payments in period t related to prior periods pre-tax incomes or current tax prepayments on future income such as unearned revenue in period $t + 1$. The first quadrant of Figure 2 graphically shows the expected relation between the level of pre-tax income and cash ETR based on the derivative presented in equation (8). For a positive intercept a, Cash ETRs will decline by $-a/PI_t^2$ if the level of pre-tax income increases by one unit. Further, the first quadrant of Figure 2 also shows that the average Cash ETR will continue to decrease as the level of pre-tax income increases and will converge from above towards the marginal propensity to tax, b. This relation is driven by the fact that the component $\frac{a}{PI_t}$ in equation (7) will decrease and converge towards zero if pre-tax income increases. We therefore hypothesize:

> *H1: For firm-year observations with a positive intercept, $a > 0$, in the tax function, average Cash ETRs will decrease and converge from above towards the marginal propensity to tax (MPT) if pre-tax income is positive and increasing.*

Tax function type II: $PI_t > 0$, $a < 0$

The second type of corporate tax functions describes a linear relation between the level of cash taxes paid and the level of pre-tax income with a negative intercept and a positive and increasing current pre-tax income. The negative intercept, $a < 0$, again reflects the component of cash taxes paid that is independent of current period's pre-tax income. A negative intercept, however, indicates e.g., reversing temporary book-tax differences in period t that cause cash tax refunds taking effect in period t that are related to prior period's pre-tax incomes. The second quadrant of Figure 2 graphically shows the expected relation between the level of pre-tax income and cash ETR based on the derivative presented in equation (8). For a negative intercept, Cash ETRs will increase by a/PI_t^2 if the level of pre-tax income increases by one unit. Further, the first quadrant of Figure 2 also shows that the average Cash ETR will continue to increase as the level of pre-tax income increases and will converge from below towards the marginal propensity to tax b. This relation is driven by the fact that the component $\frac{-a}{PI_t}$ in equation (7) will increase and converge towards zero if pre-tax income increases. We therefore hypothesize:

> *H2: For firm-year observations with a negative intercept,* $a < 0$*, in the tax function, average Cash ETRs will increase and converge from below towards the marginal propensity to tax (MPT) if pre-tax income is positive and increasing.*

Note, to the extent that a and b are not constant over time, changes in a and b will disturb the predicted relations and we might not observe the predicted trends in average Cash ETRs. It therefore remains an empirical question to what extent a and b are constant over time and if the predicted relations between Cash ETRs and levels of pre-tax income are empirically observed.

2.5 Linear tax functions and changes in firms' levels of tax avoidance

As noted above, linear tax functions do not necessarily imply that the level of tax avoidance has remained constant over the past 29 years. Although the US statutory tax rate has remained relatively constant, many other changes might have impacted the tax function and thus affected average Cash ETRs. Changes in the US tax system like the introduction of check-the-box regulations in 1997, the repatriation holiday in 2004-5, and bonus depreciation rules are likely to have affected the tax function of many US firms. Moreover, changes in financial accounting rules like SOX and/or changes in the treatment of goodwill might also have impacted the tax function as measured by a linear function between cash taxes paid and pre-tax income. Finally, variation in firm characteristic commonly shown to affect ETRs might also affect firms' tax functions and lead to changes over time. For those reasons, we acknowledge that applying our model to the real world, we cannot assume that the level of tax planning has remained constant over the past 29 year as measured by the time invariant coefficients, a and b. Thus, we extend our model by allowing a and b to be time-variant:

$$TXPD_t = a_t + b_t PI_t + u_t \tag{9}$$

where tax planning as captured by the intercept is decomposed into two components:

$$a_t = a + a_t^* \tag{10}$$

a constant portion a and a time-variant portion a_t^*. Analogously, tax planning as captured by the slope coefficient b is also decomposed into the same two components:

$$b_t = b + b_t^* \tag{11}$$

and where the residual u_t denotes a stochastic noise term. Note that, our primary aim is not to explain the variation in tax planning over time, but rather, to identify to what extent tax planning – as measured by a linear tax function – has remain constant over time in order to assess to what extent the observed declining trend in Cash ETRs is related to the growth in pre-tax income and not to tax avoidance. Thus, imposing a linear tax function regression in order to achieve this goal gives: that captures stochastic noise gives:

$$TXPD_t = (a + a_t^*) + (b + b_t^*) PI_t + u_t \tag{12}$$

which can be rearranged and simplified to:

$$TXPD_t = a + bPI_t + \varepsilon_t \tag{13}$$

where $\varepsilon_t = (a_t^* + b_t^* PI_t + u_t)$. Equation (13) shows that the constant coefficients a and b will capture the extent to which firms' tax planning is constant over time and the residual ε_t will capture changes in tax planning over time and some stochastic noise. Dividing equation (13) by pre-tax income, gives the corresponding Cash ETR function regression, which also can be empirically used to obtain estimates of a and b:

$$CASH\ ETR_t = b + a\,1/PI_t + \varepsilon_t' \tag{14}$$

where $\varepsilon_t' = (a_t^* + b_t^* PI_t + u_t)/PI_t$.

2.6 Extension of the traditional tax avoidance definition

Traditionally tax avoidance is broadly defined as any reduction in cash ETR. This definition includes both a decrease in the ETR due to a reduction of cash taxes paid while holding pre-tax income constant and an increase in pre-tax income while holding cash taxes paid constant as tax avoidance (Hanlon and Heitzman, 2010). While this definition is intuitive, it has an embedded assumption that the underlying tax function is proportional as, by definition, any change in the ratio of cash taxes paid to pretax income is a change in tax avoidance. This relation is illustrated in Figure 1(E) and 1(F) with changes in tax avoidance resulting in downward rotations of the tax function. No matter which economic factor has caused the downward rotation of the proportional tax function, it can be interpreted as tax avoidance.

This definition, however, is incomplete and misleading if the tax function is not proportional but linear. As already shown, if a linear tax function is descriptive, changes in ETRs will be related to changes in the level of pre-tax income. As shown in Figures 1(C) and 1(D) such changes are unrelated to changes in a firm's tax planning level because they arise simply due to the growth in pre-tax income without requiring any changes (rotations/shifts) to the tax function.

We therefore extend the traditional definition of tax avoidance as decreases in effective tax rates caused by downward rotations/shifts of the tax function. Given a proportional tax function,

$TXPD = bPI$, this definition implies any reduction of the $ETR = TXPD/PI = b$ (rotations/shifts illustrated in Figures 1(E) and 1(F)). Given a linear tax function, $TXPD = a + bPI$, this definition implies only ETR decreases that are associated with decreases in a – a decrease in taxes paid unrelated to pre-tax income – and/or decreases in b – taxes paid as a function of pre-tax income (rotations/shifts illustrated in Figures 1(G) and 1(H)).

To examine the plausibility of our conjectures, we first test whether a proportional or linear tax function is empirically descriptive before drawing inferences about changes in firm's tax planning levels.

III. Data and sample selection

3.1 Sample selection

We begin our sample selection following the criteria outlined in Dyreng et al., (2017) (DHMT herein) and extend the sample period by four years from 1988-2012 to 1988-2016. Specifically, 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 US tax system in 1988 and before the 2018 reform. We only include U.S. firms in our analyses. There are 173,391 firm-year observations that fulfill these requirements. Requiring non-missing values for pre-tax income, cash taxes paid, and all control variables leads to a sample size of 100,943 firm-year observations including 12,168 individual firms. Further, consistent with DHMT (2017), we exclude observations with negative pre-tax income and winsorize Cash ETRs at zero and one to ensure so all observations fall in the range $0 \leq Cash\ ETR \leq 1$. All other variables are winsorized at the 1% and 99% levels. These requirements lead to a final sample size of 61,276 firm-year observations including 6,642 individual firms. The average number of years a firm appears in the sample is 15.85.

Descriptive statistics are reported in Tables 1 and 2. Table 1 reports the descriptive statistics on the same (scaled) variables as used by DHMT. Panel A of Table 1 reports the descriptive statistics on the extended sample (1988-2016) and Panel B of the replicated sample (1988-2012).[9] Cash ETRs are similar (i.e., 0.297 versus 0.291 in DHMT) and observation are similar in other attributes (e.g., size, measured as the natural logarithm of total assets is 5.692 versus 5.938 in DHMT). The observed values are very similar to the DHMT sample, allowing for comparability of the results.

Since the focus of our analyses is primarily on the raw variables, that is, on annual mean values of the reported unscaled variables, we additionally report descriptive statistics on raw unscaled variables in Table 2, Panels A and B. Panel A reports descriptive statistics on the pooled data set whereas Panel B reports descriptive statistics on the raw aggregated variables (annual mean values).

IV. Empirical analysis and results

4.1 Regression models

To obtain empirical estimates of a and b, we estimate two different model specifications. First, we estimate the annual mean of cash taxes paid on the annual mean of pre-tax income (tax function specification). As already outlined in equation (12), the full tax function model accounts

[9] Herein we refer to the 1988 – 2016 sample as the "extended sample" or "primary sample." We refer to the 1988-2012 replicated sample as the "DHMT sample."

for the fact that both a and b are likely to change over time through firms' tax planning. Extending equation (12) by an empirical error term u_t that captures stochastic noise gives:

$$TXPD_t = (a + a_t^*) + (b + b_t^*)PI_t + u_t \quad (15)$$

Imposing a linear tax function with constant coefficients of a and b to model (13) gives:

$$TXPD_t = a + bPI_t + \varepsilon_t \quad (16)$$

where $\varepsilon_t = (a_t^* + b_t^* PI_t + u_t)$. Model (16) allows us to determine to what extend tax planning has remained constant over the past 29 year (1988-2016) as captured by empirical estimates of a and b. Changes in tax planning as reflected in changes in a_t^* and b_t^* will be captured by the empirical residual.

In our second specification, we estimate the annual mean of the Cash ETR linearly on one over the annual mean of pre-tax income (Cash ETR function). We obtain this regression simply by dividing equation (16) by the mean pre-tax income:

$$CASH\ ETR_t = b + a\,1/PI_t + \varepsilon_t' \quad (17)$$

where $\varepsilon_t' = (a_t^* + b_t^* PI_t + u_t)/PI_t$. Again, estimates of a and b will capture the extent to which tax planning has remained constant and changes in a and b will be captured by the residual ε_t'.

Next, in order to isolate how much of the observed trend in the average Cash ETR is related to growth in pre-tax income, we first assess the average decline over the last 29 years in the actual ETR by regressing the actual ETR on a time trend variable:

$$Cash\ ETR_t = \delta_0 + \delta_1 TIME_t + v_t \quad (18)$$

where $TIME_t$ takes on the values 1, 2, …, 29. The coefficient δ_1 measures the annual decline of the actual ETR. Multiplying this annual decrease by 29 gives the cumulative decrease of the actual ETR over the sample period.

In order to determine how much of the decline in actual ETRs is related to growth in PI and thus unrelated to tax avoidance we use estimates of a and b obtained from either equation (16) or equation (17) and calculate the predicted Cash ETR, denoted as Cash ETR Hat:

$$\widehat{Cash\ ETR}_t = \hat{a}\frac{1}{PI_t} + \hat{b} \tag{19}$$

Finally, to determine how much of the observed trend is simply related to growth, we regress the calculated Cash ETR Hat on a time trend variable:

$$\widehat{Cash\ ETR}_t = \delta_0' + \delta_1' TIME_t + v_t' \tag{20}$$

Similar to equation (19), the coefficient δ_1' measures the annual decline of the Cash ETR Hat and multiplying this annual decrease by 29 gives the cumulative decrease of the ETR over the sample period which is solely related to the growth in pre-tax income. Relating the two cumulative decreases (i.e., $29\times\delta_1'/29\times\delta_1 = \delta_1'/\delta_1$) gives the ratio indicating how much of the observed trend in the actual Cash ETR is related to growth in pre-tax income.

