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# Corporate Tax Incentives and Capital Structure: Empirical Evidence from UK Tax Returns

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**ABSTRACT**

This paper examines how companies' capital structure is affected by the corporate income tax system. Our analysis employs confidential company-level corporation tax return data in the UK. Our main identification strategy is based on variation in companies' marginal tax rates due to the existence of kinks in the corporate tax rate schedule. Using a dynamic adjustment model of capital structure, we find a positive and substantial long-run tax effect on companies' financial leverage. We show that there are considerable discrepancies between estimates of taxable profits reported in tax return data and in financial statements and that the estimated tax effect on capital structure using financial statements is likely to be biased downward. We find that companies adjust their capital structures gradually in response to changes in the marginal tax rate. Moreover, we find that the external leverage of domestic stand-alone companies and of multinational companies responds strongly to corporate tax incentives.

**JEL category**: G3, H2
**Key words**: Corporate taxation, capital structure, tax returns

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Corporation taxes typically permit to deduct interest payments but not the opportunity cost of equity finance. They therefore create an incentive to using debt, rather than equity, finance. The potential costs of using excessive debt became more apparent in the recent financial crisis and equalising the tax treatment of debt and equity has been the subject of numerous tax proposals (see, for example, Mirrlees et al., 2011). Although theories of capital structure predict tax effects to be of first-order importance, researchers have found it difficult to identify clear effects of taxation on the choice between debt and equity finance.[2] Previous empirical research has however faced the difficulty in identifying with any precision the variation across companies in the marginal tax rate that they face, and it has typically found rather small effects of taxation on capital structure.[3]

This paper examines how companies' capital structures are affected by the corporate income tax system using confidential corporation tax return data for a panel of UK companies. These data allow us to measure precisely the tax incentives faced by companies with different tax status, and hence to make two related important innovations to reduce measurement error relative to the previous literature.

Our first key contribution to reducing measurement error is the use of corporate tax returns. The previous literature has largely relied for information about taxation on accounting financial statements, rather than tax returns. For a number of legitimate reasons there are both temporary and permanent differences between the tax charge in a profit and loss statement and the current tax liability of the company. We find a substantial proportion of companies either "over-report" or "under-report" their taxable income in the financial statements relative to their actual tax liability. Compounding the problem of using financial statements, the previous literature has largely used data from the consolidated accounts of large companies. To the extent to which companies borrow in different countries, their aggregate borrowing should depend on tax rates in those different countries, rather than simply the tax rate in the country of the parent company. By contrast, we exploit unconsolidated data of individual UK

[2] Myers (1984) challenges researchers to show that capital structure is affected by taxes as the trade-off theory predicts. Graham (2003) points out that, notwithstanding the increasing evidence after Myers (1984) for the existence of tax effects on capital structure, it would still be helpful to investigate whether these tax effects are economically important.

[3] For example, Graham (1996a) finds a positive correlation between the simulated marginal tax rate and incremental changes in debt, although the point estimate is rather small, at around only 0.07. Graham et al. (1998) estimates directly the relationship between the simulated marginal tax rate and the leverage ratio and finds a positive, although small effect on leverage - again, around 0.07.

companies – on taxation from tax returns and on other variables from unconsolidated financial accounts.

We are aware of only three papers that use tax return data to examine the impact of taxation on capital structure. Two of these - Gordon and Lee (2001) and Dwenger and Stainer (2014) – use data aggregated over companies.[4] Both studies find positive, though again small, effects of the tax rate on capital structure. Gordon and Lee (2001) follow a similar approach to that used in this paper, exploiting the fact that in the US small companies have faced different tax rates than larger companies. For example, during the late 1970s, the corporate tax rate was 22% on the first $50,000 of income, but 46% on any additional income. However, the aggregated nature of these studies may hide important heterogeneities across companies. In contrast, the company-level data used in this paper allows us not only to observe more accurately each company's tax status but also to control for important company-level non-tax characteristics that are likely to affect companies' financing decisions.

The only other study that has attempted to use company-level tax return data to estimate the tax effect on capital structure is Graham and Mills (2008). The authors simulated the effective marginal tax rate separately using tax return data and financial statements, for a sample of US public companies during the period 1998-2000. Their identification relies on cross-section variation in the simulated marginal tax rate due to the asymmetric tax treatment between profit and loss. The approach using the simulated marginal tax rate based on financial statements generates a larger and more significant point estimate than using tax returns. However, the comparison between the two types of accounts could be problematic because the tax return data and the financial statement data use different consolidation rules. As recognized by the authors, US companies in their sample typically include all controlled domestic and foreign entities in their financial statements. In contrast, for tax purposes, a U.S. parent corporation can elect to file a consolidated tax return that includes net income or loss only from all its domestic subsidiaries plus repatriations of profits from the foreign subsidiaries. Due to the difference in the consolidation rules, the authors acknowledge that the two simulated marginal tax rates may not be directly comparable. The authors also recognize that it may not be appropriate to match the simulated marginal tax rate based the

[4] Tax return data in these studies are aggregated according to firms' asset sizes or their industries and locations of headquarters.

tax return filed in the US with the company's worldwide leverage ratio, if the company operates in different tax jurisdictions.

Our second innovation is that, as our main identification strategy, we exploit kinks in the corporation tax rate schedule in the UK - where there are jumps in the marginal tax rate - to estimate the effects of corporate taxation on capital structure. Kinks in the marginal tax rate schedule are significant. For example, at the £300,000 kink in the tax rate schedule, the marginal tax rate has typically jumped by 12 to 13 percentage points. There is therefore a considerably higher incentive to use debt finance for companies above, compared to below, the kink. Due to the existence of these kinks, we can accurately exploit cross-section as well as time-series variation in the marginal tax rate facing a company in each period. Time series variation arises partly because there have been a number of reforms to the tax rate schedule. In addition, conditional on the tax rate schedule, as the taxable profit of a company changes over time then it may find itself in a different tax bracket and therefore facing a different marginal tax rate.

Previous studies have instead primarily focused on variation in the marginal tax rate arising from the asymmetric treatment of losses.[5] We also follow this approach as a second identification strategy and to compare our results with the previous literature. A marginal increase in the interest cost of a loss-making company does not typically have an immediate impact on tax liabilities, but instead increases the tax loss carried forward to set against profit in subsequent periods. Cross-section variation in the "effective" marginal tax rate is therefore introduced and it depends on how long the company expects to reach a positive taxable profit. There have been a number of attempts to estimate such effective tax rates, the best-known being Graham (1996a).[6] Any methodology to identify the effective tax rate of loss-making companies, however, requires assumptions about the distribution of a company's taxable income. For example, Graham (1996a, 1996b) and Graham et al. (1998) assume that the level

[5] A different approach in the empirical literature has instead relied for identification on variation in the statutory corporate income tax rate across countries (see, for example, Rajan and Zingales, 1995, and Faccio and Xu, 2013). While the statutory corporate income tax rate has varied little over time in some countries such as the US, it does differ substantially across countries. However, a potential drawback of such an approach is that the statutory top marginal corporate income tax rate may be a poor proxy for the true corporation tax incentives faced by companies. For example, the top statutory marginal corporate income tax rate does not take into account the existence of kinks in the tax rate schedule or incorporate specific provisions of the tax code, such as loss carry forwards.

[6] See also the earlier studies that exploit cross-section variation in marginal tax rates due to losses (Shevlin, 1987, 1990; Devereux, 1989; Devereux et al., 1994; and Altshuler and Auerbach, 1990).

of a company's future taxable income follows a random walk. However, recent studies (for example, Blouin et al., 2010) have shown that this assumption may bias upward the simulated effective marginal tax rate.

Apart from making use of more precise measures of the corporation tax rate, we make two other important innovations relative to the previous literature. First, we apply panel data estimation techniques to control for company-level fixed effects, which are found by Lemmon et al. (2008) to be important in explaining companies' capital structure. Further, in contrast to most previous studies which estimate the tax effects on capital structure based on a static model (for example, Graham 1996a; and Faccio and Xu, 2013), we estimate a dynamic adjustment model that allows companies to gradually adjust their leverage ratio towards the optimal.[7] This allows us to investigate not only how large are the long term effects of corporation tax on leverage, but also the speed of adjustment.[8] For comparison with the previous literature, we also present results using a static model.

Second, we investigate heterogeneity between UK stand-alone companies and UK companies that are part of a multinational group. In our main analysis we use the combination of internal and external debt of a company, based on the unconsolidated company-level financial statements. However, since a multinational may use internal debt to shift profit to low-taxed jurisdictions, then for the purposes of comparison with domestic companies – and to identify only debt that affects default risk - we analyse only external debt in this separate exercise. We are not aware of any previous study that has compared the sensitivity of external debt to tax incentives between domestic and multinational firms. This exercise is also necessary to compare our results with previous work that focuses on the external leverage ratio of the company, based on consolidated financial statements.[9]

[7] This approach is based on studies of capital structure that estimate the speed of adjustment as a test between the trade-off theory and the pecking order theory since the trade-off theory, but not the pecking order theory, predicts that leverage should be mean-reverting (see, Fama and French, 2002, Flanery and Rangan, 2006, and Lemmon et al., 2008).

[8] Although this approach has been adopted to examine the tax effects on banks recently (Keen and de Mooij, 2015), to our knowledge, we are not aware of any study using this approach to estimate the tax effects on non-financial firms.

[9] Empirical studies based on firms' consolidated financial statements from data sources like Compustat and Datastream would estimate the effects of corporate tax incentives on firms' overall external leverage. This approach would create a potential measurement error as multinationals may be able to undertake external borrowing in many jurisdictions and hence, they may respond to the tax rate in the location in which they borrow rather than the tax rate in the country of the parent company.

Our results suggest a much larger impact of taxation on leverage than is found in the previous literature. In our main specification with identification coming from kinks in the marginal tax rate schedule, we find large, positive and highly significant effects of taxation. In the long run we estimate that a one percentage point rise in the corporation tax rate would increase the leverage ratio by around 1 percentage point (our central estimates range from 0.76 to 1.40, depending in the instruments used). In these estimates we find that firms close about 24% of the gap between their actual leverage ratio and the targeted level each year, similar to the estimated adjustment speed found in Lemmon et al. (2008).

We undertake four exercises to compare our results with the previous literature. First, we find similar effects when we also allow for variation in marginal tax rates due to the asymmetric treatment of losses (where estimates of the long-run effect of a one percentage point rise in the tax rate are 0.98 and 1.12 percentage points). Second, we re-estimate our model based on estimates of the marginal tax rate derived from financial statements. Here we find that the model performs much better using the tax return data. This strongly suggests that companies respond to real tax liabilities rather than charges in accounting statements, contrary to the previous evidence of Graham and Mills (2008). Third, we estimate a static model, similar to that used in most of the literature. Here we continue to find positive effects of taxation, though rather smaller than in the dynamic model. Fourth, we estimate the effects of taxation on external debt separately for domestic stand-alone companies and companies that are part of multinational groups. We present some evidence that the external debt of multinationals is less sensitive to taxation, perhaps because multinationals have the opportunity to borrow elsewhere and use internal debt to allocate funds within the group.[10]

The rest of the paper is structured as follows. Section I describes our identification strategies in more detail. Section II describes the data and sample selection. Section III reports our benchmark estimation results. Section IV presents various extensions described above which serve as a comparison to the previous literature. Section V concludes.

[10] For example, Desai et al. (2004) point out that multinational firms employ internal capital markets opportunistically to overcome imperfections in external capital markets.

# I. Identification strategies

Our main identification strategy relies on the fact that there are a number of kinks in the corporation tax rate schedule in the UK during the fiscal years 2001/2002-2009/2010. Table I reports the statutory marginal tax rate associated with each bracket of taxable profit during this period. Figure 1 illustrates the marginal tax rate schedule graphically. Figure 1 shows some substantial jumps in the statutory marginal tax rate, for example at the £300,000 threshold for taxable profit. Another significant kink arises due to the zero starting rate for companies with less than £10,000 taxable profits in place between fiscal year 2002/2003 and 2005/2006. Our main identification strategy for the tax effect on leverage ratio relies on the fact that companies face different incentives to use debt finance depending on the tax bracket and hence marginal tax rate. If a company changes tax bracket and the benefits of adjusting the leverage ratio outweigh the associated costs, this company would have an incentive to adjust its leverage ratio according to the trade-off theory. As noted above, our identification strategy is in the spirit of Gordon and Lee (2001).[11]

To carry out our main identification strategy, we construct a sample of companies that report only positive taxable profits in the tax returns (Sample I). The purpose of this selection is to avoid measurement error in companies' effective marginal tax rates which is likely to arise if loss-making company-year observations are included, where the relevant tax measure depends on companies' perception of the distribution of their future taxable profits (Shevlin, 1987, 1990; Graham1996a; and Graham et al.,1998). Given access to tax return data, we obtain identification largely free of measurement error for companies with positive taxable profit.[12]

As recognized by previous studies (Graham et al., 1998; and Gordon and Lee, 2001), the marginal tax rate calculated using taxable profits after interest deduction may suffer from endogeneity problems. This is because a company with higher leverage would tend to have higher interest payments and hence lower after-financing taxable profits, mechanically

[11] It is possible in principle that the corporation tax gains to greater use of debt are outweighed to some extent by the taxation of the interest received by the lender (Miller, 1977). However, if we assume that the variation in corporation tax rates is uncorrelated with variation in tax rates of the lenders, then our empirical strategy remains valid.

[12] A potential selection problem arises from this strategy as profit-making firms may differ from firms that experienced losses. To examine this issue, we compare the observed firm-level characteristics between Sample I and a larger sample with loss-making firm-year observations (Sample II) in Section II.A.

implying that the leverage ratio is negatively correlated with the after-financing marginal tax rate. Moreover, with the presence of kinks in the tax rate schedule, companies could be induced to use more debt to shift into the tax bracket with a lower tax rate. To deal with such endogeneity of the after-financing marginal tax rate, researchers (such as Graham et al., 1998; and Gordon and Lee, 2001) have used a "before-financing" marginal tax rate based on companies' taxable profits before deducting interest expenses as an instrument. We adopt this convention, constructing the before-financing marginal tax rate as an instrument for the after-financing marginal tax rate.

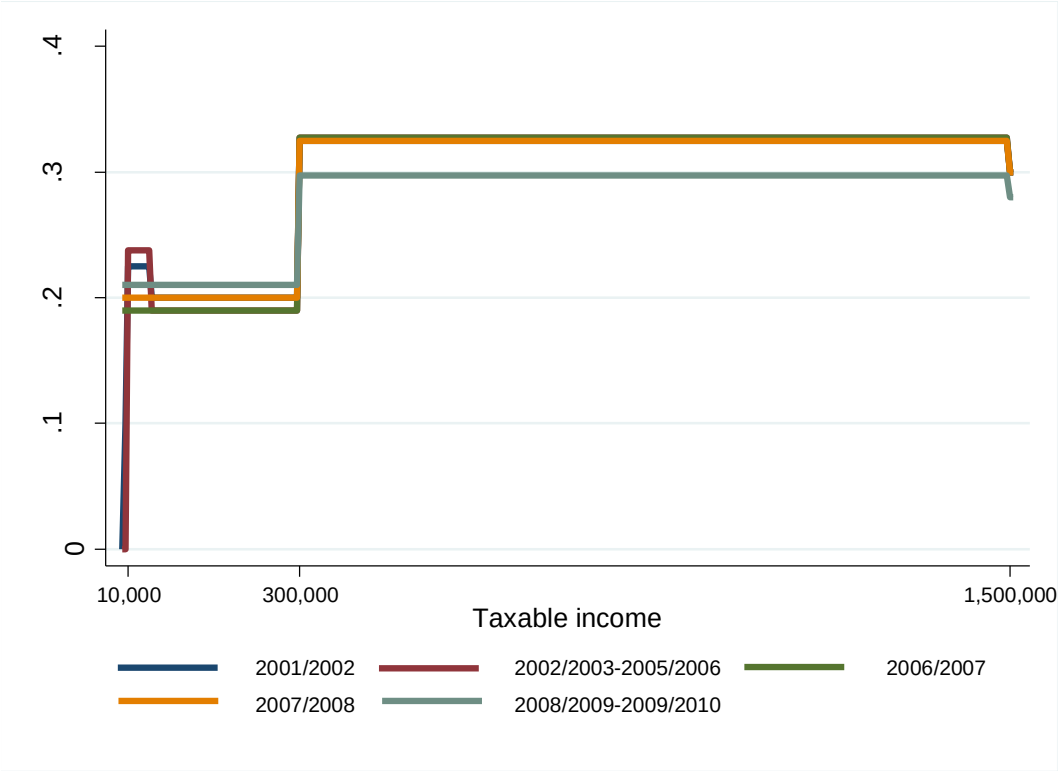


**Figure 1. Statutory corporate income tax rate in the UK.** This figure shows the statutory marginal tax rates for different corporate income tax brackets during the fiscal years 2001/2002-2009/2010 in the United Kingdom.

The marginal tax rate, whether it is measured before- or after-financing, is also likely to be endogenous because taxable profits may be correlated with unobserved shocks that can also affect companies' leverage. For example, companies that experience large positive demand shocks may accumulate higher internal funds and taxable profits. The pecking-order theory of capital structure predicts that such companies would tend to have lower leverage. To deal with this type of endogeneity, we estimate the effect of the marginal tax rate on leverage ratio

using the first-difference Generalized Method of Moments (GMM) estimator (Arrellano and Bond, 1991), and instrument the company's contemporaneous after-financing marginal tax rate by its historical after-financing (or before-financing) marginal tax rate. The validity of this strategy relies on the following two assumptions: first, a company's taxable profits across different years are correlated and hence, its historical marginal tax rates are informative about its current marginal tax rate; and second, any unobserved contemporaneous shock that changes the company's leverage ratio, such as a windfall of cash, is not serially correlated beyond a certain period of time.[13]

As a supplement to our main identification strategy, we construct a second sample that contains both profit-making and loss-making companies (Sample II). Variation in the marginal tax rate for companies in Sample II comes from two sources: the existence of kinks in the corporate tax rate schedule; and the asymmetric tax treatment between profits and losses. The statutory marginal tax rate of zero could be below the true marginal tax rate for companies in the loss-making position since it does not take into account the possibility of carrying losses forward or backward. The most sophisticated approach to incorporate such dynamics in the tax code is to simulate companies' future taxable profits and then calculate the effective marginal tax rate accordingly. Graham (1996a) and Graham et al. (1998) provide a detailed explanation of this approach. However, it requires strong assumptions about the distribution of companies' taxable profits as well as about companies' expectations, and preferably also many years of observations for each company.[14]

We do not pursue such a strategy due to these concerns. Instead, for loss-making companies, we use in turn both the statutory marginal tax rate of zero and the "perfect-foresight" marginal tax rate. The "perfect-foresight" marginal tax rate is calculated in the spirit of the simulated marginal tax rate (Graham, 1996a, 1996b; and Graham et al., 1998) assuming companies have unbiased estimates of their future taxable income. Graham (1996b) finds that the simulated marginal tax rates are highly correlated with the "perfect-foresight" marginal tax rates assuming companies can predict their future taxable income. Under this assumption, when in a loss position, a firm's marginal tax rate depends on when it will realize positive

[13] More specifically, the set of instruments that contains the lags of the after-financing marginal tax rate will be chosen according to the test of serial correlation in the unobserved error term in the dynamic adjustment model of capital structure.

[14] The simulated marginal tax rate usually requires a reasonably long time-series for each firm to forecast future taxable income. This is a luxury we do not have since we only have a maximum 9 years of tax returns or 10 years of accounting data for individual firms.

taxable income, which is recorded in the tax returns. We discuss the construction of the "perfect-foresight" marginal tax rate in Section IV.A.

## II. Sample Construction and Data Description

### *A. Sample Construction*

We use confidential tax returns for a panel of UK companies to identify the heterogeneous tax incentives faced by companies. The tax return data is collected by Her Majesty's Revenue and Customs (HMRC), the UK tax authority, and covers the universe of companies that file a corporate income tax return in the UK during the period 2001/2002-2009/2010.[15] UK tax returns are filed on an unconsolidated basis.

The tax return data provides precise information on the tax position of each company in each period. However, it contains little information on financial statement variables. In particular, it does not contain information on debt or interest payments. We therefore merge the tax return data with the unconsolidated accounting data from the financial statement database FAME (provided by Bureau van Dyjk) by the company identification number and the end dates of the tax-returns and the financial statements.[16] FAME provides information from balance sheets and income statements.[17] As the capital structure of financial companies is a rather different concept from that of non-financial companies, we exclude the financial sector from our analysis.

We use information from balance sheets to construct the leverage ratio, defined as the sum of short-term and long-term debt expressed as a proportion of total debt and book equity.[18] We drop company-year observations where the leverage ratio exceeds 100% or is below 0%. Theories of capital structure suggest that the leverage ratio depends on a number of factors. For example, the trade-off theory predicts that larger and more tangible companies are likely to use more debt (for example, Bradley et al., 1984). On the other hand, the pecking-order theory of capital structure suggests a negative correlation between companies' profitability

[15] The UK corporate tax return form is called the CT600 form.
[16] Each firm is assigned a unique identifier (ID) in both the tax return data and the accounting data by the HMRC. We use this firm ID to carry out the matching. We keep only firms with 12 months in each accounting period, which are the majority of firms in our sample.
[17] We only keep the years when companies report unconsolidated accounts in FAME.
[18] As the majority of firms in our sample are private, we do not observe the market value of their equity. Hence, book equity is included in the denominator of the leverage ratio.

and leverage ratio (for example, Myers and Majluf, 1984). We include company size, tangibility and profitability as our main control variables since these have been found to be among the most reliable factors for explaining leverage (Frank and Goyal, 2009; and Graham and Leary, 2011). We measure company size as the logarithm of the book value of total assets, tangibility as the ratio of tangible fixed assets to total assets and profitability as the ratio of after-tax earnings to total assets.[19] Appendix A provides a detailed description of the variable construction for our empirical analysis.

To construct Sample I we exclude companies that reported taxable losses at least once during the sample period. Sample II includes both loss-making and profit-making company-year observations. We require each company to have at least 4 consecutive years of observations after data-cleaning procedures.[20] Sample I contains the unconsolidated accounts of 9,439 companies and 51,051 company-year observations. Sample II contains 16,124 companies and 93,259 company-year observations. Table II provides summary statistics for leverage ratio, size, tangibility, profitability, and the marginal tax rate measured in different ways for the two samples. Of course, companies in Sample I reported higher average taxable profits and profitability. Nonetheless, we do not find the average size and tangibility to be very different in our two samples.

### *B. Descriptive Analysis of Leverage Ratio and Marginal Tax Rate*

Figure 2 plots the time-series of the unweighted average leverage ratio for companies in Sample I, using both the unbalanced panel and a balanced panel where companies in Sample I are required to have 9 years of contiguous observations between 2001/2002 and 2009/2010.[21] For the balanced panel (solid line), the unweighted average leverage ratio declined gradually during the sample period. The dotted line for the unbalanced panel exhibits a similarly declining pattern although less prominent, which suggests that there are either entries of companies with higher leverage ratio or exit of companies with lower leverage ratio during this period.

[19] To eliminate outliers, we drop company-year observations that are in the top and bottom 1% of the distributions of these control variables.
[20] This is necessary for carrying out the GMM estimations as explained later. All firms in Sample I are also included in Sample II.
[21] A similar pattern is observed when we plot the average leverage ratio of firms in Sample II. There are 755 firms and 6,795 observations in the balanced panel.

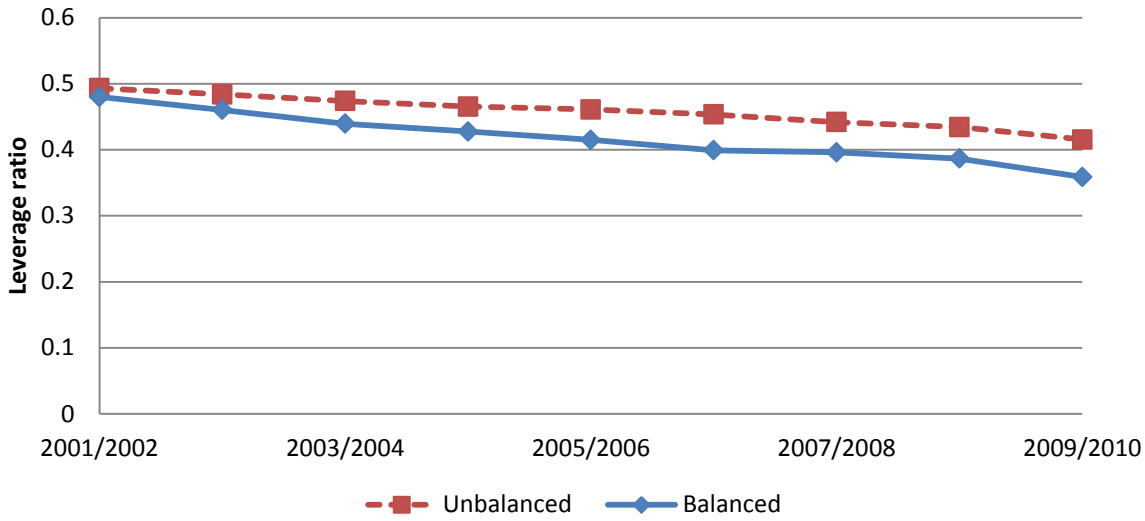


**Figure 2. Unweighted average leverage ratio 2001/2002-2009/2010 (Sample I).** The unbalanced sample consists of 9,439 companies and 51,051 observations during the fiscal years 2001/2002-2009/2010. The balanced sample consists of 755 companies and 6,795 observations with all 9 years of observations during the same period. Leverage ratio is defined as Total debt/(Total debt+Book equity).

Figure 3 plots the distribution of companies' statutory marginal tax rates for the period 2001/2002-2009/2010; the left panel shows the after-financing marginal tax rate and the right panel the before-financing marginal tax rate.[22] These histograms show rich variation in both measures of marginal tax rates across companies.[23] We present the histogram of the after-financing marginal tax rate for companies in Sample II in Appendix B.

With the presence of company-specific fixed effects, we rely for identification on time-series variation in the marginal tax rate faced by individual companies. Table III reports the transitional probability matrix for companies' taxable profits from year *t-1* to year *t* shown separately for Sample I and Sample II. There is some persistence in allocations to tax brackets for firms in both samples. For firms in Sample I, the probability of staying within the same tax bracket from period *t-1* to period *t* is around 70%-80%. Similar analysis of Sample II indicates the persistence of firms' loss-making status-when companies are in the loss-making position in period *t-1*, with around 70% probability it would remain non-taxable in

[22] It is worth pointing out that firms with taxable profits below £10,000 during the fiscal year 2002/2003 to 2005/2006 had zero statutory marginal tax rate, which explains the mass at zero in Figure 3.
[23] As the summary statistics in Table II suggests, both the mean and the median of the before-financing marginal tax rate are higher than those of the after-financing marginal tax rate. This indicates that firms' marginal tax rate is reduced by using debt.

period *t*.[24] Nevertheless, there is still considerable time-series variation in companies' tax status as suggested by the non-zero off-diagonal figures in Table III.

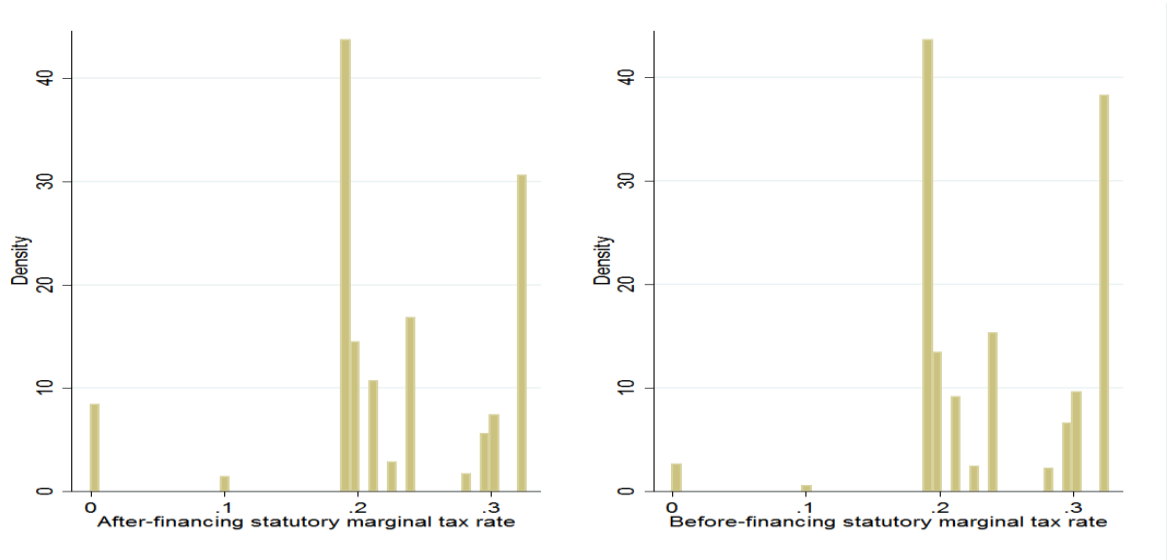


**Figure 3. Distribution of the after- and the before-financing marginal tax rate (Sample I).** The sample consists of 9,439 companies and 51,051 observations during the fiscal years 2001/2002-2009/2010. The left panel shows the distribution of the after-financing marginal tax rate, calculated based on firms' taxable profits filed in the tax returns (Box 37, CT600). The right panel shows the distribution of the before-financing marginal tax rate, calculated based on firms' taxable profits before deducting interest expenses. We obtain interest expenses from the database FAME.