Although not our focus, we also test how much of the remaining variation of cash taxes paid as measured by the empirical residual from equation (16) being $\varepsilon_t = (a_t^* + b_t^* PI_t + u_t)$ can be explained by firm characteristics commonly shown to affect ETRs. In choosing those characteristics we follow DHMT and regress the following model:

$$\begin{aligned}\widehat{\varepsilon_t} = \beta_0 + \beta_1 MNE_t + \beta_2 XRD_t + \beta_3 PPE_t + \beta_4 INTAN_t + \beta_5 DT_t \\ + \beta_6 CAPX_t + \beta_7 XAD_t + \beta_8 SPI_t + \beta_9 \Delta NOL_t + \pi_t\end{aligned} \tag{21}$$

where *MNE* is the annual mean of an indicator variable capturing whether or not a firm is a multinational, *XRD* is research and development expense, *PPE* is property, plant, and equipment, *INTAN* is intangible assets, *DT* is total debt, *CAPX* is capital expenditures, *XAD* is advertising expense, *SPI* is special items, Δ*NOL* is the change in firms net operating loss carryforward, and π a residual.

4.2 Primary Sample Results

4.2.1 How much of the observed ETR decline is related to growth?

Our main results focus on annual means of the Cash ETR, cash taxes paid, and pre-tax income based on the extended sample (1988-2016). The descriptive statistics reported in Table 2, Panel B reveal a mean Cash ETR of 0.28, a positive mean of cash taxes paid of 67.69, and a positive mean of pre-tax income of 249.70. Further, Figure 3, Panels A and B illustrate the evolution of the three variable over the sample period. Both cash taxes paid and pre-tax income are positive and growing over time. Consistent with the results in DHMT, the annual mean Cash ETR is declining over the sample period.

Estimating regression (16) leads to the results presented in Table 3, Column (1) and Figure 4, Panel A. Both the intercept (t-Stat.: 5.09) and the slope coefficient (t-Stat.: 38.79) are statistically significant at the 1% level. The intercept is positive and is 7.67; the slope coefficient, the MPT, is 0.24. This implies that firms pay an on-average fixed \$7.67 million of taxes plus 24 cents on each dollar of pre-tax income. The relative amount of cash taxes paid that is not proportionally related to pre-tax income equals 11.3% (7.67/67.69=0.113). The r-squared of 0.98, as well as the scatter diagram in Figure 4, Panel A, provide strong evidence on the existence of a predominantly stable linear tax function.

Figure 5, Panel A shows the evolution of the average Cash ETRs, the fitted value of cash ETR ($\widehat{Cash\,ETR}_t = 7.67\,1/PI_t\; + 0.24$), and the estimated MPT of 0.24. These results are consistent with H1. Since the primary sample's tax function has a positive intercept and a positive and growing mean pre-tax income, the average Cash ETR decreases and converges from above towards the MPT of 0.24.

Next, we repeat our analysis to obtain estimates of a and b from the ETR function. Estimating regression (17) leads to the results presented in Table 4, Column (1) and Figure 4, Panel B. Again, both the intercept (t-Stat.: 9.48) and the slope coefficient (t-Stat.: 30.89) are statistically significant at the 1% level. The intercept is positive and is 11.37; the slope coefficient is 0.22. The relative amount of cash taxes paid that is not proportionally related to pre-tax income equals 17% (11.37/67.69=0.17). The r-squared of 0.74 is lower than the one from the level regression. The scatter diagram in Figure 4, Panel B, however, still provides strong evidence on the existence of a predominantly stable linear tax function.

Given this evidence of stable linear tax functions, we turn to estimating the relative portions of the decrease in ETRs over time that are attributable to the growth in pre-tax income versus other factors such as changes in tax avoidance behavior. Table 5, Column 1 reports formal results on the illustrated declining trend in Figure 5, Panel A. The actual ETR decreases at a rate of -0.0034 whereas the predicted ETR decreases at a rate of -0.0024. These results lead to a cumulative decrease of -0.0992 for the actual ETR and of -0.0687 of the predicted ETR (i.e., Cash ETR hat). Relating the cumulative decrease of the predicted ETR to the cumulative decrease of the actual ETR reveals how much of the observed trend is simply driven by growth in pre-tax income, and thus, is unrelated to tax avoidance. This ratio equals 0.69 (29x-0.0024/29×-0.0034) and indicates that 69% of the observed decreasing trend is unrelated to tax avoidance.

Further, as illustrated in Figure 6, Panel A, the error term from regression (16) does not exhibit a statistically significant time trend (untabulated). Consequently, changes in firms' tax avoidance activities as captured by the variation of the residual do not reveal systematic changes that increased/decreased over time. Since 69% of the documented trend is related to growth in pre-tax income, the results highlight why prior research has been unable to explain the decreasing trend with changes in firm characteristics (other than *PI*).

Table 6, Column 1 reports formal results on the illustrated declining trend in the cash ETR function illustrated in Figure 5, Panel B. The actual ETR decreases at a rate of -0.0034 whereas the predicted ETR decreases at a rate of -0.0035. These results lead to a cumulative decrease of -0.0992 for the actual ETR and of -0.1018 of the predicted ETR. Relating the cumulative decrease of the predicted ETR to the cumulative decrease of the actual ETR reveal how much of the observed trend is simply driven by growth in pre-tax income, and thus, is unrelated to tax avoidance. This ratio equals 1.03 (29x-0.0035/29×-0.0034) and indicated that virtually all (i.e., an estimated 103%) of the observed decreasing trend is unrelated to tax avoidance.

Further, as illustrated in Figure 6, Panel B, the error term from regression (17) does not exhibit a statistically significant time trend (untabulated). Consequently, changes in firms' tax avoidance activities as captured by the variation of the residual do not reveal systematic changes that increased/decreased over time. Since under this specification approximately 100% of the documented trend is related to growth in pre-tax income, the results highlight why prior research has been unable to explain the decreasing trend with changes in firm characteristics (other than *PI*).

We also repeat our analysis for the original DHMT sample period of 1988-2012. The results are qualitatively and quantitatively similar as those from the primary sample reported and discussed above. These results are reported in Tables 3 through 6, Columns (2). Applying the tax function specification to this sample leads to the result that 79% of the observed trend is not related to tax avoidance; applying the ETR function shows that 98% of the decline are unrelated to tax avoidance.

4.2.2 How much of the remaining residual can be explained by firm characteristics?

We next test how much of the unexplained variation in cash taxes paid, as captured by the residual from equation (16), can be explained by firm characteristics commonly shown to affect firms' tax planning. Table 7, Column (1) present results from estimating the regression of equation (21). The r-squared from this model is 0.75, indicating that observable firm characteristics explain 75% of the portion of cash taxes paid not related to the constant or pre-tax income in the linear model. Alternatively stated, the results indicate that 75% of the remaining trend and variation which is unrelated to changes in pre-tax income can be explained by common firm characteristics. The significant firm characteristics indicate that increase multinationality (MNE), size (PPE), special items (SPI), and net operation losses (NOL) decrease cash tax payments. Conversely, intangibility (ITAN), capital expenditures (CAPX) and advertising (XAD) increase cash tax payments.

4.3 Subsample Analyses

4.3.1 Results solely based on a>0 & a<0 firm-year obs.

In order to provide further results on our main hypotheses, we separate the individual 6,642 sample firm solely into firms with a positive intercept (a>0) and firms with a negative intercept (a<0). In doing so, we first regress tax function (16) separately for each of the 6,642 sample firms. The mean of the estimated firm-specific intercepts is 17.77 and the mean of the estimated marginal propensity to tax is 0.20. Out of the 6,642 sample firms, 4,533 (68%) have a positive intercept, 2,037 (31%), have a negative intercept, and 72 firms (1%) have an intercept of zero. This result indicates that only 1% of firms have proportional tax functions. The other 99% of firms have linear tax function. Thus, for the majority of firms levels of pre-tax income will affect the level of the Cash ETR. Untabulated results on the evolution of the mean ETR of the 1% of firms with an intercept of zero show – consistent with our hypotheses – no trend over time although the mean pre-tax income of those firms is increasing over time. This result is consistent with, our prediction that if a proportional tax function is descriptive, ETRs will not exhibit a time trend.

Next, in order to ensure that we only include firms with a growing pre-tax income into our analysis, we also estimate firm-specific regressions of the pre-tax income on a time trend variable:

$$PI_t = c + gTIME_t + v_t \quad (22)$$

where $TIME_t$ takes on the values 1, 2, 3, … 29 for the time period 1988-2016. We estimate equation (22) to identify whether the pre-tax income of a specific firm has an increasing ($g > 0$), a decreasing ($g < 0$), or no time-trend ($g \approx 0$) in the time-series of its pre-tax income over time. The mean estimated coefficient of g is 14.69.

Subsample A: tax function type I

In order to strengthen our results on H1, that is, firms with a positive and growing pre-tax income (g > 0) that, on average, have positive income independent cash tax payments, will have Cash ETRs that are decreasing over time and converge towards the MPT, we only include firm-year observations with a positive intercept, $a > 0$ that is significant at least at a 10% level from the firm-specific regressions of the linear tax functions. Further, we only include firms into this subsample that have a positive and significant growth coefficient g that is higher than the mean g of this subsample (high growth firms). Finally, we calculate the annual means for this subsample and estimate regression (16) and (17) for this subsample in order to obtain estimates for a and b.

The results are reported in Tables 3 and 4, Columns (3). Focusing solely on the subsample of firms with a significant positive intercept and above-average growth shows that the mean intercept equals 87.51 and 89.33 respectively, and thus is significantly higher than for the primary sample (7.67 and 11.36). The estimated marginal propensity to tax is only slightly lower and amounts to 0.19 for both the tax function and ETR function (as compared to 0.22 and 0.24 for the primary sample). Consistent with these results, the cumulative decrease of the mean Cash ETR is 14.59 percentage points (Tables 5 and 6, Columns (3)). Traditionally, this high decline in ETRs would be interpreted as increased tax avoidance over time. However, calculating how much of this decrease is simply driven by growth (Tables 5 and 6, Columns (3)) shows that 98 to 100% of this decrease is driven by growth of pre-tax income. Figure 10, Panel A illustrates this result. Figure 10, Panel A also shows that the results are also consistent with H1, that is, given a positive intercept and a growing pre-tax income, average ETRs will decline and converge from above towards the MPT of 0.19.

Subsample B: tax function type II

In order to test H2, that is, firms with a positive and growing pre-tax income (g > 0) with a negative intercept, reflecting, on average, income independent tax reductions, will exhibit Cash ETRs that are increasing over time and converging from below towards the MPT.

In this subsample, we only include firm-year observations with a negative intercept, $a < 0$, that is significant at least at a 10% level from the firm-specific regressions of the linear tax functions. Further, we only include firms in this subsample that have a positive and significant growth coefficient g that is higher than the mean g of this subsample (high growth firms). Finally, we calculate the annual means for this subsample and estimate regression (16) and (17) for this subsample in order to obtain estimates for a and b.