As a further check, Table IV reports the number of tax status changes within companies, separately for the two samples. For Sample I, around a quarter of companies never changed their tax brackets.[25] Around 28% of companies changed their location on the tax rate schedule once and more than 20% of companies changed their location on the rate schedule at least three times. As one of the most significant kinks in the tax rate schedule is at £300,000, we further calculate how often companies in Sample I move in and out of the tax bracket for profits above £300,000. Around 35% of companies in Sample I moved into or out of this tax bracket at least once during the sample period. For Sample II, around 80% of firms changed tax bracket at least once during the sample period. As we include loss-making firm-year observations in Sample II, we calculated how often firms shifted into or out of taxable loss. Our calculation shows that although the tax loss status is likely to persist, we still

[24] This suggests that as the loss status is rather persistent over time, the measurement errors in the simulated marginal tax rate will also be persistent, which in turn may lead to biased estimates of the tax effect on capital structure in a simple static capital structure model.
[25] These serve as the control group in our estimations.

observe around half of the companies in Sample II moving in or out of taxable losses at least once during the sample period.

## III. Benchmark Results Using Kinks for Identification

### *A. Benchmark Analysis*

We begin our estimation using our main identification strategy and Sample I. We allow for a dynamic adjustment model of leverage specified as Equation 1, where $Lev_{i,t}$ is the leverage ratio of company *i* in year *t*; $MTR_{i,t}$ is the after-financing marginal corporate income tax rate faced by company *i* in year *t*; $Z_{i,t}$ is a vector of control variables, including size, tangibility, and profitability; $\mu_i$ is an unobserved company-specific fixed effect; $\theta_t$ is a time effect; and $\epsilon_{i,t}$ is an unobserved company-level, time-varying shock.

$$(1)\ Lev_{i,t} = \alpha_0 + \alpha_1 Lev_{i,t-1} + \beta_1 MTR_{i,t} + \beta_2 MTR_{i,t-1} + \gamma_1 Z_{i,t} + \gamma_2 Z_{i,t-1} + \mu_i + \theta_t + \epsilon_{i,t}$$

It has been documented in the previous literature that the leverage ratio is highly persistent over time (Lemmon et al., 2008), as companies move only gradually towards their optimal leverage due to the existence of adjustment costs (Fisher et al., 1989; and Lemmon et al., 2008). This feature of the capital structure has not been widely incorporated into the analysis of the effects of corporation tax on leverage and most previous studies instead estimate a static model (for example, Graham, 1996a; Graham et al., 1998; and Faccio and Xu, 2013).[26] With the presence of adjustment costs, however, it is more reasonable to estimate a dynamic adjustment model of capital structure as specified as in (1), which allows us to estimate the long-run size of the effect of corporation tax on leverage but also how quickly companies respond to changes in tax incentives.

Re-arranging (1), we obtain an error-correction specification:

$$(2)\ \Delta Lev_{i,t} = \alpha_0 + (\alpha_1 - 1) Lev_{i,t-1} + (\beta_1 + \beta_2) MTR_{i,t-1} + (\gamma_1 + \gamma_2) Z_{i,t-1} + \beta_1 \Delta MTR_{i,t} + \gamma_1 \Delta Z_{i,t} + \mu_i + \theta_t + \epsilon_{i,t}$$

[26] More recent studies on the effects of tax on leverage of banks have estimated similar dynamic models (see, Keen and de Mooij, 2015).

where the long-run effect of the corporate tax rate on leverage is given by $\frac{\beta_1+\beta_2}{1-\alpha_1}$, and $(1-\alpha_1)$ measures the convergence speed of the leverage ratio towards its long-run target.[27] Similarly, the long-run effect of other control variables in (2) is measured as $\frac{\gamma_1+\gamma_2}{1-\alpha_1}$. Implicitly, we assume that there is a linear long-run relationship between optimal leverage, the marginal tax rate, and size, tangibility and profitability.

Table V reports the estimation results based on the error-correction model specified as in (2) using Sample I.[28] Column 1 presents results using OLS. In this and all our subsequent analysis, we include a set of common year dummies to control for any common business cycle effect on leverage. Lemmon et al. (2008) point out that unobserved company-specific fixed effects are important for explaining companies' capital structure. In column 2 we control for company-specific fixed effects using the Within-Groups (WG) estimator. As discussed in Section 1, the endogeneity of the contemporaneous after-financing marginal tax rate may bias the estimated coefficient on $\Delta MTR_{i,t}$ $(\beta_1)$ as well as other estimated coefficients in (2) including the estimated long-run tax effect on leverage. Indeed, in both Columns 1 and 2, the estimated long-run coefficient on the after-financing marginal tax rate is negative and significant, contrary to predictions of the trade-off theory of capital structure.[29]

To investigate the endogeneity of the contemporaneous after-financing marginal tax rate, we plot the distribution of firms' taxable income based on Sample I in Appendix C. Figure C.1 shows the number of firms in each bin of taxable income based on the tax returns. Without kinks in the corporate tax rate schedule, the distribution of taxable income is likely to be smooth. However, we observe significant bunching of taxable income around the £300,000 threshold in Figure C.1. To have a closer look, Figures C.2-C.5 plot the distribution of taxable income around the £10,000, £50,000, £300,000, and £1,500,000 thresholds, respectively (red line). These detailed figures further confirm the observation in Figure C.1 that bunching of taxable income mostly occurs around the £300,000 threshold. However,

[27] Equation 2 is similar to the partial adjustment model reported in Lemmon et al. (2008).
[28] We obtain similar results without controlling for firm size, tangibility, and profitability. The results are available upon request.
[29] For comparability, we have applied the OLS and the WG estimation using the sample employed for the GMM estimations, with similar results. The sample using the GMM is smaller because we need a longer time series when lagged values of the covariates are used as instruments. Some companies are dropped because they do not have enough observations available.

these figures show that taxable income also bunches around other kink points on the corporate tax rate schedule, although to a lesser degree. Interestingly, when we focus on the before-financing taxable income (light brown bars), its distribution appears to be smooth around all the kink points. Nevertheless, the distribution of taxable income before deducting capital allowances (and after deducting interest expenses) is also smooth (dark brown line). Hence, it appears that firms use both debt and capital allowances to shift into a lower tax bracket.

Graham (1996a) and Graham et al. (1998) argue that the current before-financing marginal tax rate can be used to instrument after-financing marginal tax rate. However, this is true only if the before-financing marginal tax rate is not affected by unobserved shocks in $\epsilon_{i,t}$. In Column 3, we report the Instrumental Variables (IVs) estimation of (2) when $MTR_{i,t}$ is instrumented by the current, the first, second, and third lags of the before-financing marginal tax rate. [30] The estimated long-run coefficient on the statutory marginal tax rate remains negative, and the Hansen test clearly rejects the null hypothesis that these instruments are valid.[31]

As alternative instruments for the contemporaneous after-financing marginal tax rate, in Column 4 we use the second and the third lags of the after-financing marginal tax rate.[32] The rationale for using the lags of the after-financing marginal tax rate as instruments is as follows. Since taxable profits are persistent over time, the lagged marginal tax rates should be informative about the current marginal tax rate. However, historical taxable profits are less likely to be correlated with current unobserved shocks that affect the availability of internal funds and taxable income in year *t*, provided that such shocks are transitory.

Using these lags as instruments, the estimated coefficient on $\Delta MTR_{i,t}$ and the estimated long-run tax effect both become positive and significant, consistent with the prediction of the trade-off theory. The estimated long-run tax effect on leverage is around 0.4, suggesting that a 10 percentage point increase in the marginal tax rate will lead to a 4 percentage points

[30] We use the STATA command "xtivreg2" to conduct the Instrumental Variables estimations, which controls for firm-level fixed effects.
[31] The Hansen test of the null hypothesis that these instruments are exogenous provides a p-value of 0.000, indicating strong rejection of the null.
[32] We cannot include the first lag of the after-financing marginal tax rate in the set of instruments as it is already a covariate in Equation 2.

increase in leverage. The Kleibergen-Paap rank test for weak instruments and the Hansen test results indicate that the second and third lags of the after-financing marginal tax rate are both informative and valid instruments.

In Column 5, we repeat the exercise in Column 4 but use as instruments the second and the third lags of the before-financing marginal tax rates instead of the second and the third lags of the after-financing marginal tax rates. The Hansen test again suggests that these are valid instruments. Together with Column 3, this result suggests that the contemporaneous before-financing marginal tax rate is correlated with unobserved shocks in the error term. We continue to obtain a positive and significant long-run coefficient on the statutory marginal tax rate, of around 0.87.[33]

The estimated convergence speed differs considerably using the OLS and the WG estimators.[34] It is well known that for a short panel dataset like the one used here, the OLS estimator with the presence of company-specific fixed effects creates an upward bias in the estimated coefficient on the lagged dependent variable. In contrast, the WG estimator creates a downward bias. Such a bias may also confound other estimated coefficients. To deal with this problem, in Columns 6 and 7 we apply the GMM estimator.[35] More specifically, we use lags of the leverage ratio dated at *t-3* and *t-4* as instruments for $\Delta \text{Lev}_{i,t-1}$.[36] We also treat the current after-financing marginal tax rate and other control variables as endogenous and use the lags of these variables dated at *t-3* and *t-4* as instruments.

[33] The estimate has a larger standard error than that reported in Column 4. This is unsurprising since the before-financing marginal tax rate is not perfectly correlated with the after-financing marginal tax rate.

[34] Previous studies also estimate a range of adjustment speed for firms' capital structure. For example, Fama and French (2002) find a positive, significant, but slow adjustment speed when they estimate a dynamic capital structure model using the OLS estimator (0.07-0.1 for non-dividend paying firms, 0.15-0.18 for dividend paying firms). Flannery and Rangan (2006) find a much faster adjustment speed (around 0.3) using the mean-differencing estimator. Lemmon et al. (2008) also find a larger adjustment speed (around 0.25) using the GMM estimator.

[35] We conduct the GMM estimation using the STATA command xtabond2 (Roodman, 2009).

[36] We choose to use the third and the forth lags of these variables as instruments based on the serial correlation test results shown at the bottom of Table V. If the error term $\epsilon_{i,t}$ is not serially correlated, we would reject the null hypothesis that there is no AR(1) type of serial correlation in the first-differenced equation, and we would accept the null hypothesis that there is no higher order of serial correlation in the error term of the first-differenced equation. Since the null hypothesis that there is no AR(2) type of serial correlation in the first-differenced error term is clearly rejected, it suggests that only the third or further lags of the leverage ratio, as well as of other control variables, could be valid instruments.

In Column 6, we obtain a convergence speed around 0.24, which is close to that in the previous literature.[37] The point estimate on $Lev_{i,t-1}$ in Column 6 lies between the OLS estimate in Column 1 and the WG estimate in Column 2, consistent with the existence of an upward bias in the OLS estimations and a downward bias in the WG estimations.[38] The point estimate for the coefficient on $MTR_{\mathrm{i,t-1}}$ is around 0.18, which is significant at the 5 percent level. This translates into a long-run coefficient of around 0.76, suggesting that a 10 percentage points increase in the marginal tax rate will lead to a 7.6 percentage points increase in leverage. This tax effect is much larger than that reported in, for example, Graham et al. (1998). Nevertheless, as we obtain a large standard error for this long-run coefficient, we cannot reject the null hypothesis that the estimated long-run tax effect in Column 6 is equal to that in Column 4.[39]

In Column 7, we instead instrument the contemporaneous after-financing marginal tax rate by the before-financing marginal tax rate dated at *t-3* and *t-4*.[40] We obtain a larger long-run coefficient on the statutory marginal tax rate in this specification of around 1.4. However, the standard error also rises and the null hypothesis that the estimated long-run tax effects on leverage in Columns 6 and 7 are equal cannot be rejected at the 10 percent level.

*B. Which Tax Rate matters? Marginal Tax Rate versus Average Tax Rate*

Recent studies find that many firms employ the more salient average tax rate to make capital structure decisions rather than the theoretically correct marginal tax rate (Graham et al., 2015). One of the argument is that the average tax rate is more salient to managers and the marginal tax rate is more difficult to calculate. We test this hypothesis based on firms in Sample I. To construct the average effective tax rate (AETR), we divide the total amount of corporate tax paid by the amount of taxable income.[41] On average, firms in Sample I paid around 23% of their pre-tax income in the form of corporate taxes during the sample period.

[37] For example, Lemmon et al. (2008) estimated the speed of convergence to be around 0.25 in their GMM estimations, using a sample of US listed non-financial companies.
[38] When we estimate the model using the OLS and WG estimators based on the same sample as for the GMM estimation, the convergence speed is -0.1 in the OLS estimation and -0.69 in the WG estimation.
[39] The t test of the null hypothesis that these two long-run coefficients are equal yields a t statistic of 0.867. This is unsurprising as we use the third and the forth lags of the after-financing marginal tax rate as instruments, which are not strongly correlated with the contemporary after-financing marginal tax rate.
[40] Again, the Hansen test of the exogeneity of the instrument set is strongly rejected when we include the before-financing marginal tax rate dated at *t, t-1,* and *t-2* in the set of instruments.
[41] Both the numerator and the denominator of this ratio are obtained from the tax returns.

In Table VI, we analyze whether the effective average tax rate or the marginal tax rate matters for firms' long-run capital structure. To ease comparison, in Column 1, we report the GMM estimation result of Column 9 of Table V, where we use only the marginal tax rate as the proxy for tax incentives for using debt. In Column 2, we instead use only the average effective tax rate as the proxy. We do not find any long-run effect of the AETR on firms' capital structure. In Column 3, we regress leverage on both the marginal tax rate and the average effective tax rate and interestingly, we continue to find a significant long-run effect of the marginal tax rate on firms' capital structure but no effect from the AETR. These results suggest that firms in our sample use the theoretically correct marginal tax rate for their capital structure decisions instead of the more salient average effective tax rate.

## IV. Comparison with Previous Studies

Our analysis so far has provided evidence for a large and positive effect of taxation on a company's long-run capital structure, consistent with the prediction of the trade-off theory. The magnitude of our estimated long-run tax effect on leverage is much larger than that found by previous studies. As mentioned above, our analysis differs considerably from previous studies in terms of identification strategies (using kinks in the corporation tax rate schedule compared to using only asymmetric tax treatment between profits and losses), data sources (tax returns compared to accounting data), model specifications (a dynamic model compared to a static model), and consolidation rules (unconsolidated data compared to consolidated data). In this section, we try to identify which aspects of our approach are most important for the differences in our results compared to the previous literature.

In Section IV.A, we use additional variation in the marginal tax rate due to the asymmetric tax treatment between profits and losses to identify the effect of taxation on capital structure. In Section IV.B, we compare the explanatory power of two marginal tax rates, one based on tax returns and the other based on financial statements. In Section IV.C, we estimate a static and a lag distributed model of capital structure. In Section IV.D, we distinguish between companies' external and internal leverage, and also distinguish between domestic stand-alone companies and those that are a part of a multinational corporation group.

### *A. Identification Based on the Asymmetric Tax Treatment Between Profit and Loss*

Many previous studies use variation in the simulated marginal tax rate due to the asymmetric tax treatment between profit and loss for identification (notably Graham 1996a, 1996b, and Graham et al., 1998). Loss-making firms may be able to carry losses back to the previous period, in which case the effective marginal tax rate is the statutory rate of the previous period. However, in most cases, firms must carry forward losses to set against profit in later years, in which case the effective marginal tax rate in the loss-making period depends on the expectation of when they will become taxable again. UK firms are allowed to carry losses back for 12 months or forward indefinitely.[42] We consider two alternative approaches to measuring the marginal tax rate: in Columns 1-4 in Table VII, we assume that companies do not take into account any losses carried forward or backward and simply set the marginal tax rate to zero. In Columns 5-9, we use the "perfect-foresight" marginal tax rate, assuming firms can fully anticipate their future tax status. We provide more detail about the construction of the perfect-foresight marginal tax rate in Appendix D. [43]

Columns 1-4 of Table VII report the OLS, WG, IV, and GMM estimation results based on Equation 2.[44] The results are similar to our benchmark analysis in Table V. We find a negative and significant long-run coefficient on the after-financing marginal tax rate in the OLS and the WG estimations. Controlling for the endogeneity of the after-financing marginal tax rates in the IV estimation in Column 3, we again find a positive long-run tax effect on companies' leverage ratio – here of around 0.42 and significant at the 1 percent level. Dealing with the endogeneity of the lagged leverage ratio and other control variables in the GMM estimation in Column 4, we find a long-run tax effect on the leverage ratio of around 1.04, which is significant at the 1 percent level.

Columns 5-8 repeat this exercise using the "perfect-foresight" after-financing marginal tax rate. The results in Columns 5-8 are similar to those in Columns 1-4. In the GMM estimation in Column 8 we find a positive and significant long-run tax effect of around 0.98. One concern about this "perfect-foresight" marginal tax rate is that, as explained in more details in Appendix D, we impose strong assumption about the first and the last observations for each

[42] Note that companies are also, subject to some limitations, able to set losses in one company against profit in another company in the same group, in which case, the relevant tax rate is in principle that of the group member to which losses are transferred. We do not observe the recipient company. However, only around 5% of firms in our sample are part of a UK domestic group.

[43] Due to confidentiality concerns, we cannot report the histogram of the perfect-foresight marginal tax rate.

[44] In this table, we use the same sample for the OLS, WG and the GMM estimations. Similar results are obtained for the OLS and WG estimations when we use the full sample.

company if it is in a loss-making position in those years. For the first year we do not observe whether the company carries losses backwards; for the last year we do not observe how long it takes before the company reaches a tax-paying position. In Column 9 we repeat the approach of Column 8, but omitting the first and the last observations. The long-run coefficient on the "perfect-foresight" marginal tax rate in Column 9 has a similar magnitude to that reported in Column 8.

### *B. Marginal Tax Rate Based on Tax Returns: A Better Measure to Capture Capital Structure Tax Incentives?*

The major advantage of using tax return data to study the effects of corporate taxes on capital structure is that it provides accurate information on companies' tax status. Table VIII illustrates the correspondence between the taxable income reported in the tax return data and the estimated taxable income based on the accounting data from FAME, using both samples. It reveals considerable discrepancies between these two data sources. This discrepancy is particularly severe when a company makes a loss — only around 50% of companies making a loss according to tax return data show a loss in accounting data. This suggests that using companies' financial statements to simulate variation in the marginal tax rate is likely to generate large measurement errors.

Table IX reports the correlations between different measures of the marginal tax rate: the after-financing and the before-financing marginal tax rates calculated based on tax return data and based on FAME. We find a partial correlation of around 0.688 between the after-financing marginal tax rate based on tax returns and that based on financial statements, and a similar correlation for before-financing marginal tax rates (insert the specific correlation coefficient – see my previous comment as well). Consistent with Table VIII, these figures suggest considerable differences between the marginal tax rates based on tax returns and that based on financial statements.

Our observation of the discrepancies between companies' actual taxable income and that estimated based on companies' financial statement is consistent with the large literature on the existence of book-tax differences (for example, Scholes and Wolfson, 1992; Cloyd et al., 1996; Plesko, 2000; Manzon and Plesko, 2001; Mills and Newberry, 2001; and Desai, 2003). Such book-tax differences arise due to different accounting rules for tax and for financial

reporting. Tax and financial reporting may have different rules for revenue and expenses recognition, such as how capital expenditures are depreciated, which leads to temporary book-tax differences. Permanent book-tax differences arise as revenue or expenses are accrued under one system but not the other. As the tax returns and financial statements are prepared for different purposes, companies have some incentive to report low taxable income to the tax authority, and to report high income in their financial statements. Although large book-tax differences may increase the probability of being audited by tax authorities, previous studies suggest that companies do not always conform their financial statements to their tax reports.[45]

Such discrepancies between the tax returns and the financial statements suggest that the marginal tax rate based on the tax return data is likely to better capture the true tax incentives for borrowing. Contrary to this intuition, Graham and Mills (2008) find that the simulated (before-financing) marginal tax rate based on financial statements captures the tax incentives for capital structure better than the corresponding marginal tax rate based on actual tax returns for a sample of US companies. This could be due to at least two reasons. First, it is possible that companies respond more to the tax position declared in their financial statements than their true tax position, since the accounting position is what is publicly disclosed. Alternatively, however, the finding could be explained by the difference in the consolidation rules between the tax and accounting data in their study, as discussed previously. Since our tax return data and the accounting data are both unconsolidated, we avoid this inconsistency.

To test our hypothesis, in Table X we compare the GMM estimation results of Equation 2 using two versions of the after-financing marginal tax rate: the first obtained according to companies' tax returns (*MTR*) and the second obtained according to their financial statements ($MTR^A$).[46] Column 1 reproduces column 6 of Table V, using the *MTR* and our main approach on Sample I. Column 2 shows the effect of instead using $MTR^A$. In Column 2, we do not find any significant tax effect on leverage. The estimated coefficient is substantially lower than in Column 1, and the standard error is higher. We obtain similar results in Columns 3 and 4 when we instrument the after-financing marginal tax rate by the before-financing marginal

[45] Cloyd et al. (1996) and Mills and Newberry (2001) find that book-tax differences exist for both public and private firms, although private firms appear to conform their financial statements with tax returns more.
[46] For succinct presentation, we only report the estimated convergence speed, the long-run coefficients on different measures of the marginal tax rate, and relevant test results.

tax rate. We have also compared the two approaches without controlling for company size, tangibility, and profitability, and we again obtain the same conclusion.

The results are more mixed using Sample II. In Columns 5 and 6 we compare results when we set the *MTR* to zero in the period in which the company makes a loss. In this case, the estimate of the long-run effect of tax on leverage is positive and significant also when we use the financial statement data (Column 6). However, even in this case, the coefficient is lower, and the standard error higher, than in the case in which we use tax return data. Finally, when using the "perfect foresight" *MTR*, based on Column 9 of Table VII, the estimate using the financial statement data is again insignificant due to a high standard error.

Overall, these results suggest strongly that marginal tax rates calculated using tax return data better capture the corporate tax incentives for capital structure, when the tax returns and accounting data are based on the same consolidation rules. Importantly, using our first sample and main identification strategy, the estimated long-run tax effect on leverage ratio is close to zero in Columns 2 and 4. Based on the results of Columns 2 and 4, without the availability of tax return data, we would therefore conclude that there is little impact of the marginal tax rate on capital structure.

*C. Static and Lag Distributed Models*

In this section, we estimate a static model and a distributed lag model of capital structure. Most existing empirical studies of the impact of taxation on leverage estimate a static capital structure model (for example, Graham 1996a, 1996b; Graham et al., 1998; Graham and Mills, 2008; and Faccio and Xu, 2013). To compare our study to previous work, we also estimate a static model as in (3):

$$(3)\ Lev_{i,t} = \alpha_0 + \beta_1 MTR_{i,t} + \gamma_2 Z_{i,t} + \mu_i + \theta_t + \epsilon_{i,t}$$

This static model assumes that companies adjust immediately their leverage ratio towards the new equilibrium in response to any shocks. This is in contrast to the corporate finance literature, in which it has been pointed out that companies only adjust their capital structure infrequently (see, Fisher et al., 1989; and Hovakimian et al., 2001; and Flannery and Rangan, 2006). Comparing the static model with the error correction model, we restrict the

coefficients on all lagged variables in (1) to be zero in the static model. According to our results above, these restrictions are not valid. We are therefore estimating the static model primarily to investigate the size of its bias.

As an alternative way of investigating the nature of the adjustment of capital structure, we also estimate a distributed lag model as follows:

$$(4)\ Lev_{i,t} = \alpha_0 + \beta_1 MTR_{i,t} + \beta_2 MTR_{i,t-1} + \beta_3 MTR_{i,t-2} + \beta_4 MTR_{i,t-3} + \gamma_1 Z_{i,t} + \gamma_2 Z_{i,t-1} + \gamma_3 Z_{i,t-2} + \gamma_4 Z_{i,t-3} + \mu_i + \theta_t + \epsilon_{i,t}$$

The sum of $\beta_1, \beta_2, \beta_3,$ and $\beta_4$ is the long-run tax effect on leverage in this specification. This distributed lag model can be viewed as a specification between the static model in (3) and the error-correction model specified in (2). If the dynamic adjustment takes a long time, we would need to include further lags of the variables on the right-hand side of (4), although this would be empirically difficult as we only have a short panel. In contrast, the error-correction model used in our main specification is a more parsimonious specification than the lag distributed model and it allows us to estimate the long-run tax effect on leverage using a short panel of data.

Table XI reports the IVs estimation results based on (3) and (4), using Sample I and II separately. We use lags of the after-financing marginal tax rate as instruments for the current after-financing marginal tax rate, although similar results are obtained when we use the lags of the before-financing marginal tax rate as instruments instead. Details of these instruments are provided at the bottom of Table XI. For sample I, in Column 1, we obtain a positive and precisely estimated coefficient on $MTR_{i,t}$ of around 0.6 from the static model where all the control variables are dated at time *t*. To deal with the potential endogeneity of the control variables other than the tax measure, previous studies often include those variables dated at *t-1* on the right-hand side. In Column 2, when all control variables are dated at *t-1*, we obtain a smaller positive coefficient on $\mathrm{MTR}_{i,t}$ of around 0.4. This suggests that the static model appears to bias downward the coefficients compared to the error-correction model.

In Column 3, we report the results based on the distributed lag model. Note that the difference between the distributed lag model and the error correction model is that we do not

include the lagged leverage ratio on the right-hand side of the lag distributed model. All the coefficients on the current and on the lags of the after-financing marginal tax rate are positive, and the coefficients on $MTR_{i,t}$ and $MTR_{i,t-2}$ are both significant. We also find significant coefficients on companies' profitability, size, and tangibility dated prior to year *t*. We repeat these analyses using Sample II and the results are reported in Columns 4-6. Again, we observe the coefficients on the lags of the marginal tax rate to have explanatory power on the company's current leverage ratio in Column 6. These results provide some evidence that companies adjust their capital structure in response to changes in their marginal tax rate over time and hence, it would be more appropriate to estimate a dynamic adjustment capital structure model than a static model.

*D. External Leverage: Domestic versus Multinational Companies*

So far our analysis focused on how corporate taxes affect companies' overall leverage. Since we use unconsolidated financial statements to construct the leverage ratio to match with the unconsolidated tax returns, for companies that are a part of a corporate group, our measure of leverage is the sum of external and internal leverage.[47] By contrast, most previous studies have estimated the tax effects on companies' consolidated data, implying that they consider only external debt.[48] To compare our study with previous work, we now consider only external leverage.

We further distinguish between domestic stand-alone companies, companies that are part of a UK group, and companies that are part of a multinational group. We make such a distinction for two reasons. First, in our sample around 70% of companies are stand-alone companies, and it is of policy interest to analyse the effects of taxation for such smaller, domestic stand-alone companies. This is generally not possible using data on public companies since they tend to be part of large groups. Second, multinational companies may have more sophisticated debt policies than domestic stand-alone companies.[49] In particular, they may have the opportunity to borrow externally in different jurisdictions, and allocate internal debt

[47] External debt is borrowed from unconnected, third parties such as commercial banks or other financial institutions. Internal debt is borrowed from connected entities in the same corporate group.

[48] This is because most studies construct the leverage ratio using the consolidated balance sheets of listed firms. One exception is Desai et al. (2004) who study how taxes affect the external and internal leverage of subsidiaries of US multinational firms. The authors found that internal leverage is more sensitive to local tax rates.