The results are reported in Tables 3 and 4, Columns (4). The regression results indicate that focusing solely on firms with a negative intercept leads to an average negative intercept of -41.97 to -21.34. These results indicate that the estimated marginal propensity to tax is 0.296 to 0.266 for these firms, which is higher than for firm-year observation with a positive intercept. Table 5 and 6, Columns (4) as well as Figure 10, Panel B show that the cumulative increase of the ETR amounts to 7.89 percentage points in this subsample. Thus, consistent with H2, our results show that if firms have a negative intercept and a positive and growing pre-tax income, average Cash ETRs will increase and converge from below to the MPT.

Increasing ETRs would traditionally not be interpreted as tax avoidance. Our analysis shows, however, that in order to assess a firm's increase/decrease in tax avoidance it is necessary to isolate the impact of growth in income on ETRs. Applying our two specifications, that is the tax function regression (equation 16) and the Cash ETR regression (equation 17), provides inconsistent results on this.

Using the tax function specification shows that the predicted increase in the average ETR simply due to growth in pre-tax income should have been 12.01 percentage points; the actual increase, however, was only 7.88 percentage points (Table 5, Column (4). Thus, difference of 4.13 percentage points can be interpreted as tax avoidance.

Using the Cash ETR specification, however, shows that the cumulative predicted ETR increase should have been 0.0612 percentage points. An actual cumulative increase of the Cash ETR of 0.0789 therefore indicates that only 78% of the observed increasing trend firms was attributable to growth. Thus, firms have forgone a cumulative tax planning benefits of 22% (1-0.78) during the sample period.

4.3.2 Results Multinationals vs. Domestics

The conventional wisdom is that multinational firms have more tax planning opportunities than purely domestic firms and therefore it is expected that multinationals should have lower effective tax rates than domestic firms. However, DHMT document that multinational firms, on average, have higher average Cash ETRs during their 25-year sample period than domestic firms.

We provide additional evidence related to this somewhat surprising result by performing aggregated regressions of the linear tax function and ETR function models on separate subsamples of multinational and purely domestic firms. Figure 11, Panel A illustrates the evolution of the annual means of cash taxes paid and pre-tax income separately for domestic and multinational corporations. Multinational corporations have a higher mean pre-tax income and pay higher raw amounts of taxes. Figure 11, Panel B shows a slightly different picture of the evolution of Cash ETRs for multinational and domestics as compared to DHMT, here domestic corporations have higher average ETRs. The decline for this period is however, larger for domestics. The differences shown in this figure from the DHMT findings arise because of a different calculation of mean Cash ETRs in our paper and the DHMT. While DHMT first compute ETRs on the firm-level and calculate the mean Cash ETR subsequently, we first calculate the mean of cash taxes paid and the mean of the pre-tax income, and then calculate the men Cash ETR by dividing the two values. The net effect of the two procedures is that DHMT obtain an equally weighted average (mean) value for cash ETRs whereas we obtain a weighted average mean value for cash ETRs. It is likely that low ETRs for some large multinational corporations are driving the difference in findings between our study and DHMT.

Our findings are consistent with the conjecture that, owing to the U.S. system of worldwide taxation with deferral and the high U.S. statutory rate during the sample period, multinational firms have greater opportunities for intertemporal income shifting. Consequently, we expect the intercept of the linear tax function, capturing the mean effect of cash tax reversals from prior periods in period t to be larger than the intercept of purely domestic firms. Results reported in Tables 3 and 4, Columns (5) and (6) provide consistent evidence with our conjecture. Domestic firm have a significantly lower intercept of 3.68 to 6.217 as compared to multinationals 15.34 to 20.61. The estimated marginal propensities to tax are only slightly higher for domestics (DOM: 0.225 to 0.246 vs. MNE: 0.212 to 0.228) indicating that domestic firm pay a slightly higher amount of cash taxes paid on the current re-tax income.

Calculating the cumulative decreases in Cash ETRs based on the tax function regression (Table 5, Columns (5) and (6)) shows that for domestic firms only 62% of the observed trend is attributable to income growth whereas for multinational firms 72% of the trend is attributable to growth in income. These results are consistent with 38% of the declining trend in Cash ETRs of domestics is attributable to tax avoidance whereas only 28% of the declining trend of MNEs is attributable tax avoidance. The results based on the Cash ETR do not show such differences. Finally, Figure 12, Panels A and B show results consistent with H1. Since both domestics and multinationals have a positive intercept and a positive and growing pre-tax income, average Cash ETRs decline and converge from above to their respective MPT.

V. Conclusion

Prior research documents a decreasing trend in Cash ETRs over the last 25 years (i.e., during the time period 1988-2012). Firm characteristics and declining foreign tax rates fail to explain this trend. We therefore aim to extend this literature and explain the decreasing trend based on the economic relation between average Cash ETRs and the marginal propensity to tax (MPT) inherent in linear tax functions in the presence of income growth. In particular, we show that to the extent that cash taxes paid are not proportionally related to pre-tax income but rather linearly, changes in Cash ETRs will be related to changes in pre-tax income and thus will be unrelated to firms' tax avoidance activities.

We illustrate that for US firms over our sample period (1988 – 2016) the intercept a is positive indicating that some portion of current cash taxes paid is unrelated to pre-tax income and thus that a linear rather than a proportional tax function is empirically descriptive. Given these conditions, Cash ETRs will change and decline over time as a result of growth in pre-tax income. Our main results show that 89% of the documented decline in Cash ETRs is driven by pre-tax income growth and thus is unrelated to firms' tax avoidance behavior. This fact explains why firm characteristics and decreasing foreign tax rates fail to explain the declining trend in Cash ETRs.

Due to the increasing disparty between the statutory tax rate and the continuous decline in effective tax rates, many have accused firms of not paying their fair share of taxes and have suggested that the U.S. tax system is broken. The main implication of our findings is that wholesale concerns regarding increasing tax avoidance over time are potentially overstated given the empirical evidence of a linear tax function and their inherent economic relation between average Cash ETRs and the MPT in the presence of growth in pre-tax income.

References

Atwood, T.J., Drake, M.S., Myers, J.N., Myers, L.A., 2012. Home Country Tax System Characteristics and Corporate Tax Avoidance: International Evidence. The Accounting Review 87, 1831-1860.

Desai, M.A., Dharmapala, D., 2006. Corporate Tax Avoidance and High-Powered Incentives. Journal of Financial Economics 79, 145-179.

Dyreng S.D., Hanlon, M., Maydew, E.L., 2008. Long-Run Corporate Tax Avoidance. The Accounting Review 83, 61-82.

Dyreng, S.D., Hanlon, M., Maydew, E.L., Thornock, J.R., 2017. Changes in Corporate Effective Tax Rates Over the Past 25 Years. Journal of Financial Economics 124, 441-463.

Dyreng, S.D., Lindsey, B.P. 2009. Using Financial Accounting Data to Examine the Effect of Foreign Operations Located in Tax Havens and Other Countries on U.S. Multinationl Firms' Tax Rates. Journal of Accounting Research 47(5), 1283-1316.

Edwards, A., Schwab, C., Shevlin, T., 2016. Financial Constraints and Cash Tax Savings. The Accounting Review 91, 859-881.

Graham, J.R., 1996. Debt and the Marginal Tax Rate. Journal of Financial Economics 41, 41-73.

Hanlon, M., Heitzman, S., 2010. A Review of Tax Research. Journal of Accounting and Economics 50, 127-178.

Hanlon, M., Slemrod, J., 2009. What Does Tax Aggressiveness Signal? Evidence from Stock Price Reactions to News about Tax Shelter Involvement. Journal of Public Economics 93, 126-141.

Hanna, C. H., 2009. The Real Value of Tax Deferral. Florida Law Review, 61(2), 203-247.

Helpman, E., Sadka, E., 1978. The Optimal Income Tax. Journal of Public Economics 9, 383-393.

Cooter, R. and Helpman, E., 1974. Optimal Income Taxation For Transfer Payments Under Different Social Welfare Criteria. The Quarterly Journal of Economics 88, 656-670.

Romer, T., 1975. Individual Welfare, Majority Voting, and the Properties of a Linear Income Tax. Journal of Public Economics 4, 163-185.

Scholes, M.S., Wolfson, M.A., Erickson, M.M., Hanlon, M.L., Maydew, E.L., Shevlin, T.J., 2015. Taxes & Business Strategy - A Planning Approach 5ed: Pearson.

Shevlin, T.J. and Porter, S. 1992. The Corporate Tax Comeback in 1987: Some Further Evidence. Journal of the American Taxation Association 14(1), 58-79.

Wilkie, P.J. 1988. Corporate Average Effective Tax Rates and Inferences about Relative Tax Preferences. The Journal of the American Taxation Association, 75-88.

Wilkie, P.J. and Limberg, S.T., 1990a. The relationship between firm size and effective tax rate: A reconciliation of Zimmerman [1983] and Porcano [1986]. Journal of the American Taxation Association 11, 76-91.

Wilkie, P.J. and Limberg, S.T., 1993. Measuring Explicit Tax (Dis)Advantage for Corporate Taxpayers: An Alternative to Average Effective Tax Rates. Journal of the American Taxation Association 15, 46-71.

Zimmerman, J.L., 1983. Taxes and Firm Size. Journal of Accounting and Economics 5, 119-149.

Appendix A: The anatomy of linear corporate tax functions

I. A general corporate tax function model

In this appendix we develop a general corporate tax function model to show under what economic circumstances average Cash ETRs are economically related to changes in pre-tax income and therefore should not be interpreted as tax avoidance.[10]

We start with the basic assumption that cash taxes paid ($TXPD$) equal the statutory tax rate (str) multiplied by the taxable income (TI):

$$TXPD_t = strTI_t \tag{A1}$$

Taxable income is defined as pre-tax income (PI), plus or minus total book-tax differences (BTD), where book-tax differences are all items (including NOLs) 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:

$$TI_t = PI_t - BTD_t \tag{A2}$$

Our key assumption is that to the extent book-tax differences are not proportionally related to the pre-tax income, ETRs can change simply because of changes in the pre-tax income and are not associated with tax avoidance. We first model the relation between book-tax differences and pre-tax income in the following general way:

$$BTD_t = f(PI_t) \tag{A3}$$

with more specificity it in the next section. Solving the three equations model above leads to the following general tax function:

$$TXPD_t = str\left(1 - \frac{BTD_t f(PI_t)}{PI_t}\right)PI_t \tag{A4}$$

Dividing the tax function (A4) by pre-tax income gives the following general Cash ETR function:

$$Cash\ ETR_t = \frac{TXPD_t}{PI_t} = str\left(1 - \frac{BTD_t f(PI_t)}{PI_t}\right) \tag{A5}$$

Both the cash taxes paid in (A4) and the Cash ETR in (A5) are functions of the statutory tax rate, book-tax differences, and pre-tax income. Taking the first partial derivative of the Cash ETR function gives:

$$\frac{\partial Cash\ ETR_t}{\partial PI_t} = -\frac{str}{PI_t} \times \frac{\partial BTD_t f(PI_t)}{\partial PI_t} + BTD_t(PI_t) \times \frac{str}{PI_t^2} \tag{A6}$$

Depending on the specification of equation (A3), that is, on how specifically book-tax differences are determined by pre-tax income, different associations between average Cash ETRs and pre-tax income can be derived based on equation (A6).