[49] For example, multinational firms can allocate their debt internally across different tax jurisdictions to reduce their worldwide tax liabilities (see, for example, Desai et al., 2004).

so that high tax subsidiaries are financed by low tax entities in the same group.[50] The tax effect on the external leverage of multinational groups may therefore differ from that for domestic stand-alone companies.[51]

We identify whether a company is a domestic stand-alone or a part of a multinational group using information on companies' ownership structure from FAME.[52] More specifically, FAME records whether a company is independent or not.[53] If a company is not independent, we know the name and location of its global ultimate owner. We define a company to be a part of a multinational group if it satisfies one of the following criteria: 1) the company itself is independent and it has foreign subsidiaries outside of the UK; 2) it is a subsidiary of a group with a UK ultimate owner and which has foreign subsidiaries; 3) it is a subsidiary of a group with a non-UK ultimate owner. We define a company to be part of a domestic corporation group if: 1) it is independent and has only domestic subsidiary; 2) or it is a subsidiary of a group with a UK ultimate owner and which has no foreign subsidiary. We define the rest of the companies to be domestic stand-alone companies. It is worth noting that for domestic stand-alone companies defined this way, the ownership information is missing in FAME. This is consistent with the hypothesis that FAME only collects ownership information for companies that are part of a group. Table XII presents summary statistics, for these three different groups of companies, for both Sample I and II.

Panel A of Table XII reports the summary statistics of key variables for UK domestic stand-alone companies, companies that are part of a UK domestic group, and companies that are part of a multinational group, based on Sample I. Around 70% of companies in Sample I are UK domestic stand-alone companies, and around 26% of companies are part of a multinational group. These figures for Sample II are 65% and 28%, respectively. Panel B of Table XII reports the same set of statistics for different groups of companies in Sample II. We define the internal leverage ratio as the ratio between the internal debt and the sum of

[50] For example, Huizinga et al. (2008) show that a foreign subsidiary's capital structure reflects local corporate tax rates and the tax rate differences between the parent firm and other foreign subsidiaries.
[51] Most countries have some form of thin capitalisation rule to combat excessive use of debt by subsidiaries of multinational companies. The UK does have such rules, though they are generally weaker than in other countries (Blouin et al., 2013).
[52] A caveat of our approach is that the ownership information is only available for the most recent year for each firm in FAME. Therefore, we need assume that firms' ownership structures did not change during the sample period.
[53] We define a company to be independent if no other company owns more than 50% of its total shares.

total debt and book equity.[54] For domestic stand-alone companies, the internal debt is almost always zero. For example, for our second sample, at the 75% percentile, companies do not have any internal debt at all. The mean internal leverage ratio is around 5% for these companies, considerably lower than 16% for companies that are part of a domestic group and 19% for companies that are part of a multinational group. The non-zero mean of internal leverage for this group of firms can be explained as the ownership status might have changed in the sample period and we cannot track this.

Table XII shows that domestic stand-alone companies are smaller than those belonging to a multinational group. To make sure that there is variation in the marginal tax rate for the two groups of companies, we present the histograms of different measures of marginal tax rates and the number of tax status changes within companies for these two groups in Appendix E. We observe rich variation in companies' tax status for both groups. We also find that companies that belong to a multinational group change their tax brackets more frequently than domestic stand-alone companies.[55]

Table XIII presents the GMM estimation results when the external leverage ratio instead of the overall leverage ratio is the dependent variable in Equation 2. We find a strong positive long-run tax effect on companies' external leverage when we pool different types of companies together (Columns 1 and 4). We do not report the result using the sample of firms that are part of a domestic group as they only consist of around 5% of the whole sample. We continue to find positive and substantial long-run tax effect on capital structures when we focus on domestic stand-alone companies (Columns 2 and 5). Companies that are part of a multinational group also increase their external leverage ratio when facing a higher marginal tax rate (Columns 3 and 6). We obtain somewhat mixed result comparing the sensitivity of external leverage toward changes in the tax incentives between the two types of firms. Based on Sample I, the estimated long-run tax effect on external leverage for the two types of firms are similar in terms of magnitude (1.000 in Column 2 versus 1.104 in Column 3). However, based on Sample II, we find the external leverage of firms that are part of a multinational group is much less sensitive to changes in tax incentives than that of domestic stand-alone firms (0.285 in Column 6 versus 0.920 in Column 5). This latter result is consistent with the

[54] The external and internal debt information is reported in FAME.
[55] For example, the proportion of firms that always stayed above or below the £300,000 threshold in Sample I and the proportion of firms that always make taxable profits (or taxable losses) in Sample II are both lower for multinational firms.

hypothesis that there is possible substitution between external and internal debt for companies that belong to a multinational group, as discussed in Desai et al. (2004).[56] Interestingly, we also find that companies that are a part of multinational group adjust their external leverage ratio much faster than domestic stand-alone companies (0.34 versus 0.27 based on Sample I, and 0.49 versus 0.29 based on Sample II). This suggests that the affiliation to a multinational corporation group helps reduce companies' adjustment costs associated with external borrowing.

## V. Discussions and Conclusions

In this paper, we analyse the effects of corporation tax on companies' capital structure. We combine data from confidential tax return data and financial statements for a panel of UK companies during the fiscal years 2001/2002-2009/2010. Our main identification relies on the existence of kinks in the corporate tax rate schedule in the United Kingdom which create variation in companies' incentives to borrow. Using a dynamic capital structure model we find a large and positive long-run effect of taxation on companies' leverage ratio. Our findings provide strong support for the trade-off theory of capital structure.

We find substantial differences between companies' true taxable income and taxable income estimated using their financial statements. We also find that the marginal tax rate according to the former has better explanatory power for companies' capital structures than the marginal tax rate based on the latter. Although we also identify positive and substantial corporation tax effects on leverage ratio in the framework of a static capital structure model, we provide evidence that companies gradually adjust their capital structure in response to changes in their marginal tax rates. Finally, we find evidence that corporate tax incentives affect the external leverage of both domestic and multinational companies. If a higher external leverage ratio leads to higher risk of financial distress or bankruptcy, our findings have important welfare implications and contribute to the on-going debate on whether preferential tax treatment for debt financing over equity financing contributes to instability in the economy.

[56] To understand the tax effects on capital structure for firms that are a part of a multinational group, one needs to estimate a more sophisticated model in which firms can simultaneously choose how much to borrow externally and internally, which is beyond the scope of the current study.

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## Table I: Statutory Marginal Tax Rates and Tax Brackets: 2001-2009

This table displays the statutory marginal corporate income tax rates and the corresponding tax bracket for UK companies during the fiscal years 2001/2002-2009/2010. A graphical illustration is provided by Figure 1 in the main text.

| Taxable profits | 2001/2002 | 2002/2003 to 2005/2006 | 2006/2007 | 2007/2008 | 2008/2009-2009/2010 |
|---|---|---|---|---|---|
| 0-10,000 | 10% | 0% | 19% | 20% | 21% |
| 10,001-50,000 | 22.5% | 23.75% | 19% | 20% | 21% |
| 50,001-300,000 | 20% | 19% | 19% | 20% | 21% |
| 300,001-1,500,000 | 32.5% | 32.75% | 32.75% | 32.5% | 29.75% |
| >1,500,000 | 30% | 30% | 30% | 30% | 28% |

## Table II: Summary Statistics of Key Variables

Panel A summarizes the statistics of key variables for firms in Sample I, which consists of 9,439 companies and 51,051 observations. We calculate the mean, the standard deviation (S.D.), the first quartile, the median, and the third quartile of firms' taxable profits, after-financing marginal tax rate (MTR), before-financing MTR, size, tangibility, profitability, and leverage ratio. Panel B summarize the statistics of the same set of variables for firms in Sample II, which consists of 16,124 companies and 93,259 observations. Definitions of these key variables are provided in Appendix A.

**A: Excluding loss-making observations (Sample I)**

| **Variables** | **Mean** | **S.D.** | **p25** | **p50** | **p75** | **No. obs.** |
|---|---|---|---|---|---|---|
| Taxable profits | 561,260 | 2,344,378 | 39,551 | 138,420 | 401,850 | 51,051 |
| After-financing MTR | 0.227 | 0.080 | 0.190 | 0.210 | 0.300 | 51,051 |
| Before-financing MTR | 0.244 | 0.067 | 0.190 | 0.238 | 0.330 | 51,051 |
| Size | 14.590 | 1.639 | 13.430 | 14.826 | 15.651 | 51,051 |
| Tangibility | 0.430 | 0.320 | 0.146 | 0.353 | 0.706 | 51,051 |
| Profitability | 0.086 | 0.104 | 0.026 | 0.055 | 0.108 | 51,051 |
| Leverage | 0.462 | 0.261 | 0.249 | 0.446 | 0.663 | 51,051 |

**B: Including loss-making observations (Sample II)**

| **Variables** | **Mean** | **S.D.** | **p25** | **p50** | **p75** | **No. obs.** |
|---|---|---|---|---|---|---|
| Taxable profits | 362,042 | 1,838,355 | 0.000 | 40,504 | 229,999 | 93,259 |
| After-financing MTR | 0.156 | 0.122 | 0.000 | 0.190 | 0.238 | 93,259 |
| Perfect-foresight MTR | 0.183 | 0.108 | 0.178 | 0.196 | 0.238 | 93,259 |
| Size | 14.771 | 1.672 | 13.649 | 14.931 | 15.798 | 93,259 |
| Tangibility | 0.444 | 0.320 | 0.156 | 0.386 | 0.726 | 93,259 |
| Profitability | 0.056 | 0.101 | 0.007 | 0.036 | 0.083 | 93,259 |
| Leverage | 0.502 | 0.264 | 0.291 | 0.500 | 0.715 | 93,259 |

**Table III: Transitional Probability Matrix of Taxable Profits from Year *t-1* to Year *t***

Panel A reports the transitional probability of taxable profits from one year to the next for firms in Sample I. For confidentiality reason, we groups observations in Sample I into three tax brackets: 0-£50,000, £50,000-300,000, >£300,000. Each number in the diagonal indicates the probability of the firm stays in the same tax bracket from year *t-1* to year *t*. Each off-diagonal number indicates the probability of the firm switching from one tax bracket to a different one from year *t-1* to year *t*. Panel B reports the transitional probability of taxable profits for firms in Sample II, including those making taxable losses.

**A. Sample I**

| | | t | | |
|---|---|---|---|---|
| | Taxable Profits | £0-50,000 | £50,000-300,000 | >£300,000 |
| | £0-50,000 | 73.68% | 23.04% | 3.28% |
| t-1 | £50,000-300,000 | 14.05% | 68.25% | 17.7% |
| | >£300,000 | 2.6% | 17.47% | 79.93% |

**B. Sample II:**

| | | t | | | |
|---|---|---|---|---|---|
| | Taxable Profits | Loss | £0-50,000 | £50-300,000 | >£300,000 |
| | Loss | 69.57% | 16.04% | 9.62% | 4.77% |
| t-1 | £0-50,000 | 19.98% | 59.02% | 18.30% | 2.70% |
| | £50,000-300,000 | 11.55% | 13.81% | 58.96% | 15.68% |
| | >£300,000 | 8.79% | 2.89% | 16.40% | 71.93% |

## Table IV: Number of Tax Status Changes within Companies

This table shows information on the number of times companies changed tax brackets. For both Sample I and Sample II we indicate how many companies do not change tax brackets at all, or change once, twice or more than twice.

| Number of changes | Number of companies | Percent of total companies | Number of observations | Percent of total observations |
|---|---|---|---|---|
| **Sample I: Total number of tax status changes** | | | | |
| 0 | 2,385 | 25.30% | 11,946 | 23.40% |
| 1 | 2,618 | 27.70% | 13,419 | 26.29% |
| 2 | 2,450 | 26.00% | 12,987 | 25.44% |
| >=3 | 1,986 | 21.10% | 12,699 | 24.88% |
| Total | 9,439 | 100% | 51,051 | 100% |
| **Sample I: Total number of moving in and out of the £300,000 tax bracket** | | | | |
| 0 | 6,167 | 65.34% | 32,001 | 62.68% |
| 1 | 1,506 | 15.96% | 8,173 | 16.01% |
| 2 | 1,145 | 12.13% | 6,508 | 12.75% |
| >=3 | 621 | 6.58% | 4369 | 8.56% |
| Total | 9,439 | 100% | 51,051 | 100% |
| **Sample II: Total number of tax status changes** | | | | |
| 0 | 3,308 | 20.50% | 16,882 | 18.10% |
| 1 | 3,449 | 21.40% | 17,836 | 19.13% |
| 2 | 4,091 | 25.40% | 22,274 | 23.88% |
| >=3 | 5,276 | 32.72% | 36,267 | 38.89% |
| Total | 16,124 | 100% | 93,259 | 100% |
| **Sample II: Total number of moving in and out of taxable losses** | | | | |
| 0 | 8,063 | 50.01% | 44,041 | 47.22% |
| 1 | 3,977 | 24.67% | 22,414 | 24.03% |
| 2 | 2,700 | 16.75% | 16,705 | 17.91% |
| >=3 | 1,384 | 8.58% | 10,099 | 10.83% |
| Total | 16,124 | 100% | 44,041 | 47.22% |

## Table V: Estimated Tax Effects on Leverage Based on Equation 2: Sample I

We report estimation results based on the error-correction model of capital structure as Equation 2:

$$(2)\ \Delta Lev_{i,t} = \alpha_0 + (\alpha_1 - 1)Lev_{i,t-1} + (\beta_1 + \beta_2)MTR_{i,t-1} + (\gamma_1 + \gamma_2)Z_{i,t-1} + \beta_1 \Delta MTR_{i,t} + \gamma_1 \Delta Z_{i,t} + \mu_i + \theta_t + \epsilon_{i,t}$$

We use Sample I for this table, which consists of 9,439 profit-making companies during the fiscal years 2001/2002-2009/2010. $Lev_{i,t}$ is the firm i's leverage ratio in year t, defined as (Total debt/Total debt+Book Equity). $MTR_{i,t}$ is the after-financing marginal tax rate (MTR) that firm i faced in year t. $Z_{i,t}$ is a vector of non-tax firm-level characteristics including firm size, tangibility, and profitability. Column 1 reports the OLS estimation result based on Equation 2. Column 2 reports the Within-Group estimation result when we control for firm-specific fixed effect. In Column 3, we instrument the current after-financing MTR by the current, the first to the third lags of the before-financing MTR. In Column 4, we instrument the current after-financing MTR by the second and the third lags of the after-financing MTR. In Column 5, we instrument the current after-financing MTR by the second and the third lags of the before-financing MTR. In Columns 6-7, we estimate Equation 2 using the GMM estimator, and we include the third and the forth lags of all the explanatory variables on the right-hand side of Equation 2 in the set of instruments. In Columns 6, the after-financing MTR is instrumented by its lags. In Column 7, the after-financing MTR is instrumented by the lags of the before-financing MTR. In all Columns, a set of year dummies are included. We compute the long-run coefficients on the after-financing MTR, profitability, size, and tangibility. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| Dependent variable: $\Delta Lev_{i,t}$ | OLS (1) | WG (2) | IVs (3) | IVs (4) | IVs (5) | GMM (6) | GMM (7) |
|---|---|---|---|---|---|---|---|
| $Lev_{i,t-1}$ | -0.110*** | -0.619*** | -0.732*** | -0.737*** | -0.742*** | -0.238*** | -0.222*** |
| | (0.002) | (0.008) | (0.015) | (0.015) | (0.016) | (0.034) | (0.034) |
| $MTR_{i,t-1}$ | -0.058*** | -0.073*** | -0.107** | 0.294** | 0.643** | 0.182** | 0.310*** |
| | (0.010) | (0.016) | (0.044) | (0.135) | (0.276) | (0.083) | (0.106) |
| $Profitability_{i,t-1}$ | -0.133*** | -0.568*** | -0.562*** | -0.641*** | -0.710*** | -0.272 | -0.323* |
| | (0.011) | (0.023) | (0.043) | (0.051) | (0.071) | (0.193) | (0.190) |
| $Size_{i,t-1}$ | -0.001** | 0.046*** | 0.067*** | 0.066*** | 0.064*** | 0.121* | 0.113* |
| | (0.001) | (0.005) | (0.009) | (0.009) | (0.010) | (0.072) | (0.069) |
| $Tangibility_{i,t-1}$ | 0.004** | 0.088*** | 0.108*** | 0.111*** | 0.114*** | -0.268* | -0.272** |
| | (0.002) | (0.013) | (0.022) | (0.022) | (0.023) | (0.137) | (0.129) |
| $\Delta MTR_{i,t}$ | -0.103*** | -0.076*** | -0.097*** | 0.272** | 0.593** | 0.203* | 0.196 |
| | (0.010) | (0.011) | (0.035) | (0.124) | (0.255) | (0.116) | (0.137) |
| $\Delta Profitability_{i,t}$ | -0.451*** | -0.512*** | -0.473*** | -0.542*** | -0.603*** | -0.163 | -0.222 |
| | (0.015) | (0.017) | (0.029) | (0.038) | (0.057) | (0.249) | (0.236) |
| $\Delta Tangibility_{i,t}$ | 0.120*** | 0.122*** | 0.088*** | 0.092*** | 0.096*** | -0.164 | -0.082 |
| | (0.011) | (0.013) | (0.018) | (0.019) | (0.019) | (0.166) | (0.156) |
| $\Delta Size_{i,t}$ | 0.107*** | 0.121*** | 0.124*** | 0.119*** | 0.115*** | 0.102 | 0.112 |
| | (0.005) | (0.006) | (0.010) | (0.010) | (0.011) | (0.073) | (0.076) |
| **Long-run coefficients** | | | | | | | |
| MTR | -0.525*** | -0.118*** | -0.146** | 0.399** | 0.867** | 0.764** | 1.397** |
| | (0.091) | (0.026) | (0.060) | (0.183) | (0.370) | (0.379) | (0.564) |
| Profitability | -1.202*** | -0.917*** | -0.768*** | -0.870*** | -0.958*** | -1.144 | -1.455 |
| | (0.103) | (0.039) | (0.059) | (0.069) | (0.093) | (0.828) | (0.890) |
| Size | -0.011** | 0.074*** | 0.092*** | 0.089*** | 0.087*** | 0.507* | 0.511* |
| | (0.005) | (0.008) | (0.012) | (0.012) | (0.013) | (0.296) | (0.304) |
| Tangibility | 0.034** | 0.141*** | 0.148*** | 0.151*** | 0.154*** | -1.127* | -1.229** |
| | (0.017) | (0.021) | (0.030) | (0.030) | (0.031) | (0.586) | (0.605) |
| Hansen test | | | 0.017 | 0.416 | 0.948 | 0.754 | 0.713 |
| Weak instrument | | | 0.000 | 0.000 | 0.000 | | |
| F-statistics | | | 799.232 | 121.863 | 24.813 | | |
| AR(1) | | | | | | 0.000 | 0.000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AR(2) | | | | | | 0.001 | 0.000 |
| AR(3) | | | | | | 0.620 | 0.728 |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Company FE | No | Yes | Yes | Yes | Yes | Yes | Yes |
| No. of groups | 9,439 | 9,439 | 9,439 | 9,439 | 9,439 | 9,439 | 9,439 |
| No. of obs. | 41,612 | 41,612 | 32,173 | 32,173 | 32,173 | 32,173 | 32,173 |
| R-squared | 0.178 | 0.424 | 0.450 | 0.432 | 0.384 | NA | NA |

**Table VI: The Effects of MTR and AETR on Capital Structure (Sample I)**

This table presents the GMM estimation results based Equation 2. Column 1 is identical to Column 7 in Table V. In Column 2, we replace MTR by AETR in Equation 2. AETR is the firms' average effective tax rate, which is constructed by dividing total corporate income taxes paid by the amount of taxable income. In Column 3, we include both $AETR_{i,t-1}$ and $\Delta AETR_{i,t}$ on the right-hand side of Equation 2 as additional explanatory variables. We include the third and the forth lags of all the explanatory variables in each specification in the set of instruments for the GMM estimations. In all Columns, a set of year dummies are included. We compute the long-run coefficients on the after-financing marginal tax rate and the average effective tax rate. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

| Dependent variable: $\Delta Lev_{i,t}$ | GMM (1) | GMM (2) | GMM (3) |
|---|---|---|---|
| $Lev_{i,t-1}$ | -0.222*** | -0.234*** | -0.239*** |
| | (0.034) | (0.034) | (0.033) |
| $MTR_{i,t-1}$ | 0.310*** | | 0.198** |
| | (0.106) | | (0.092) |
| $AETR_{i,t-1}$ | | 0.046 | -0.006 |
| | | (0.086) | (0.040) |
| $Profitability_{i,t-1}$ | -0.323* | -0.243 | -0.318 |
| | (0.190) | (0.196) | (0.193) |
| $Size_{i,t-1}$ | 0.113* | 0.104 | 0.100 |
| | (0.069) | (0.068) | (0.061) |
| $Tangibility_{i,t-1}$ | -0.272** | -0.282** | -0.218* |
| | (0.129) | (0.123) | (0.116) |
| $\Delta MTR_{i,t}$ | 0.196 | | 0.213* |
| | (0.137) | | (0.112) |
| $\Delta AETR_{i,t}$ | | 0.027 | -0.006 |
| | | (0.048) | (0.020) |
| $\Delta Profitability_{i,t}$ | -0.222 | -0.173 | -0.205 |
| | (0.236) | (0.256) | (0.233) |
| $\Delta Tangibility_{i,t}$ | -0.082 | -0.199 | -0.152 |
| | (0.156) | (0.161) | (0.157) |
| $\Delta Size_{i,t}$ | 0.112 | 0.086 | 0.115* |
| | (0.076) | (0.078) | (0.070) |
| **Long-run coefficients** | | | |
| MTR | 1.397** | | 0.832** |
| | (0.564) | | (0.406) |
| AETR | | 0.196 | -0.024 |
| | | (0.375) | (0.169) |
| Hansen test | 0.713 | 0.727 | 0.874 |
| AR(1) | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.001 |
| AR(3) | 0.728 | 0.757 | 0.635 |
| Year dummies | Yes | Yes | Yes |
| Company FE | Yes | Yes | Yes |
| No. of groups | 9,439 | 9,439 | 9,439 |
| No. of obs. | 32,173 | 32,173 | 32,173 |

## Table VII: Estimated Tax Effects on Leverage: Sample II

We report estimation results based on the error-correction model of capital structure as Equation 2 using Sample II, which consists of 16,124 companies during the fiscal years 2001/2002-2009/2010. In Columns 1-4, we use the statutory after-financing marginal tax rate as a proxy for the corporate tax incentives for using debt. In Columns 5-9, we use the perfect-foresight marginal tax rate as a proxy for the corporate tax incentives for using debt. In the IVs estimations in Column 3 (or 7), we instrument the current after-financing MTR by the second and the third lags of the after-financing statutory (or perfect-foresight) MTR. All variables are defined as in Table V, and $PMTR_{i,t}$ denotes the "perfect-foresight" MTR for firm i in year *t*. In the GMM estimations in Column 4 (or 8), we instrument the current after-financing MTR by the third and the forth lags of the after-financing statutory (or perfect-foresight) MTR, and we also include the third and the forth lags of all other right-hand side variables in the set of instruments. In Column 9, we drop the first or the last observation for each company if it reported a taxable loss, and conduct the GMM estimation with the smaller sample. A set of common year dummies are included in all columns. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | **Statutory MTR** | | | | **"Perfect-foresight" MTR** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: $\Delta Lev_{i,t}$ | (1) OLS | (2) WG | (3) IVs | (4) GMM | (5) OLS | (6) WG | (7) IVs | (8) GMM | (9) GMM |
| $Lev_{i,t-1}$ | -0.099*** | -0.629*** | -0.663*** | -0.250*** | -0.097*** | -0.630*** | -0.655*** | -0.247*** | -0.203*** |
| | (0.002) | (0.007) | (0.010) | (0.024) | (0.002) | (0.007) | (0.010) | (0.024) | (0.026) |
| $MTR_{i,t-1}$ | -0.098*** | -0.119*** | 0.280*** | 0.261*** | | | | | |
| | (0.005) | (0.010) | (0.057) | (0.054) | | | | | |
| $PMTR_{i,t-1}$ | | | | | -0.071*** | -0.100*** | 0.356*** | 0.242*** | 0.226*** |
| | | | | | (0.005) | (0.011) | (0.087) | (0.062) | (0.079) |
| $Profitability_{i,t-1}$ | -0.238*** | -0.721*** | -0.946*** | -0.376*** | -0.257*** | -0.750*** | -0.938*** | -0.268* | -0.435** |
| | (0.011) | (0.019) | (0.041) | (0.144) | (0.011) | (0.019) | (0.042) | (0.141) | (0.193) |
| $Size_{i,t-1}$ | -0.002*** | 0.043*** | 0.050*** | -0.003 | -0.002*** | 0.044*** | 0.046*** | 0.026 | 0.033 |
| | (0.000) | (0.004) | (0.006) | (0.055) | (0.000) | (0.004) | (0.006) | (0.051) | (0.081) |
| $Tangibility_{i,t-1}$ | -0.004** | 0.055*** | 0.056*** | 0.027 | -0.004*** | 0.056*** | 0.056*** | -0.036 | -0.193** |
| | (0.001) | (0.010) | (0.013) | (0.079) | (0.001) | (0.010) | (0.013) | (0.072) | (0.084) |
| $\Delta MTR_{i,t}$ | -0.114*** | -0.086*** | 0.322*** | 0.359*** | | | | | |
| | (0.005) | (0.006) | (0.058) | (0.107) | | | | | |
| $\Delta PMTR_{i,t}$ | | | | | -0.111*** | -0.077*** | 0.493*** | 0.361*** | 0275*** |
| | | | | | (0.007) | (0.008) | (0.110) | (0.121) | (0.127) |
| $\Delta Profitability_{i,t}$ | -0.551*** | -0.613*** | -0.786*** | -0.558*** | -0.577*** | -0.636*** | -0.741*** | -0.490*** | 0.275** |
| | (0.012) | (0.014) | (0.033) | (0.181) | (0.012) | (0.013) | (0.029) | (0.164) | (0.127) |
| $\Delta Tangibility_{i,t}$ | 0.064*** | 0.062*** | 0.062*** | 0.037 | 0.065*** | 0.063*** | 0.056*** | 0.035 | -0.647*** |
| | (0.008) | (0.009) | (0.012) | (0.114) | (0.008) | (0.009) | (0.012) | (0.107) | (0.224) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\Delta Size_{i,t}$ | 0.116*** | 0.120*** | 0.119*** | 0.062 | 0.116*** | 0.120*** | 0.116*** | 0.074 | -0.079 |
| | (0.004) | (0.005) | (0.007) | (0.070) | (0.004) | (0.005) | (0.007) | (0.067) | (0.120) |
| **Long-run coefficients** | | | | | | | | | |
| MTR | -0.991*** | -0.189*** | 0.423*** | 1.044*** | | | | | |
| | (0.050) | (0.015) | (0.085) | (0.243) | | | | | |
| PMTR | | | | | -0.731*** | -0.160*** | 0.543*** | 0.980*** | 1.115** |
| | | | | | (0.053) | (0.018) | (0.134) | (0.279) | (0.443) |
| Profitability | -2.397*** | -1.145*** | -1.428*** | -1.504** | -2.649*** | -1.190*** | -1.432*** | -1.084* | -2.146** |
| | (0.118) | (0.034) | (0.063) | (0.591) | (0.120) | (0.033) | (0.068) | (0.575) | (0.939) |
| Size | -0.020*** | 0.068*** | 0.075*** | -0.012 | -0.022*** | 0.069*** | 0.070*** | 0.107 | 0.162 |
| | (0.003) | (0.007) | (0.009) | (0.218) | (0.003) | (0.007) | (0.009) | (0.209) | (0.409) |
| Tangibility | -0.037** | 0.088*** | 0.084*** | 0.109 | -0.040*** | 0.089*** | 0.086*** | -0.144 | -0.951** |
| | (0.015) | (0.016) | (0.020) | (0.315) | (0.015) | (0.016) | (0.020) | (0.294) | (0.459) |
| Weak Inst. | | | 0.000 | | | | 0.000 | | |
| Hansen test | | | 0.759 | 0.121 | | | 0.242 | 0.079 | 0.607 |
| AR(1) | | | | 0.000 | | | | 0.000 | 0.000 |
| AR(2) | | | | 0.004 | | | | 0.002 | 0.000 |
| AR(3) | | | | 0.888 | | | | 0.592 | 0.330 |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Company FE | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| No. of groups | 16,124 | 16,124 | 16,124 | 16,124 | 16,124 | 16,124 | 16,124 | 16,124 | 15,158 |
| No. of obs. | 61,011 | 61,011 | 61,011 | 61,011 | 61,011 | 61,011 | 61,011 | 61,011 | 50,906 |

**Table VIII: Correspondence between Tax Returns and Accounting Data in terms of Companies' Taxable Profits**

We observe companies' taxable profits in the tax returns and estimate their taxable profits based on the financial statements. We then calculate the correspondence of tax brackets between the tax returns and the accounting data. For confidentiality reason, we group the tax brackets £0-10,000 and £10,000-50,000 together. For firms in each tax bracket according to the tax returns (CT600), we calculate the percentages of these firms in different tax brackets according to the estimated taxable profits based on firms' financial statements. Figures in each row would add up to unity. Taxable income is reported as zero in CT600 if the firm makes zero or negative taxable income.