II. Book-Tax difference functions

In this subsection, we differentiate between three types of book-tax difference functions; our

[10] For simplicity, we ignore here tax credits (C_t) and cash taxes paid effects on earnings from a different period, stemming from IRS audits (A_t) completed in the current year. Inclusion of the two variables does not change the predictions derived in this appendix.

own hypothesized relation between book-tax differences and two from prior literature. We start with the presentation of our own specification which assumes that book-tax differences consist of two components, first, a current period's pre-tax income independent portion, θ_0, and a second portion that is directly associated with the magnitude of the pre-tax income, θ_1:

$$BTD_t = \theta_0 + \theta_1 PI_t \tag{A7}$$

The pre-tax income independent portion, θ_0, contains both pre-tax income independent book-tax differences in period t and reversing book-tax differences in t stemming from prior periods. The coefficient θ_1 is the proportionality coefficient that directly relates book-tax differences with the pre-tax income.

In contrast, prior literature, e.g. Dyreng and Lindsey (2009), implicitly assumes a purely proportional relation between book-tax differences and pre-tax book-income of the form:

$$BTD_t = \theta_1 PI_t \tag{A8}$$

This assumption ignores the fact that book-tax differences originating in prior periods may reverse in the current period ignoring U.S. GAAP interperiod tax allocation.

Lastly, Wilkie (1988) assumes book-tax differences to be fully independent of the current pre-tax income and constant over time. This assumption also seems to be restrictive because book-tax differences are likely to depend at least to some degree on the magnitude of current period pre-tax income.

$$BTD_t = \theta_0 \tag{A9}$$

III. Tax functions

Substitution of the three different book-tax differences tax functions (A7) to (A9) in equation (A3) and solving the model gives three different tax functions. Starting with our own specification gives the following linear tax function:

$$TXPD_t = -str\theta_0 + str(1 - \theta_1)PI_t \tag{A10}$$

Equation (A10) shows that allowing book-tax differences to consist of two components, an unrelated portion, θ_0, and a directly related portion, θ_1, creates an intercept and thus a linear tax function.

Ignoring the fact that book-tax differences may be reversing in the current period stemming from a prior period, leads to a proportional tax function:

$$TXPD_t = str(1 - \theta_1)PI_t \tag{A11}$$

Lastly, ignoring the fact that book-tax differences may depend on the magnitude of the current pre-tax income yields a tax function where the slope coefficient is restricted to correspond to the statutory tax rate:

$$TXPD_t = -str\theta_0 + strPI_t \tag{A12}$$

On the theoretical level our book-tax differences specification seems to be the most flexible. However, it remains an empirical question which specification is descriptive.

IV. ETR functions

Division of the tax functions (A10) to (A12) by the pre-tax income gives three corresponding ETR functions. Again, starting with our own specification gives:

$$\frac{TXPD_t}{PI_t} = \frac{-str\theta_0}{PI_t} + str(1-\theta_1) \tag{A13}$$

Division of the proportional tax function from Dyreng and Lindsey (2009) gives:

$$\frac{TXPD_t}{PI_t} = str(1-\theta_1) \tag{A14}$$

Finally, division of the tax function used in Wilkie (1988) gives:

$$\frac{TXPD_t}{PI_t} = \frac{-str\theta_0}{PI_t} + str \tag{A15}$$

Recalling our main prediction, that is, to the extent that book-tax differences are not purely proportionally related to the pre-tax income, ETRs can change simply because of changes in pre-tax income and are not associated with tax avoidance, we next formally show that only under the assumption of a purely proportional tax function (e.g. Dyreng and Lindsey (2009)) the average ETR will be unaffected by pre-tax income. In both other cases where the average ETR is not purely proportionally related to pre-tax income, the ETR will change simply because of changes in the pre-tax income. Such changes should not be interpreted as tax avoidance, showing that before one can infer whether a firms particular firm characteristic (such as leverage, size, R&D etc.) has led to a greater book-tax difference, it is necessary to control for changes in income.

V. Partial derivatives of average Cash ETRs with respect to pre-tax income

Taking the first derivative of the Cash ETR with respect to pre-tax income under consideration of the respective book-tax differences function shows whether the level of pre-tax income will affect the level of the Cash ETR. If the derivative is zero, changes in pre-tax income will not affect the ETR. If the first derivative is non-zero, changes in pre-tax income will affect the ETR.

If (A7) representing a linear *BTD* function as per this MS, is descriptive (A6) becomes:

$$\frac{\partial Cash\ ETR_t}{\partial PI_t} = -\frac{str}{PI_t}\times\theta_1 + (\theta_0 + \theta_1 PI_t)\times\frac{str}{PI_t^2} \tag{A16}$$

Solving (A16) gives:

$$\frac{\partial Cash\ ETR_t}{\partial PI_t} = \frac{\theta_0 str}{PI_t^2} \tag{A17}$$

If (A8), representing a purely proportional BTD function (Dyreng and Lindsey 2009), is descriptive (A6) becomes:

$$\frac{\partial Cash\ ETR_t}{\partial PI_t} = -\frac{str}{PI_t}\times\theta_1 + \theta_1 PI_t\times\frac{str}{PI_t^2} \tag{A18}$$

Solving (A18) gives:

$$\frac{\partial Cash\ ETR_t}{\partial PI_t} = -\frac{str\theta_1}{PI_t} + \frac{str\theta_1}{PI_t} = 0 \tag{A19}$$

If (A9), representing a constant BTD function (Wilkie 1988) is descriptive, (A6) becomes:

$$\frac{\partial Cash\,ETR_t}{\partial PI_t} = -\frac{str}{PI_t}\times 0 + \theta_0\times\frac{str}{PI_t^2} \tag{A20}$$

Solving (A20) gives:

$$\frac{\partial Cash\,ETR_t}{\partial PI_t} = \frac{\theta_0 str}{PI_t^2} \tag{A21}$$

Equations (A17), (A19), and (A21) show the effect of a one unit change in pre-tax income on the average Cash ETR. In both cases where book-tax differences are not purely proportionally related to pre-tax income the partial derivative is given by $\frac{\theta_0 str}{PI_t^2}$ showing that a change in pre-tax income will affect the ETR. Only in the case where book-tax differences are purely proportional to the pre-tax income, the partial derivative is zero showing that changes in pre-tax income will not affect the ETR. Thus, to the extent that book-tax differences and consequently corporate tax functions are not purely proportional to pre-tax income, changes in pre-tax income (as growth) will affect the ETR. Such changes in the ETR, however, should not be interpreted as tax avoidance.

Appendix B: Examples of Interperiod 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).[11]

Income dependent book-tax differences (i.e., θ_1),

Assuming that a corporation owns 2% of the stock of XYZ Corporation. During the period t, the corporation receives $10,000 of dividends from XYZ Corporation. The corporation includes the $10,000 of dividends in its pre-tax income and its taxable income. For tax purposes, the corporation is entitled to a 70% dividend-received deduction in computing its taxable income. In computing its pre-tax income, however, the corporation simply includes the entire amount of the dividend. This results in a permanent difference of $7,000 between the taxable income and pre-tax income. Formally, this US tax law settlement can also be expressed as: $TI = (1 - \theta_1)PI$ where θ_1 is the pre-tax income dependent relative book-tax difference of 0.7 leading to: $3000 = (1 - 0.7)10{,}000$.

Income independent book-tax differences (i.e., θ_0)

Assume a publicly held corporation pays its CEO a salary of $1.4 million in period t. The salary is not payable on a commission basis and is not performance-based compensation. The salary payment of $1.4 million is an expense on the corporation's income statement; however, 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 $400,000 difference between the $1.4 million expense on the income statement and the $1 million deduction on the tax return is 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., $\theta_0 = -400{,}000$). Alternatively stated. As operating income rises and falls from year to year, if the CEO is always paid $1.4 million, the non-deductible portion will not vary with income but will remain stable at $400,000.

Additionally, we note that the use of $NOLs$ in period t is very likely to be independent of pre-tax income in period's t, as they are primarily based on the level of losses reported in prior periods. $NOLs$ will therefore mainly be reflected in θ_0.

[11] These examples are based on those presented in Hanna (2009). See pages 213 and 214.

Appendix C: Variable Definitions[12]

PI	*PI* denotes the unscaled level of pre-tax income.
TXPD	*TXPD* denotes unscaled the level of cash taxes paid.
Cash ETR	The ratio of cash taxes paid to pre-tax income.
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 of if the absolute vale of the foreign tax expense (*TXFO*) is greater than zero.
AT, logAT	*AT* denotes the unscaled level of total assets. *logAT* denotes the natural logarithms of total assets.
XRD, xrd	*XRD* denotes the unscaled level of research and development expense. *xrd* denotes the amount of research and development expense scaled by the level of sales; if missing, it is set to zero.
PPE, ppe	*PPE* denotes the unscaled level of property, plant, and equipment. *ppe* denotes the ratio of net property, plant, and equipment to total assets.
INTAN, intan	*INTAN* denotes the level of intangible assets. *intan* denotes intangible assets scaled by the level of total assets.
DT, lev	*DT* denotes the unscaled level of total debt. *lev* denotes the leverage, i.e., the amount of total debt (*DLTT+DLC*) scaled by total assets.
CAPX, capx	*CAPX* denotes the unscaled level of capital expenditures. *capx* denotes the amount spent on capital assets scaled by net property, plant, and equipment.
XAD, xad	*XAD* denotes the unscaled level of advertising expense. *xad* denotes the ratio of advertising expense to the level of sales; if missing, it is set to zero.
SPI, spi	*SPI* denotes the unscaled level of special items. *spi* denotes the level of special items divided by to total assets; if missing, it is set to zero.
LSPI, Lspi	*LSPI* denotes the level of one period lagged special items. *Lspi* denotes one period lagged special items.
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*,	Δ*NOL* denotes the level of the change in net operating losses. Δ*nol* denotes the level of the change in net operating losses scaled by lagged total assets.

[12] Upper case letters denote the unscaled level of a respective variable or a binary variable. Lower case letter denote a scaled variable.