**Sample I**

| | | Accounting data (FAME) | | | |
|---|---|---|---|---|---|
| | Taxable Profits | Loss | £0-50,000 | £50,000-300,000 | >£300,000 |
| | £0-50,000 | 8% | 74% | 14% | 4% |
| CT600 | £50,000-300,000 | 2% | 7% | 80% | 11% |
| | >£300,000 | 1% | 0% | 9% | 90% |

**Sample II**

| | | Accounting data (FAME) | | | |
|---|---|---|---|---|---|
| | Taxable Profits | Loss | £0-50,000 | £50,000-300,000 | >£300,000 |
| | Loss | 49.2% | 16.5% | 17.6% | 16.7% |
| CT600 | £0-50,000 | 10.4% | 66.7% | 17.1% | 5.9% |
| | £50,000-300,000 | 2.4% | 7.1% | 78% | 12.5% |
| | >£300,000 | 1.1% | 0.3% | 8.7% | 89.9% |

**Table IX: Correlation between Different Versions of the Marginal Tax Rate (Sample I)**

In this table, we calculate the partial correlations between different versions of the marginal tax rate. MTR is the after-financing marginal tax rate, calculated based on companies' taxable profits (Box 37 in CT600) in the tax returns. $MTR_{before}$ is the before-financing marginal tax rate, calculated based on companies' taxable profits reported in the tax returns plus interest expenses. $MTR^{A}$ is the after-financing marginal tax rate calculated based on the estimated taxable profits according to companies' financial statement. $MTR^{A}_{before}$ is the before-financing marginal tax rate calculated based on the estimated taxable profits before interest deduction according to financial statements. We calculate these partial correlations using Sample I, which consists of 9,439 companies and 51,051 observations during the fiscal years 2001/2002-2009/2010.

| | MTR | $MTR_{before}$ | $MTR^{A}$ | $MTR^{A}_{before}$ |
|---|---|---|---|---|
| MTR | 1 | | | |
| $MTR_{before}$ | 0.703 | 1 | | |
| $MTR^{A}$ | 0.688 | 0.594 | 1 | |
| $MTR^{A}_{before}$ | 0.618 | 0.737 | 0.773 | 1 |

## Table X: Which Marginal Tax Rate Better Capture Tax Incentives for Borrowing? Comparison of the GMM Estimation Results

We report the GMM estimation results of Equation 2 where we calculate the marginal tax rate based on either the tax returns or the financial statements. Columns 1-4 are estimation results of Equation 2 based on Sample I, and Column 5-8 are estimation results of Equation 2 based on Sample II. In all these GMM estimations, we include the third and the forth lags of leverage ratio, marginal tax rate and other control variables in the set of instruments. In Columns 1, 2, 5, and 6, we instrument the current after-financing MTR by the third and the forth lags of the after-financing MTR. In Columns 3-4, we instrument the current after-financing MTR by the third and the forth lags of the before-financing MTR. In Columns 7-8, we instrument the current perfect-foresight MTR (PMTR) by its third and fourth lags. To reduce measurement errors in the PMTR, we drop the first and the last observations if the company was in the loss-making position according to either the tax returns (Column 7) or the financial statements (Column 8). Year dummies and company-specific fixed effects are included in all columns. Short-run dynamics are included in each column. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | **Sample I** | | | | **Sample II** | | | |
|---|---|---|---|---|---|---|---|---|
| Dependent variable: $\Delta Lev_{i,t}$ | After-financing statutory MTR | | | | After-financing statutory MTR | | Perfect foresight MTR PMTR | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Convergence speed** | | | | | | | | |
| $Lev_{i,t-1}$ | -0.238*** | -0.248*** | -0.222*** | -0.241*** | -0.250*** | -0.245*** | -0.203*** | -0.211*** |
| | (0.034) | (0.034) | (0.034) | (0.035) | (0.024) | (0.024) | (0.026) | (0.026) |
| **Long-run coefficients** | | | | | | | | |
| MTR | 0.764** | | 1.397** | | 1.044*** | | | |
| | (0.379) | | (0.564) | | (0.243) | | | |
| $MTR^A$ | | 0.063 | | 0.499 | | 0.639** | | |
| | | (0.455) | | (0.603) | | (0.291) | | |
| PMTR | | | | | | | 1.115** | |
| | | | | | | | (0.443) | |
| $PMTR^A$ | | | | | | | | 0.958 |
| | | | | | | | | (0.601) |
| Hansen test | 0.754 | 0.535 | 0.713 | 0.702 | 0.383 | 0.125 | 0.607 | 0.567 |
| AR(1) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(3) | 0.620 | 0.762 | 0.728 | 0.763 | 0.438 | 0.411 | 0.330 | 0.269 |
| No. of groups | 9,439 | 9,439 | 9,439 | 9,439 | 16,124 | 16,124 | 15,158 | 15,747 |
| No. of obs. | 32,173 | 32,173 | 32,173 | 32,173 | 61,011 | 61,011 | 50,906 | 54,797 |

## Table XI: Estimated Tax Effects on Leverage based on the Static and the Lag Distributed (LD) Model

We estimate a static capital structure model in Columns 1 and 4 specified as Equation 3:

$$(3)\ Lev_{i,t} = \alpha_0 + \beta_1 MTR_{i,t} + \gamma_2 Z_{i,t} + \mu_i + \theta_t + \epsilon_{i,t}$$

Where MTR is the after-financing marginal tax rate based on companies' tax returns, and Z includes firm size, tangibility, and profitability. We estimate Equation 3 using the two-stage least square estimator. We use up to the forth lags of the after-financing MTR as instruments for the current after-financing MTR. In Columns 3 and 6, we estimate a lag distributed model of capital structure specified as Equation 4:

$$(4)\ Lev_{i,t} = \alpha_0 + \beta_1 MTR_{i,t} + \beta_2 MTR_{i,t-1} + \beta_3 MTR_{i,t-2} + \beta_4 MTR_{i,t-3} + \gamma_1 Z_{i,t} + \gamma_2 Z_{i,t-1} + \gamma_3 Z_{i,t-2} + \gamma_4 Z_{i,t-3} + \mu_i + \theta_t + \epsilon_{i,t}$$

We estimate Equation 4 using the two-stage least square estimator. More specifically, we use the forth lag of the after-financing MTR together with the third and the forth lags of the before-financing MTR as instruments for the current after-financing MTR since the after-financing MTR dated at t-1, t-2, and t-3 are already included on the right-hand side. In Column 6, we use the forth and the fifth lags of the after-financing MTR together with the third, the forth and the fifth of the perfect-foresight MTR as instruments for the current after-financing MTR. We control for firm-level fixed effect and a set of common year dummies in all these columns. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | Sample I | | | Sample II | | |
|---|---|---|---|---|---|---|
| Dependent variable: $Lev_{i,t}$ | (1) Static | (2) Static | (3) LD | (4) Static | (5) Static | (6) LD |
| $MTR_{i,t}$ | 0.601** | 0.351** | 0.346** | 0.289*** | 0.219*** | 0.293*** |
| | (0.133) | (0.153) | (0.162) | (0.086) | (0.058) | (0.096) |
| $MTR_{i,t-1}$ | | | 0.027 | | | -0.009 |
| | | | (0.030) | | | (0.017) |
| $MTR_{i,t-2}$ | | | 0.052* | | | 0.059*** |
| | | | (0.028) | | | (0.020) |
| $MTR_{i,t-3}$ | | | 0.027 | | | 0.034** |
| | | | (0.021) | | | (0.016) |
| $Profitability_{i,t}$ | -0.533*** | | -0.554*** | -0.654*** | | -0.758*** |
| | (0.039) | | (0.046) | (0.046) | | (0.062) |
| $Profitability_{i,t-1}$ | | -0.159*** | -0.274*** | | -0.233*** | -0.422*** |
| | | (0.026) | (0.037) | | (0.019) | (0.034) |
| $Profitability_{i,t-2}$ | | | -0.179*** | | | -0.316*** |
| | | | (0.032) | | | (0.031) |
| $Profitability_{i,t-3}$ | | | -0.138*** | | | -0.197*** |
| | | | (0.029) | | | (0.026) |
| $Size_{i,t}$ | 0.103*** | | 0.115*** | 0.090*** | | 0.113*** |
| | (0.010) | | (0.014) | (0.009) | | (0.012) |
| $Size_{i,t-1}$ | | 0.041*** | -0.004 | | 0.036*** | -0.013* |
| | | (0.008) | (0.009) | | (0.007) | (0.007) |
| $Size_{i,t-2}$ | | | -0.020** | | | -0.009 |
| | | | (0.008) | | | (0.006) |
| $Size_{i,t-3}$ | | | -0.042*** | | | -0.034*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (0.008) | | | (0.007) |
| $Tangibility_{i,t}$ | 0.114*** | | 0.075*** | 0.071*** | | 0.048*** |
| | (0.021) | | (0.021) | (0.016) | | (0.017) |
| $Tangibility_{i,t-1}$ | | 0.090*** | 0.058*** | | 0.060*** | 0.022 |
| | | (0.018) | (0.019) | | (0.015) | (0.015) |
| $Tangibility_{i,t-2}$ | | | 0.027 | | | 0.019 |
| | | | (0.019) | | | (0.014) |
| $Tangibility_{i,t-3}$ | | | -0.014 | | | -0.006 |
| | | | (0.019) | | | (0.014) |
| **Long-run tax effect** | | | 0.452** | | | 0.378*** |
| | | | (0.203) | | | (0.135) |
| Weak instrument (F-statistics) | 263.718 | 114.106 | 34.551 | 229.817 | 184.937 | 31.756 |
| Hansen test | 0.582 | 0.627 | 0.679 | 0.055 | 0.240 | 0.648 |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes |
| No. of groups | 5,632 | 5,632 | 3,467 | 10,646 | 10,646 | 5,041 |
| No. of obs. | 18,927 | 18,927 | 11,130 | 28,764 | 28,764 | 15,938 |

## Table XII: Summary Statistics of Key Variables for Domestic and Multinational Companies

We calculate the summary statistics of key variables for three sub-samples of firms: the UK domestic stand-alone firms, firms that are a part of a UK domestic group, and firms that are a part of a multinational group.

### A: Sample I

| **Domestic stand-alone** | Mean | S.D. | p25 | p50 | p75 | No. Obs. |
|---|---|---|---|---|---|---|
| Taxable profits | 290,360 | 948,854 | 28,391 | 93,775 | 279,522 | 34,645 |
| Size | 14.124 | 1.557 | 12.934 | 14.289 | 15.272 | 34,645 |
| Tangibility | 0.461 | 0.328 | 0.163 | 0.394 | 0.774 | 34,645 |
| Profitability | 0.092 | 0.114 | 0.026 | 0.056 | 0.115 | 34,645 |
| Total leverage | 0.470 | 0.264 | 0.253 | 0.453 | 0.675 | 34,645 |
| Internal leverage ratio | 0.050 | 0.110 | 0.000 | 0.000 | 0.000 | 34,645 |
| **Companies belonging to a domestic group** | | | | | | |
| Taxable profits | 681,761 | 1,738,484 | 73,445 | 214,395 | 602,303 | 2,821 |
| Size | 15.414 | 1.282 | 14.626 | 15.363 | 16.123 | 2,821 |
| Tangibility | 0.434 | 0.321 | 0.151 | 0.350 | 0.735 | 2,821 |
| Profitability | 0.062 | 0.064 | 0.020 | 0.046 | 0.086 | 2,821 |
| Total leverage | 0.476 | 0.251 | 0.271 | 0.470 | 0.668 | 2,821 |
| Internal leverage ratio | 0.115 | 0.194 | 0.000 | 0.005 | 0.155 | 2,821 |
| **Companies belonging to a multinational group** | | | | | | |
| Taxable profits | 1,227,098 | 4,134,946 | 109,937 | 318,880 | 850,636 | 13,585 |
| Size | 15.608 | 1.358 | 14.861 | 15.506 | 16.303 | 13,585 |
| Tangibility | 0.350 | 0.285 | 0.111 | 0.270 | 0.522 | 13,585 |
| Profitability | 0.073 | 1.358 | 0.026 | 0.055 | 0.098 | 13,585 |
| Total leverage | 0.440 | 0.285 | 0.232 | 0.422 | 0.633 | 13,585 |
| Internal leverage ratio | 0.142 | 0.222 | 0.000 | 0.013 | 0.213 | 13,585 |

### B: Sample II

| **Domestic stand-alone** | Mean | S.D. | p25 | p50 | p75 | No. Obs. |
|---|---|---|---|---|---|---|
| Taxable profits | 194,761 | 781,047 | 0.000 | 34,094 | 161,268 | 59,978 |
| Size | 14.245 | 1.566 | 13.069 | 14.432 | 15.351 | 59,978 |
| Tangibility | 0.476 | 0.325 | 0.178 | 0.430 | 0.784 | 59,978 |
| Profitability | 0.061 | 0.109 | 0.008 | 0.037 | 0.087 | 59,978 |
| Total leverage | 0.502 | 0.264 | 0.291 | 0.497 | 0.715 | 59,978 |
| Internal leverage ratio | 0.050 | 0.142 | 0.000 | 0.000 | 0.000 | 59,978 |
| **Companies belonging to a domestic group** | | | | | | |
| Taxable profits | 380,478 | 1,303,293 | 0.000 | 39,598 | 280,755 | 5,873 |
| Size | 15.519 | 1.370 | 14.672 | 15.454 | 16.352 | 5,873 |
| Tangibility | 0.473 | 0.335 | 0.163 | 0.412 | 0.808 | 5,873 |
| Profitability | 0.040 | 0.077 | 0.004 | 0.026 | 0.065 | 5,873 |
| Total leverage | 0.537 | 0.262 | 0.326 | 0.550 | 0.755 | 5,873 |
| Internal leverage ratio | 0.158 | 0.238 | 0.000 | 0.028 | 0.232 | 5,873 |
| **Companies belonging to a multinational group** | | | | | | |
| Taxable profits | 724,163 | 3,099,718 | 0.000 | 77,150 | 441,502 | 18,214 |
| Size | 15.763 | 1.427 | 14.904 | 15.634 | 16.524 | 18,214 |
| Tangibility | 0.369 | 0.292 | 0.117 | 0.299 | 0.565 | 18,214 |
| Profitability | 0.048 | 0.083 | 0.008 | 0.036 | 0.079 | 18,214 |
| Total leverage | 0.496 | 0.262 | 0.286 | 0.494 | 0.705 | 18,214 |
| Internal leverage ratio | 0.190 | 0.257 | 0.000 | 0.048 | 0.328 | 18,214 |