Table 1: Descriptive Statistics

Panel A: Primary Sample (1988-2016)

Variable	N	mean	sd	min	p25	p50	p75	max
PI	61,276	253.00	659.70	0.00	7.65	31.97	148.10	3826.00
TXPD	61,276	68.06	186.80	0.00	1.31	7.14	36.00	1116.00
CASH ETR	61,276	0.29	0.23	0.00	0.12	0.26	0.38	1.00
MNE	61,276	0.51	0.50	0.00	0.00	1.00	1.00	1.00
logAT	61,276	6.13	1.95	2.37	4.64	5.99	7.49	10.68
xrd	61,276	0.03	0.09	0.00	0.00	0.00	0.03	10.77
ppe	61,276	0.28	0.22	0.00	0.11	0.22	0.40	0.94
intan	61,276	0.14	0.18	0.00	0.00	0.07	0.22	0.74
lev	61,276	0.22	0.20	0.00	0.04	0.19	0.33	1.16
capx	61,276	0.26	0.18	0.00	0.14	0.21	0.34	1.03
xad	61,276	0.01	0.03	0.00	0.00	0.00	0.01	0.19
spi	61,276	0.00	0.02	-0.42	0.00	0.00	0.00	0.11
Lspi	61,276	-0.01	0.04	-0.37	-0.01	0.00	0.00	0.09
NOL	61,276	0.36	0.48	0.00	0.00	0.00	1.00	1.00
Δ*NOL*	61,276	0.00	0.10	-0.54	0.00	0.00	0.00	1.52

Panel B: Replication of the DHMT Sample (1988-2012)

Variable	N	mean	sd	min	p25	p50	p75	max
PI	53,818	220.00	604.10	0.00	6.91	27.52	122.90	3826.00
TXPD	53,818	59.49	171.40	0.00	1.17	6.21	30.42	1116.00
CASH ETR	53,818	0.29	0.23	0.00	0.12	0.27	0.39	1.00
MNE	53,818	0.49	0.50	0.00	0.00	0.00	1.00	1.00
logAT	53,818	5.98	1.90	2.37	4.53	5.83	7.28	10.68
xrd	53,818	0.03	0.09	0.00	0.00	0.00	0.03	10.77
ppe	53,818	0.29	0.22	0.00	0.11	0.23	0.40	0.94
intan	53,818	0.13	0.17	0.00	0.00	0.06	0.20	0.74
lev	53,818	0.21	0.20	0.00	0.04	0.19	0.33	1.16
capx	53,818	0.26	0.18	0.00	0.14	0.22	0.34	1.03
xad	53,818	0.01	0.03	0.00	0.00	0.00	0.01	0.19
spi	53,818	0.00	0.02	-0.42	0.00	0.00	0.00	0.11
Lspi	53,818	-0.01	0.04	-0.37	-0.01	0.00	0.00	0.09
NOL	53,818	0.32	0.47	0.00	0.00	0.00	1.00	1.00
Δ*NOL*	53,818	0.00	0.10	-0.54	0.00	0.00	0.00	1.52

This table presents summary statistics of the scaled variables for the primary sample and the replicated sample from DHMT. Panel A provides descriptive statistics of firm level observations for the primary sample. Panel B provides descriptive statistics of firm level observation for the replicated DHMT sample. Detailed variable definitions are provided in Appendix A.

Table 2: Descriptive Statistics

Panel A: Raw Variables Primary Sample (1988-2016)

Variable	N	mean	sd	min	p25	p50	p75	max
PI	61,276	253.00	659.70	0.00	7.65	31.97	148.10	3826.00
TXPD	61,276	68.06	186.80	0.00	1.31	7.14	36.00	1116.00
CASH ETR	61,276	0.29	0.23	0.00	0.12	0.26	0.38	1.00
MNE	61,276	0.51	0.50	0.00	0.00	1.00	1.00	1.00
AT	61,276	2929.00	7416.00	10.72	103.50	401.00	1782.00	43315.00
XRD	61,276	51.99	185.70	0.00	0.00	0.00	12.12	1156.00
PPE	61,276	867.70	2392.00	0.02	16.59	81.38	440.90	14395.00
INTAN	61,276	489.20	1430.00	0.00	0.28	20.50	212.30	8453.00
DT	61,276	739.20	1957.00	0.00	4.03	53.11	416.80	11566.00
CAPX	61,276	156.90	429.30	0.00	3.84	17.52	83.95	2625.00
XAD	61,276	21.35	75.94	0.00	0.00	0.00	1.89	435.00
SPI	61,276	-14.32	65.03	-480.80	-2.51	0.00	0.00	65.40
LSPI	61,276	-17.69	72.74	-490.00	-3.13	0.00	0.00	66.61
NOL	61,276	0.36	0.48	0.00	0.00	0.00	1.00	1.00
Δ*NOL*	61,276	5.42	64.73	-197.10	0.00	0.00	0.00	440.00

Panel B: Aggregated Raw Variables based on Primary Sample (1988-2016)

Variable	N	mean	sd	min	p25	p50	p75	max
PI	29	249.70	139.30	99.06	131.30	196.80	345.20	511.90
TXPD	29	67.69	33.78	33.18	40.92	52.07	88.89	135.30
CASH ETR	29	0.28	0.04	0.23	0.26	0.27	0.31	0.37
MNE	29	0.50	0.08	0.40	0.44	0.47	0.58	0.64
AT	29	2915.00	1708.00	1265.00	1421.00	2360.00	3618.00	6704.00
XRD	29	51.94	26.41	28.49	30.37	38.77	64.86	110.70
PPE	29	862.30	396.30	464.00	511.00	761.40	1019.00	1665.00
INTAN	29	486.30	412.60	82.27	126.40	354.40	718.30	1466.00
DT	29	743.30	449.30	340.00	380.60	618.10	847.70	1912.00
CAPX	29	155.60	67.31	84.00	103.70	134.30	194.00	291.80
XAD	29	21.54	6.21	11.28	18.51	21.19	24.47	36.77
SPI	29	-14.32	11.45	-41.97	-19.16	-11.10	-6.00	-1.16
LSPI	29	-17.61	13.04	-51.50	-23.18	-14.95	-8.51	-1.13
NOL	29	0.35	0.18	0.14	0.18	0.29	0.47	0.67
Δ*NOL*	29	5.15	5.07	-0.98	0.86	4.77	7.46	20.70

This table presents summary statistics of the raw variables for the primary sample. Panel A provides descriptive statistics of firm level observations for the primary sample. Panel B provides descriptive statistics of the 29 annual means for the primary sample. Detailed variable definitions are provided in Appendix A.

Table 3: Regression Results from Equation (16): $TXPD_t = a + bPI_t + \varepsilon_t$

VARIABLES	(1) TXPD	(2) TXPD	(3) TXPD	(4) TXPD	(5) TXPD	(6) TXPD
SAMPLE	(1988-2016)	(1988-2012)	a > 0	a < 0	DOM	MNE
PI (b)	0.240***	0.224***	0.192***	0.296***	0.246***	0.228***
	(38.79)	(31.53)	(28.80)	(34.21)	(26.07)	(28.73)
Constant (a)	7.668***	10.51***	87.51***	-41.97***	3.683***	15.34***
	(5.09)	(7.47)	(13.24)	(-5.87)	(3.45)	(5.17)
Observations	29	25	29	29	29	29
Adjusted R-squared	0.9837	0.9766	0.9603	0.9767	0.9829	0.9599

This table presents the results from estimating the annual means of cash taxes paid on the annual means of pre-tax income, i.e., estimating the tax function $TXPD = a + bPI_t + u_t$ from equation (16) for different subsamples. Column (1) presents the analysis using the primary sample, column (2) replicates the DHMT sample, column (3) restricts the sample to growth firms with positive intercepts from the estimated linear tax functions at the firm level, column (4) restricts the sample to growth firms with negative intercepts from the estimated linear tax functions at the firm level, column (5) restricts the sample to domestic only firms, and column (6) restricts the sample to US multinational firms. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Detailed variable definitions are provided in Appendix A.

Table 4: Regression Results from Equation (17): $\boldsymbol{CASH\ ETR_t = b + a\,1/PI_t + \varepsilon'_t}$

VARIABLES	(1) CASH ETR	(2) CASH ETR	(3) CASH ETR	(4) CASH ETR	(5) CASH ETR	(6) CASH ETR
SAMPLE	(1988-2016)	(1988-2012)	a > 0	a < 0	DOM	MNE
1/PI (a)	11.365***	13.074***	89.33***	-21.34***	6.217***	20.61***
	(9.48)	(9.85)	(15.69)	(-4.22)	(12.68)	(7.24)
Constant (b)	0.223***	0.210***	0.190***	0.266***	0.225***	0.212***
	(30.89)	(24.17)	(28.09)	(26.32)	(28.43)	(22.20)
Observations	29	25	29	29	29	29
Adjusted R-squared	0.7406	0.7857	0.87	0.32	0.83	0.60

This table presents the results from estimating the annual means of the Cash ETR on one over the annual means of pre-tax income, i.e., estimating the Cash ETR function $CASH\ ETR_t = b + a\,1/PI_t + u_t$ from equation (17) for different subsamples. Column (1) presents the analysis using the primary sample, column (2) replicates the DHMT sample, column (3) restricts the sample to growth firms with positive intercepts from the estimated ETR functions at the firm level, column (4) restricts the sample to growth firms with negative intercepts from the estimated ETR functions at the firm level, column (5) restricts the sample to domestic only firms, and column (6) restricts the sample to US multinational firms. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Detailed variable definitions are provided in Appendix A.

Table 5: Results from Regressions (18) $Cash\ ETR_t = \delta_0 + \delta_1 TIME_t$ and (20) $\widehat{Cash\ ETR}_t = \delta_0' + \delta_1' TIME_t$ based on the estimates of $\hat{a}$ and $\hat{b}$ from Tax Function Model (16)

	(1)		(2)		(3)		(4)		(5)		(6)	
SAMPLE	(1988-2016)		(1988-2012)		a > 0		a < 0		DOM		MNE	
VARIABLES	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT
Time	-0.0034***	-0.0024***	-0.0044***	-0.0035***	-0.00503***	-0.00495***	0.0027***	0.0041***	-0.0047***	-0.0029***	-0.0030***	-0.0022***
	(-7.22)	(-13.41)	(-8.32)	(-11.07)	(-11.23)	(-15.97)	(5.94)	(9.68)	(-7.56)	(-15.30)	(-6.50)	(-11.60)
Constant	0.336***	0.317***	0.345***	0.331***	0.372***	0.371***	0.190***	0.164***	0.364***	0.331***	0.326***	0.312***
	(39.83)	(90.09)	(42.30)	(59.09)	(41.77)	(65.46)	(21.18)	(18.71)	(35.93)	(88.51)	(38.41)	(82.67)
Obs.	29	29	25	25	29	29	29	29	29	29	29	29
Adj. R2	0.63	0.90	0.72	0.89	0.78	0.91	0.45	0.82	0.68	0.91	0.56	0.88
Cumulative Decrease	-0.0992	-0.0687	-0.1285	-0.1012	-0.14587	-0.14355	0.0788	0.1201	-0.13659	-0.08526	-0.08642	-0.06235
Ratio	0.69		0.79		0.98		1.52		0.62		0.72	

This table presents the results from estimating the mean Cash ETR and the predicted ETR (i.e., Cash ETR hat) on a time trend variable taking on the values 1, 2, … , 29 for the years 1988-2016: $Cash\ ETR_t = \delta_0 + \delta_1 TIME_t$ and $\widehat{Cash\ ETR}_t = \delta_0' + \delta_1' TIME_t$. Predicted ETRs are calculated as follows: $\widehat{Cash\ ETR}_t = \hat{a}/PI_t + \hat{b}$, where estimates of $\hat{a}$ and $\hat{b}$ are taken from Table (3), that is, from estimating the tax function $TXPD_t = a + bPI_t + u_t$ function. This table also summarizes the results of estimated annual decreases (increases) of predicted and actual mean Cash ETRs from Table 3 and presents the cumulative decreases (increases) of predicted and actual mean Cash ETRs over the sample period. The cumulative decreases (increases) are calculated by multiplying the annual decrease (increase) by either 29 or 25. Since the decrease (increase) of the predicted Cash ETR is solely driven by growth in pre-tax income, the ratio of the cumulative decrease (increase) of the predicted Cash ETR (i.e., Cash ETRs Hat) to the cumulative decrease (increase) of actual Cash ETRs indicates relatively how much of the documented decrease (increase) in the actual Cash ETR is related to growth in the pre-tax income. Column (1) presents the analysis using the primary sample, column (2) replicates the DHMT sample, column (3) restricts the sample to growth firms with positive intercepts from the estimated linear tax functions at the firm level, column (4) restricts the sample to growth firms with negative intercepts from the estimated linear tax functions at the firm level, column (5) restricts the sample to domestic only firms, and column (6) restricts the sample to US multinational firms. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Detailed variable definitions are provided in Appendix A.

Table 6: Results from Regressions (18) $Cash\ ETR_t = \delta_0 + \delta_1 TIME_t$ and (19) $\widehat{Cash\ ETR}_t = \delta_0' + \delta_1' TIME_t$ based on the estimates of $\hat{a}$ and $\hat{b}$ from Tax Function Model (17)

	(1)		(2)		(3)		(4)		(5)		(6)	
SAMPLE	(1988-2016)		(1988-2012)		a > 0		a < 0		DOM		MNE	
VARIABLES	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT	CASH ETR	CASH ETR HAT
Time	-0.0034***	-0.0035***	-0.0044***	-0.0043***	-0.00503***	-0.00505***	0.0027***	0.0021***	-0.0047***	-0.0050***	-0.00298***	-0.00289***
	(-7.22)	(-13.41)	(-8.32)	(-11.07)	(-11.23)	(-15.97)	(5.94)	(9.68)	(-7.56)	(-15.30)	(-6.50)	(-11.60)
Constant	0.336***	0.337***	0.345***	0.344***	0.372***	0.373***	0.190***	0.199***	0.364***	0.368***	0.326***	0.325***
	(39.83)	(64.59)	(42.30)	(49.31)	(41.77)	(64.42)	(21.18)	(44.80)	(35.93)	(58.29)	(38.41)	(63.97)
Obs.	29	29	25	25	29	29	29	29	29	29	29	29
Adj. R2	0.63	0.90	0.72	0.89	0.78	0.91	0.45	0.82	0.68	0.91	0.56	0.88
Cumulative Decrease	-0.0992	-0.1018	-0.1285	-0.1259	-0.14587	-0.14645	0.07888	0.06119	-0.13659	-0.14384	-0.08642	-0.08381
Ratio	1.03		0.98		1.00		0.78		1.05		0.97	

This table presents the results from estimating the mean Cash ETR and the predicted ETR (i.e., Cash ETR hat) on a time trend variable taking on the values 1, 2, … , 29 for the years 1988-2016: $Cash\ ETR_t = \delta_0 + \delta_1 TIME_t$ and $\widehat{Cash\ ETR}_t = \delta_0' + \delta_1' TIME_t$. Predicted ETRs are calculated as follows: $\widehat{Cash\ ETR}_t = \hat{a}/PI_t + \hat{b}$, where estimates of $\hat{a}$ and $\hat{b}$ are taken from Table (4), that is, from estimating the ETR function $CASH\ ETR_t = b + a\,1/PI_t + u_t$. This table also summarizes the results of estimated annual decreases (increases) of predicted and actual mean Cash ETRs from Table 4 and presents the cumulative decreases (increases) of predicted and actual mean Cash ETRs over the sample period. The cumulative decreases (increases) are calculated by multiplying the annual decrease (increase) by either 29 or 25. Since the decrease (increase) of the predicted Cash ETR is solely driven by growth in pre-tax income, the ratio of the cumulative decrease (increase) of the predicted Cash ETR (i.e., Cash ETRs Hat) to the cumulative decrease (increase) of actual Cash ETRs indicates relatively how much of the documented decrease (increase) in the actual Cash ETR is related to growth in the pre-tax income. Column (1) presents the analysis using the primary sample, column (2) replicates the DHMT sample, column (3) restricts the sample to growth firms with positive intercepts from the estimated linear tax functions at the firm level, column (4) restricts the sample to growth firms with negative intercepts from the estimated linear tax functions at the firm level, column (5) restricts the sample to domestic only firms, and column (6) restricts the sample to US multinational firms. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Detailed variable definitions are provided in Appendix A.

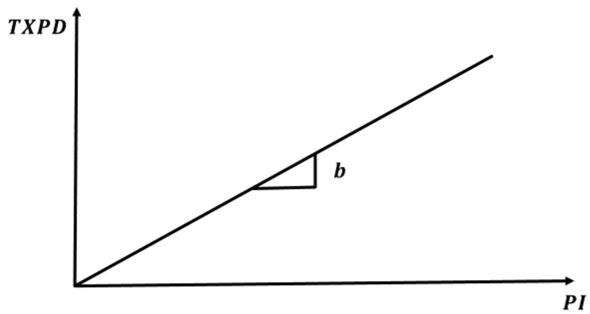
Table 7: Results from Equation (21)

VARIABLES	(1) RESID TXPD	(2) RESID TXPD	(3) RESID TXPD	(4) RESID TXPD	(5) RESID TXPD	(6) RESID TXPD
SAMPLE	(1988-2016)	(1988-2012)	a > 0	a < 0	DOM	MNE
MNE	-118.5**	-110.7**	141.1	5.257		
	(-2.80)	(-2.69)	(1.69)	(0.20)		
XRD	-0.171	-0.148	-0.119	-0.233	0.122	-0.0395
	(-0.93)	(-0.80)	(-0.56)	(-1.18)	(0.35)	(-0.20)
PPE	-0.0682***	-0.0687***	-0.0493**	-0.0990**	-0.0720**	-0.0733***
	(-3.94)	(-4.12)	(-2.39)	(-2.78)	(-2.19)	(-3.80)
INTAN	0.0603**	0.0618**	-0.0186	0.0291	0.0223	-0.00617
	(2.17)	(2.32)	(-1.34)	(1.39)	(0.76)	(-0.46)
DT	-0.0153	-0.0155	0.0203	0.0497***	0.0144	0.0170*
	(-0.91)	(-0.96)	(1.08)	(2.93)	(0.45)	(2.05)
CAPX	0.276***	0.293***	0.215***	0.153	0.182*	0.256***
	(4.82)	(5.33)	(3.09)	(1.30)	(1.93)	(4.51)
XAD	0.443***	0.441***	0.543*	-0.304	0.673*	0.565***
	(3.15)	(3.21)	(1.99)	(-1.45)	(1.73)	(3.06)
SPI	-0.312*	-0.281*	-0.363	-0.257	-0.456	-0.365**
	(-2.09)	(-1.89)	(-1.72)	(-1.59)	(-0.98)	(-2.13)
dNOL	-0.322*	-0.318**	-0.0254	0.584**	0.194	-0.225
	(-2.06)	(-2.11)	(-0.08)	(2.56)	(0.60)	(-1.35)
Constant	53.89**	46.96**	-132.4*	39.50*	0.368	-4.433
	(2.57)	(2.31)	(-1.95)	(1.79)	(0.11)	(-0.53)
Observations	29	29	29	29	29	29
Adjusted R-squared	0.75	0.82	0.38	0.52	0.47	0.71

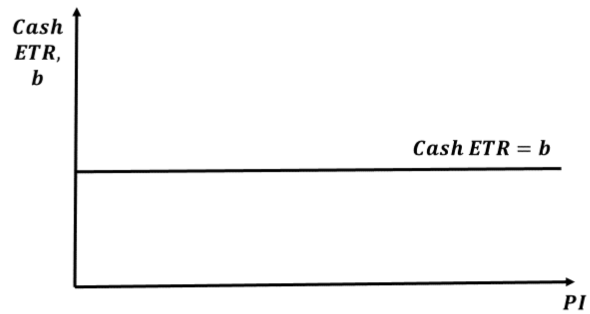
This Table presents regression results from equation (21): $\varepsilon_t = \beta_0 + \beta_1 MNE_t + \beta_2 XRD_t + \beta_3 PPE_t + \beta_4 INTAN_t + \beta_5 DT_t + \beta_6 CAPX_t + \beta_7 XAD_t + \beta_8 SPI_t + \beta_9 \Delta NOL_t + \pi_t$. RESID TXPD denotes ε_t. Column (1) presents the analysis using the primary sample, column (2) replicates the DHMT sample, column (3) restricts the sample to growth firms with positive intercepts from the estimated linear tax functions at the firm level, column (4) restricts the sample to growth firms with negative intercepts from the estimated linear tax functions at the firm level, column (5) restricts the sample to domestic only firms, and column (6) restricts the sample to US multinational firms. Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Detailed variable definitions are provided in Appendix A.

Figure 1: The Relation between Corporate Tax Functions and Tax Avoidance

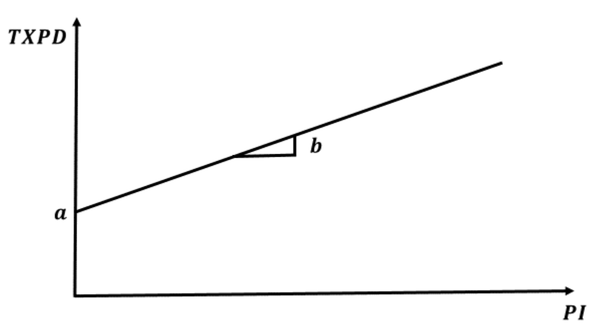
1(A) Proportional Tax Function: No Tax Avoidance



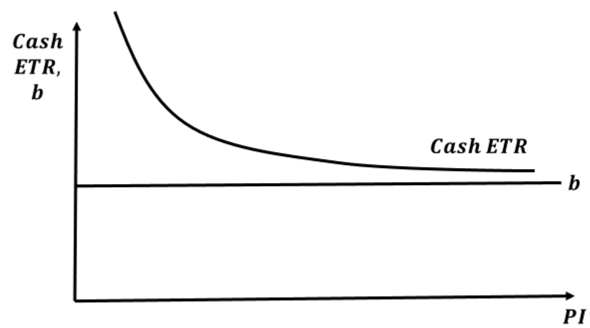
1(B) Proportional Tax Function: No Tax Avoidance



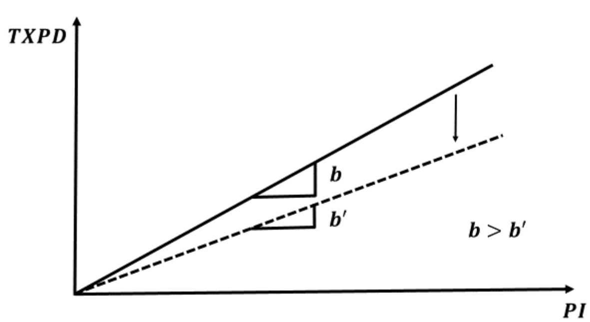
1(C) Linear Tax Function: No Tax Avoidance



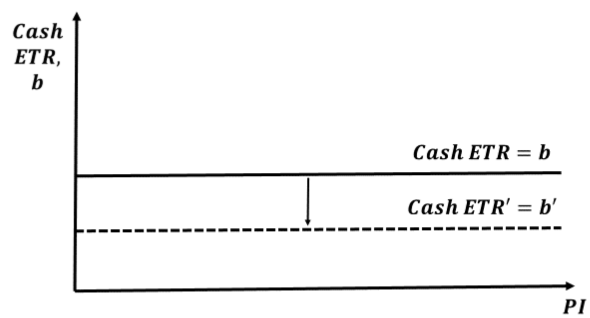
1(D) Linear Tax Function: No Tax Avoidance



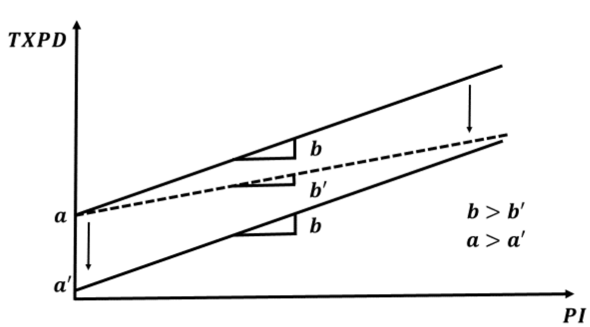
1(E) Proportional Tax Function: With Tax Avoidance



1(F) Proportional Tax Function: With Tax Avoidance



1(G) Linear Tax Function: With Tax Avoidance



1(H) Linear Tax Function: With Tax Avoidance

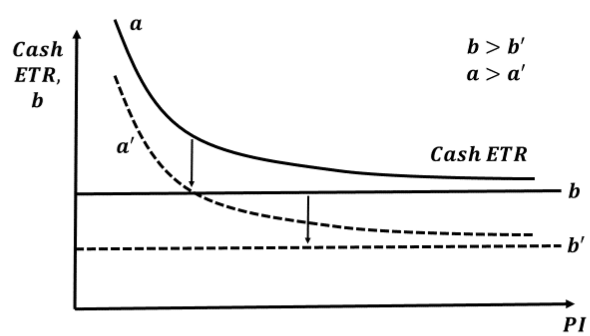
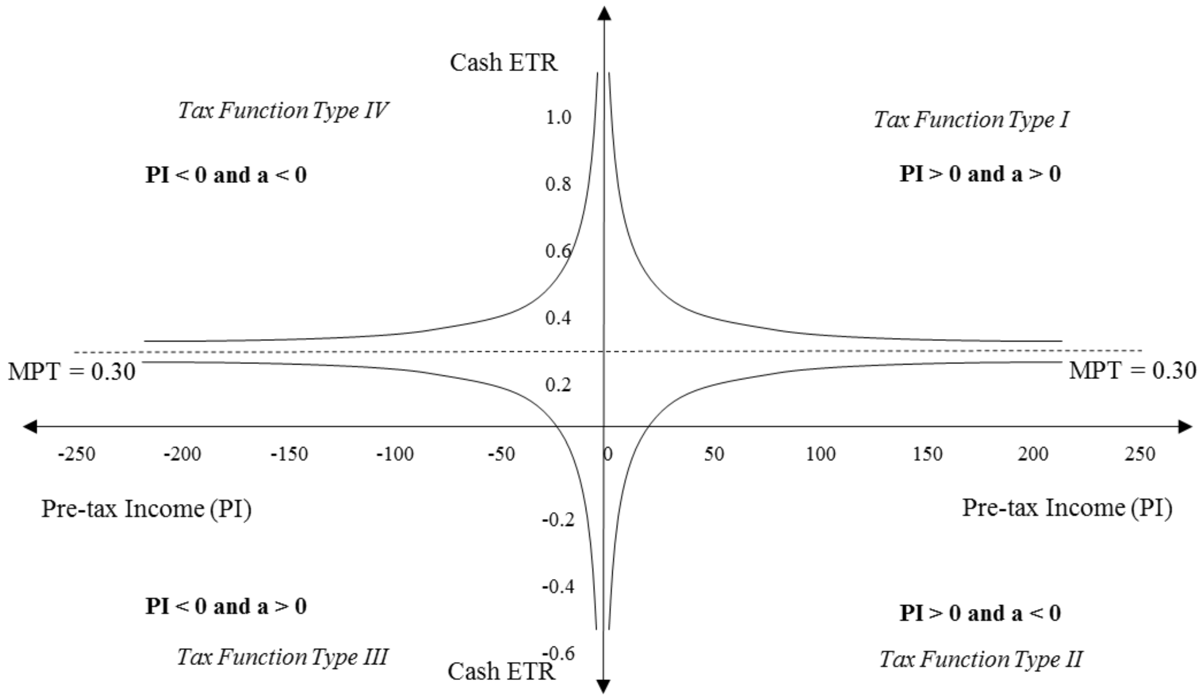


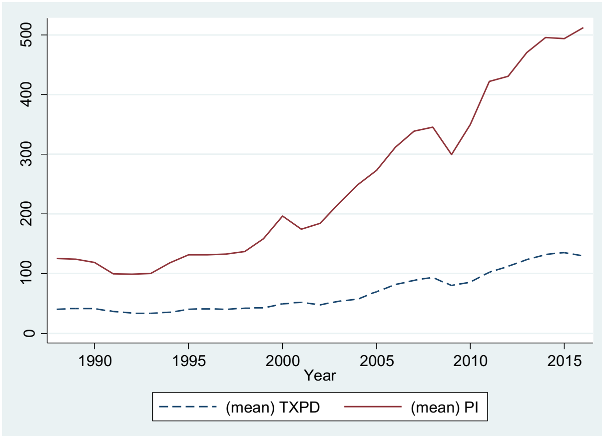
Figure 2: Associations between average Cash ETRs and the marginal propensity to tax (MPT) for tax function types I to IV



This figure illustrates the relations between the magnitudes of Cash ETRs and the marginal propensity to tax (MPT=0.30) as a function of a and PI_t, i.e.: $Cash\ ETR_t = \frac{TXPD_t}{PI_t} = \frac{a}{PI_t} + b$ for the following four types of tax functions: *Type I*: $PI_t > 0$ and $a > 0$; *Type II*: $PI_t > 0$ and $a < 0$; *Type III*: $PI_t < 0$ and $a > 0$; *Type IV*: $PI_t < 0$ and $a < 0$.

Figure 3: Evolution over Time, Pre-Tax Income, Cash Taxes Paid, and Cash ETR

A: Pre-Tax Income and Cash Taxes Paid



B: Cash ETR

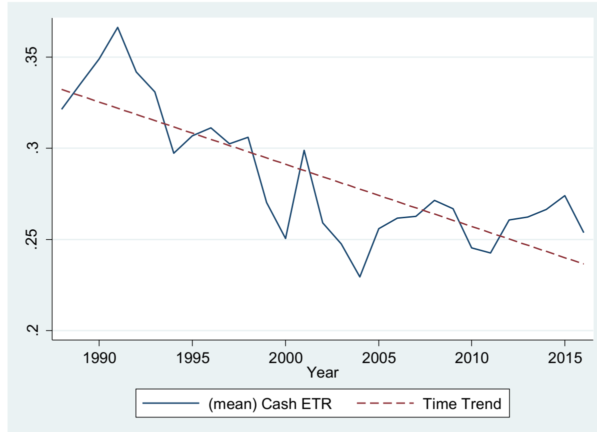
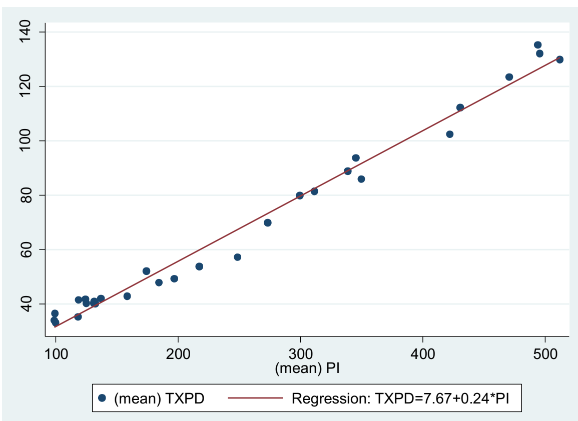


Figure 4: Scatter Diagrams

A: Cash Taxes Paid and Pre-Tax Income



B: Cash ETR and 1/ Pre-Tax Income

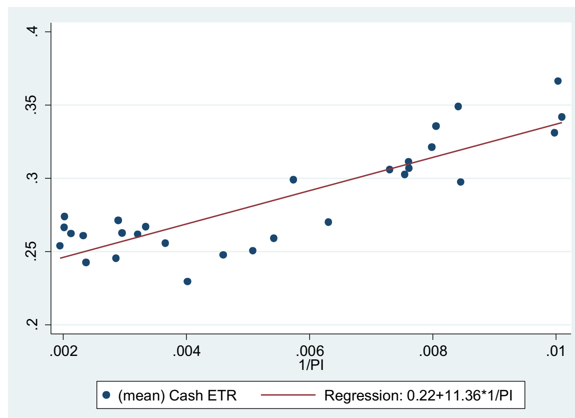
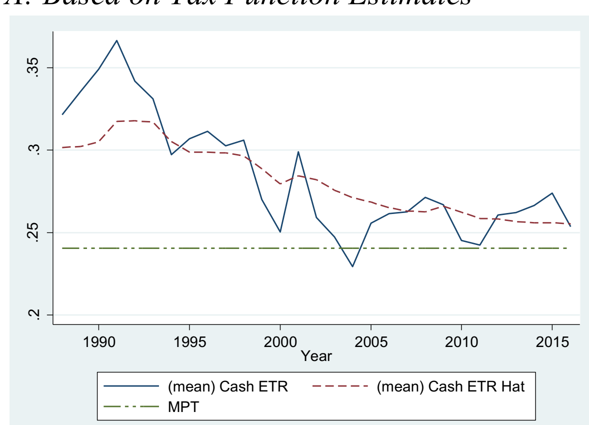


Figure 5: Associations between Cash ETR, Cash ETR Hat, and MPT

A: Based on Tax Function Estimates



B: Based on Cash ETR Function Estimates

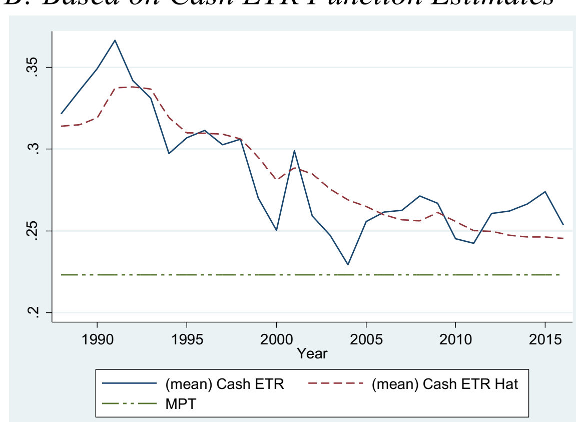


Figure 6: Residuals from Regressions (16) and (17)

A: Evolution of the Residual ε_t over Time *B: Evolution of the Residual ε'_t over Time*

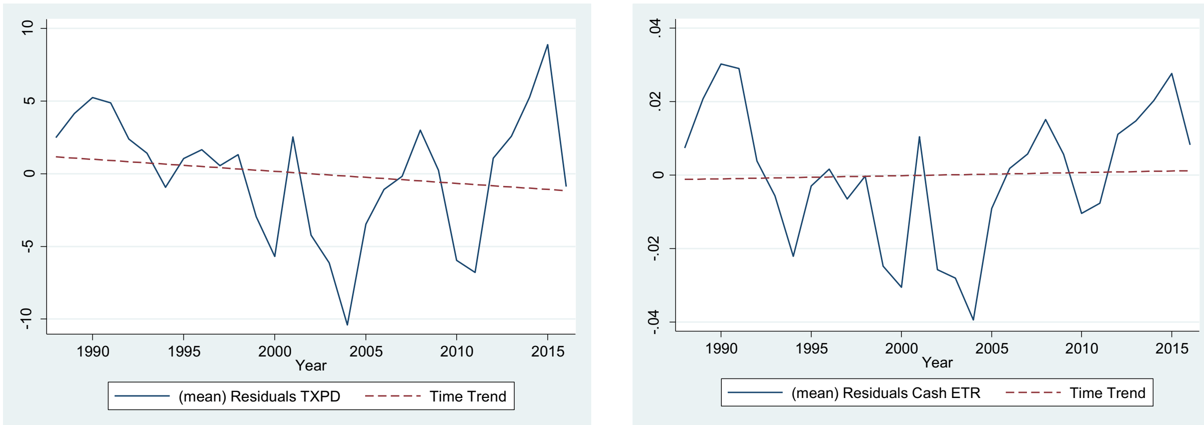


Figure 7: How much of the trend is related to growth in PI? (1988-2016)

A: Based on Tax Function Estimates *B: Based on Cash ETR Function Estimates*

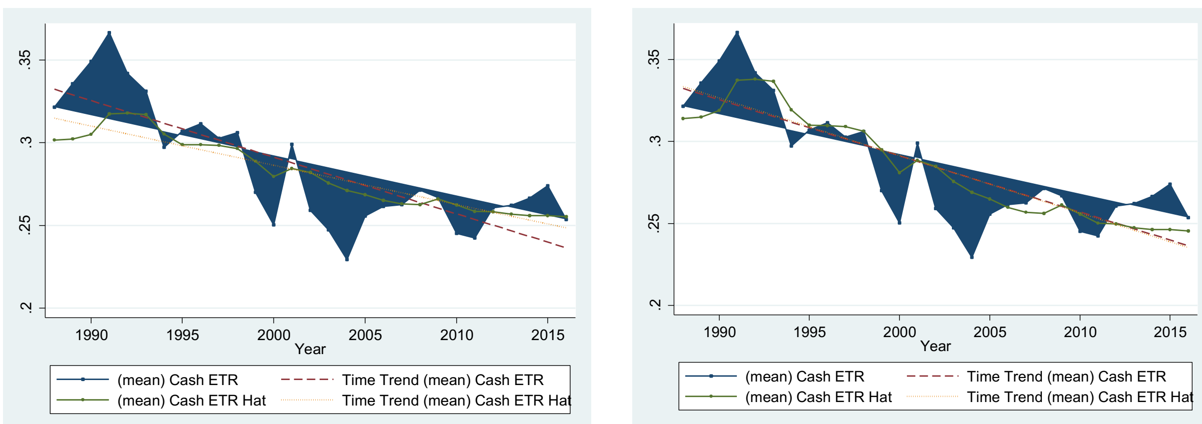


Figure 8: How much of the trend is related to growth in PI? (1988-2012)

A: Based on Tax Function Estimates *B: Based on Cash ETR Function Estimates*

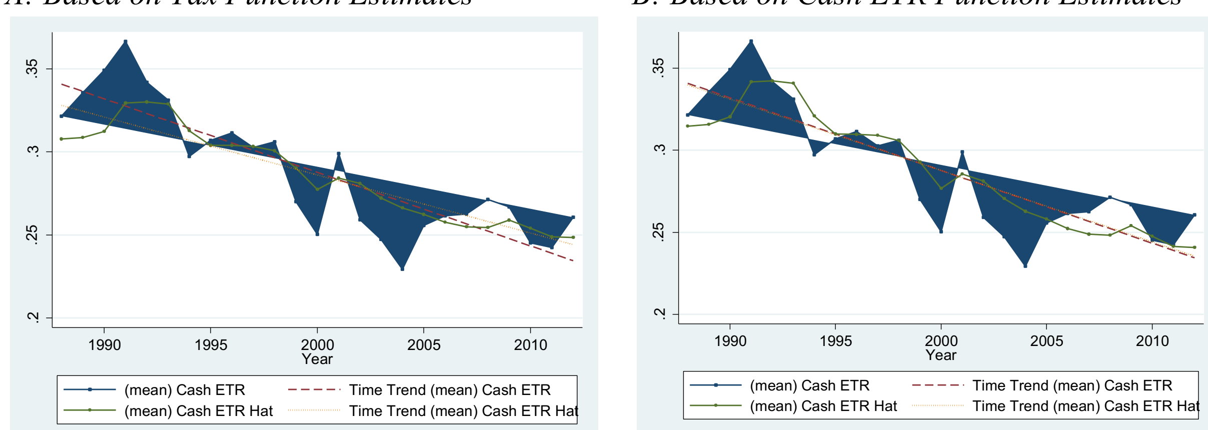


Figure 9: How much of Residual in Model (21) can be explained by firm characteristics?

A: Actual and fitted Values of ε_t *B: Evolution of the Residual π_t over Time*

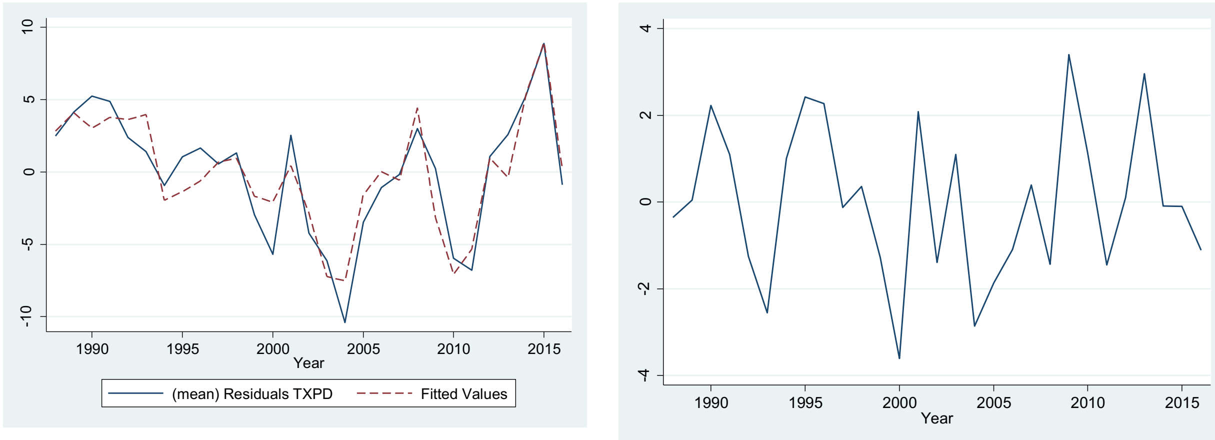


Figure 10: Results from Model (16) for the Subsamples $a > 0$ and $a < 0$

A: Subsample a > 0 *B: Subsample a < 0*

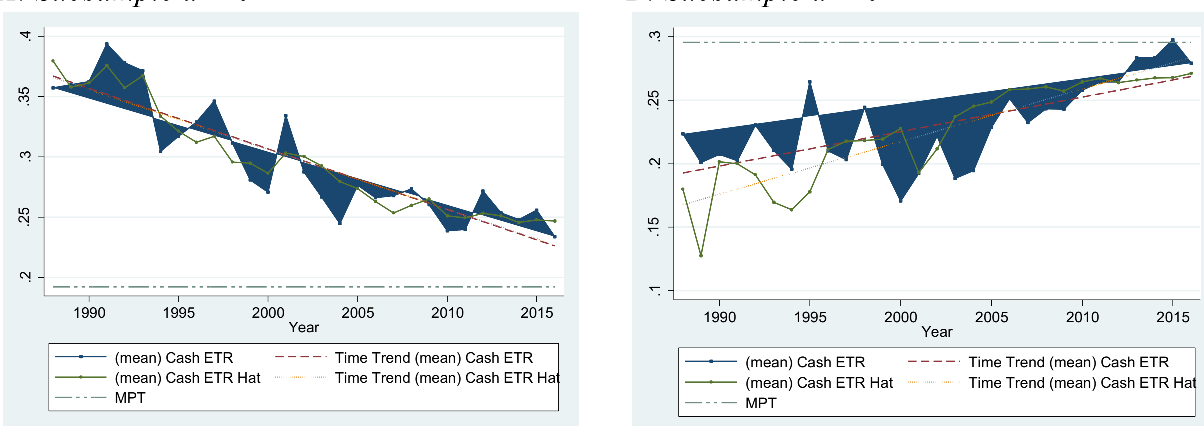


Figure 11: Evolution over Time, Pre-Tax Income, Cash Taxes Paid, and Cash ETR for Domestics and Multinationals

A: Pre-Tax Income and Cash Taxes Paid *B: Cash ETR*

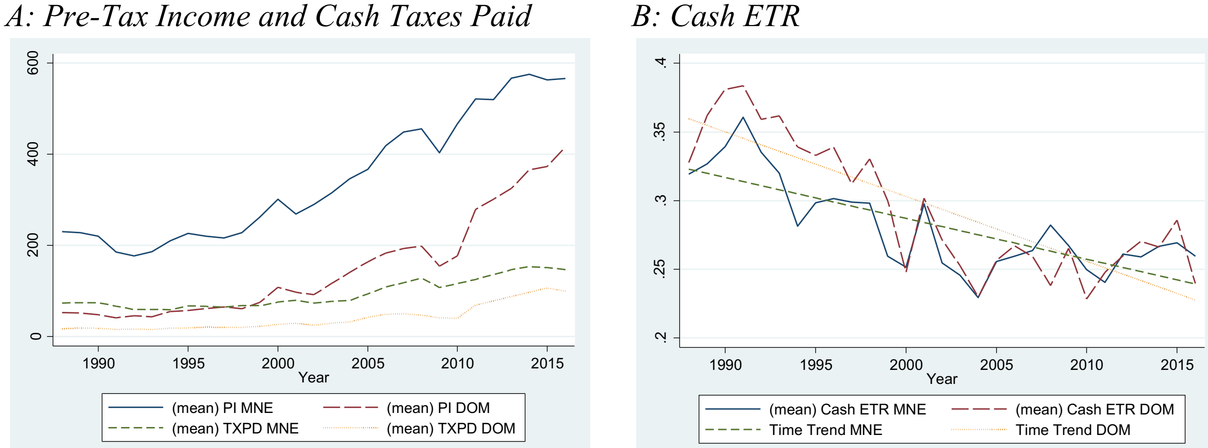
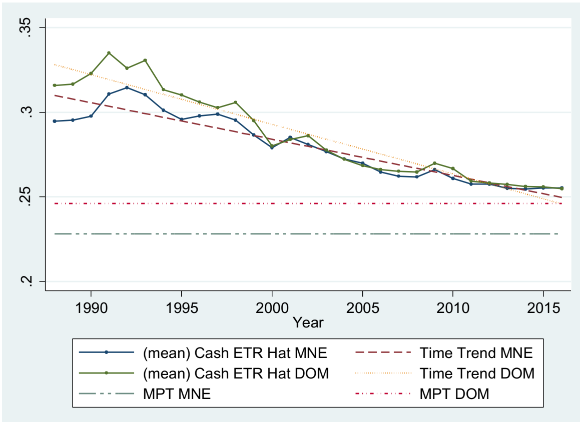


Figure 12: Results from Model (16) for the Subsamples DOM and MNE

A: Predicted Cash ETR Trends DOM vs MNE



B: Residual Cash ETRs DOM vs MNE