## Table XIII: Corporate Tax Effects on Companies' External Leverage: Domestic versus Multinational Companies

We report the GMM estimation results based on Equation 2 where the dependent variable is the first difference of companies' external leverage ratio (ExLev). In Columns 1 and 4, we use all firms in Sample I or Sample II for the GMM estimations. In Columns 2 and 5, we run the GMM estimations using the sub-sample of domestic stand-alone firms. In Columns 3 and 6, we run the GMM estimations using the sub-sample of firms that are part of a multinational group. We include the third and the forth lags of leverage ratio, marginal tax rate and other control variables in the set of instruments. Firm-level fixed effect and year dummies are included in all columns. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | Sample I | | | Sample II | | |
|---|---|---|---|---|---|---|
| Dependent variable: $\Delta ExLev_{i,t}$ | (1) Full sample | (2) Domestic stand alone | (3) Multinationals | (4) Full sample | (5) Domestic stand alone | (6) Multinationals |
| $ExLev_{i,t-1}$ | -0.236*** | -0.262*** | -0.336*** | -0.299*** | -0.285*** | -0.490*** |
| | (0.034) | (0.040) | (0.072) | (0.029) | (0.040) | (0.067) |
| $MTR_{i,t-1}$ | 0.177** | 0.262** | 0.371** | 0.156*** | 0.262*** | 0.140* |
| | (0.080) | (0.115) | (0.161) | (0.059) | (0.079) | (0.077) |
| $Profitability_{i,t-1}$ | -0.265 | -0.333* | -0.061 | -0.429*** | -0.538*** | -0.183 |
| | (0.173) | (0.197) | (0.282) | (0.153) | (0.189) | (0.207) |
| $Size_{i,t-1}$ | 0.047 | 0.010 | -0.023 | -0.112* | -0.082 | -0.076** |
| | (0.067) | (0.081) | (0.067) | (0.059) | (0.072) | (0.039) |
| $Tangibility_{i,t-1}$ | -0.191 | -0.099 | -0.255 | 0.120 | 0.210* | 0.065 |
| | (0.129) | (0.142) | (0.195) | (0.084) | (0.110) | (0.084) |
| $\Delta MTR_{i,t}$ | 0.169 | -0.047 | 0.241 | 0.263** | 0.494*** | 0.264** |
| | (0.108) | (0.146) | (0.213) | (0.114) | (0.145) | (0.110) |
| $\Delta Profitability_{i,t}$ | -0.207 | -0.139 | 0.202 | -0.461** | -0.884*** | -0.073 |
| | (0.214) | (0.201) | (0.298) | (0.204) | (0.229) | (0.199) |
| $\Delta Tangibility_{i,t}$ | -0.084 | 0.100 | 0.029 | -0.083 | 0.061 | -0.063 |
| | (0.160) | (0.149) | (0.212) | (0.130) | (0.127) | (0.162) |
| $\Delta Size_{i,t}$ | 0.068 | 0.044 | 0.039 | 0.015 | 0.060 | -0.051 |
| | (0.065) | (0.086) | (0.082) | (0.075) | (0.092) | (0.043) |
| **Long-run coefficient** | | | | | | |
| MTR | 0.749** | 1.000** | 1.104** | 0.522** | 0.920*** | 0.285* |
| | (0.368) | (0.498) | (0.545) | (0.214) | (0.319) | (0.167) |
| Hansen test | 0.280 | 0.295 | 0.594 | 0.066 | 0.067 | 0.060 |
| AR(1) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.615 | 0.001 | 0.000 | 0.919 |
| AR(3) | 0.984 | 0.984 | 0.711 | 0.203 | 0.928 | 0.151 |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Company FE | Yes | Yes | Yes | Yes | Yes | Yes |
| No. of groups | 9,439 | 6,466 | 2,458 | 16,124 | 10,545 | 4,597 |
| No. of obs. | 32,173 | 21,713 | 8,669 | 61,011 | 38,888 | 18,214 |

## Appendix A: Definition of variables

*Taxable income in tax returns***:** box 37 in CT600, which reports companies' actual taxable income after deducting interest expenses.

*Estimated taxable income in financial statement***:** we estimate companies' taxable income using financial statements by adding tax expenses to net income, which includes minority interest.

*Statutory after-financing marginal tax rate (MTR)***:** this is calculated based on companies' taxable income (either reported in tax returns or estimated based on financial statements, the latter is labelled as $MTR^A$) after deducting interest expenses. For loss-making companies, this measure equals to zero.

*Statutory before-financing marginal tax rate* ($MTR_{before}$)*:* this is calculated based on companies' taxable income (either reported in tax returns or estimated based on financial statements, the latter is labelled as $MTR^A_{before}$) before deducting interest expenses. If a firm's before-financing taxable profit is non-positive, this measure is set to be zero.

*Perfect-foresight after-financing marginal tax rate (PMTR)*: see details in Appendix D. The corresponding measure based on financial statements is labelled as $PMTR^A$.

*Leverage ratio (LEV)*: this is defined as $\frac{LTD+STD}{LTD+STD+BE}$, where LTD is long-term debt, STD is short-term debt, and BE is the value of the company's book equity, all of which are obtained from companies' balance sheets provided by FAME.

*Average effective tax rate (AETR)*: this is defined as the ratio between gross corporate income tax paid and taxable income. Both the numerator and the denominator are obtained from the tax returns.

*External leverage ratio* (*EXLEV*): this is constructed as $\frac{External\ debt}{Total\ debt}$. Total debt is the sum of internal and external debt, both reported in FAME.

*Profitability*: this is the ratio of net income (profits/loss for the period) to total assets. Both the numerator and the denominator are obtained from FAME.

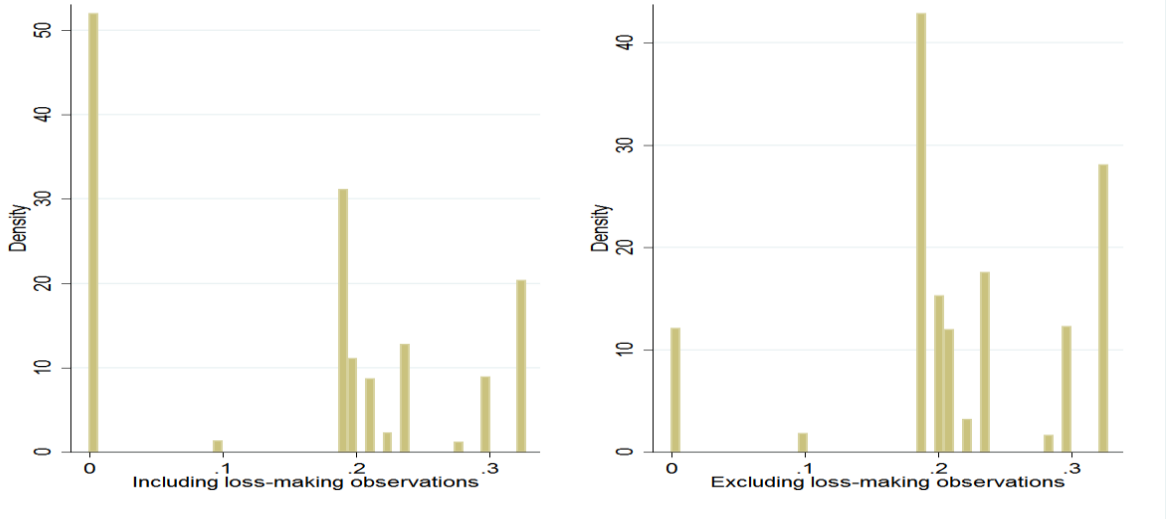
*Tangibility*: this is the ratio of tangible fixed assets to total assets. Both the numerator and the denominator are obtained from FAME.

*Size*: this is proxied as the logarithm of companies' total assets.

## Appendix B: Distribution of the marginal tax rate for Sample II

The left panel of Figure B plots the distribution of the after-financing statutory marginal tax rate for companies in Sample II. We cannot measure the before-financing marginal tax rate for this sample as taxable profit reported in the tax returns is recorded as zero if a company makes a loss.[57] In total, around 28% of company-year observations in this sample reported taxable losses. In the right panel of Figure B, we plot the distribution of the after-financing statutory marginal tax rate excluding loss-making observations from Sample II. As companies with taxable profits less than £10,000 were subject to a zero tax rate during the fiscal years 2002/2003 to 2005/2006, we still observe a mass at zero although this is a considerably smaller mass relative to that in the left panel of Figure B.

**Figure B: Distribution of the after-financing marginal tax rate (Sample II)**




[57] When this paper was written, the tax return data did not provide sufficient information for calculating the total loss arising in each fiscal year. This would be a natural extension when such information becomes available in the future.

## Appendix C: Distribution of taxable income

In this appendix, we provide the histograms of taxable income based on Sample I to illustrate firms' bunching behaviour. Figure C.1 shows the entire distribution of taxable income for firms in Sample I. Figures C.2-C.5 show the distribution of taxable income around the £10,000, £50,000, £300,000, and £1,500,000 thresholds, respectively. In Figures C.2-C.5, we distinguish between taxable income, before-financing taxable income, and taxable income before deducting capital allowances.

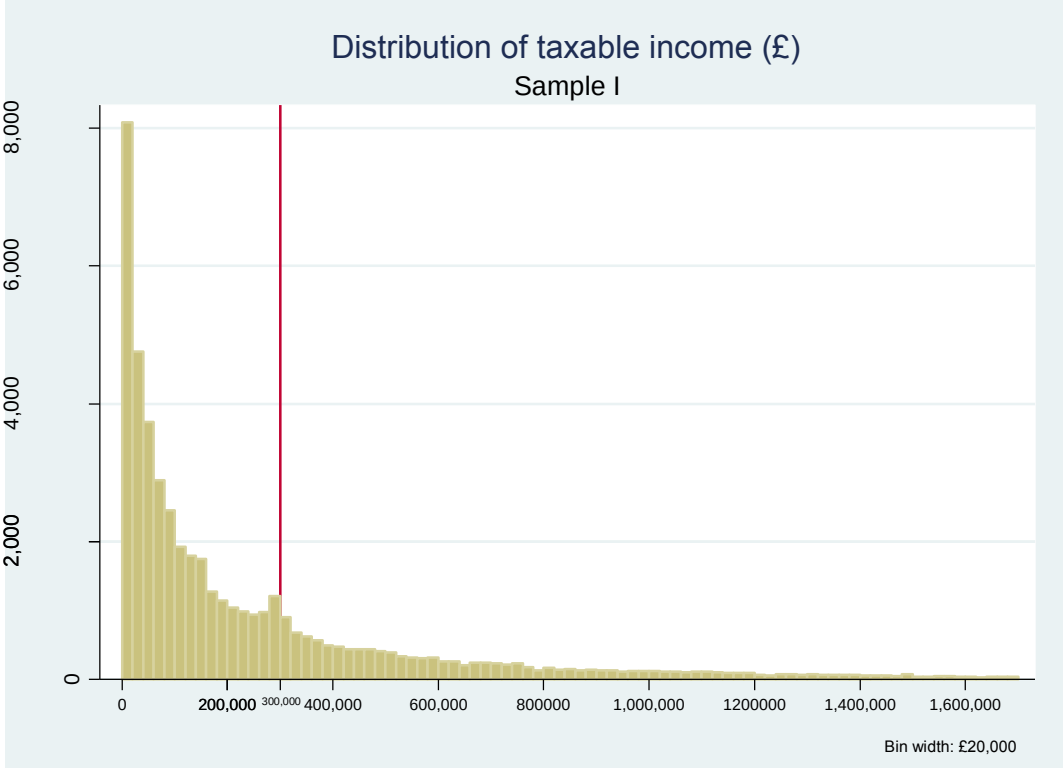



**Figure C.1: Distribution of taxable income (Sample I).**

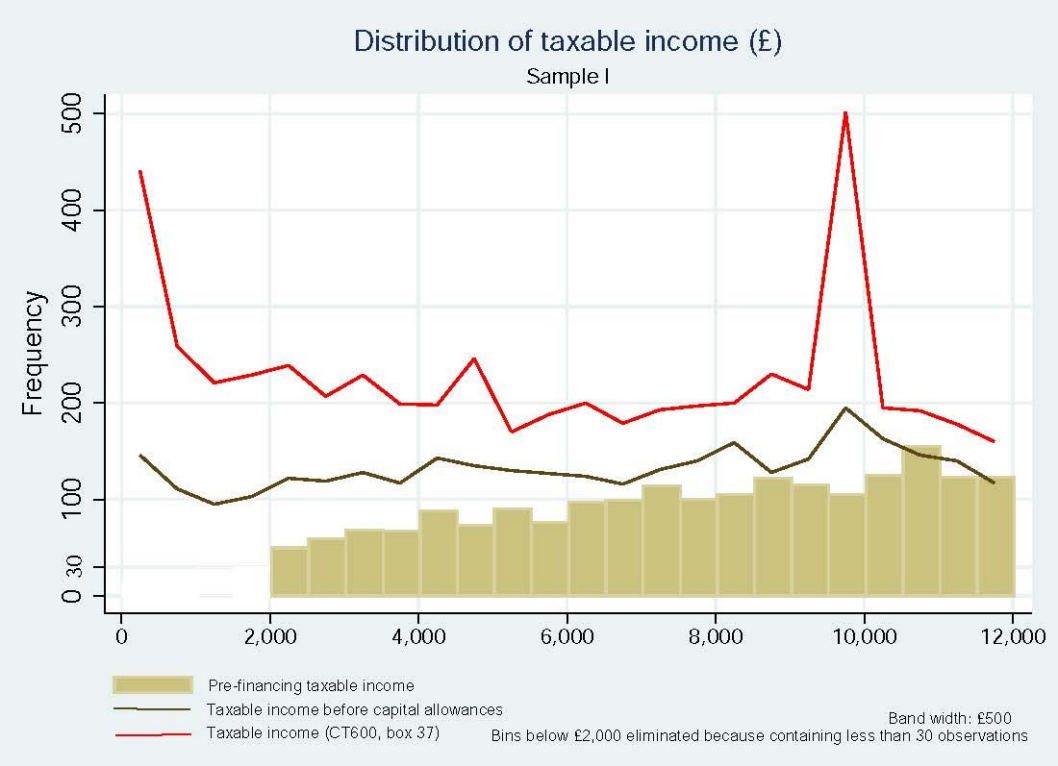



**Figure C.2 Distribution of taxable income around the £10,000 threshold (Sample I)**

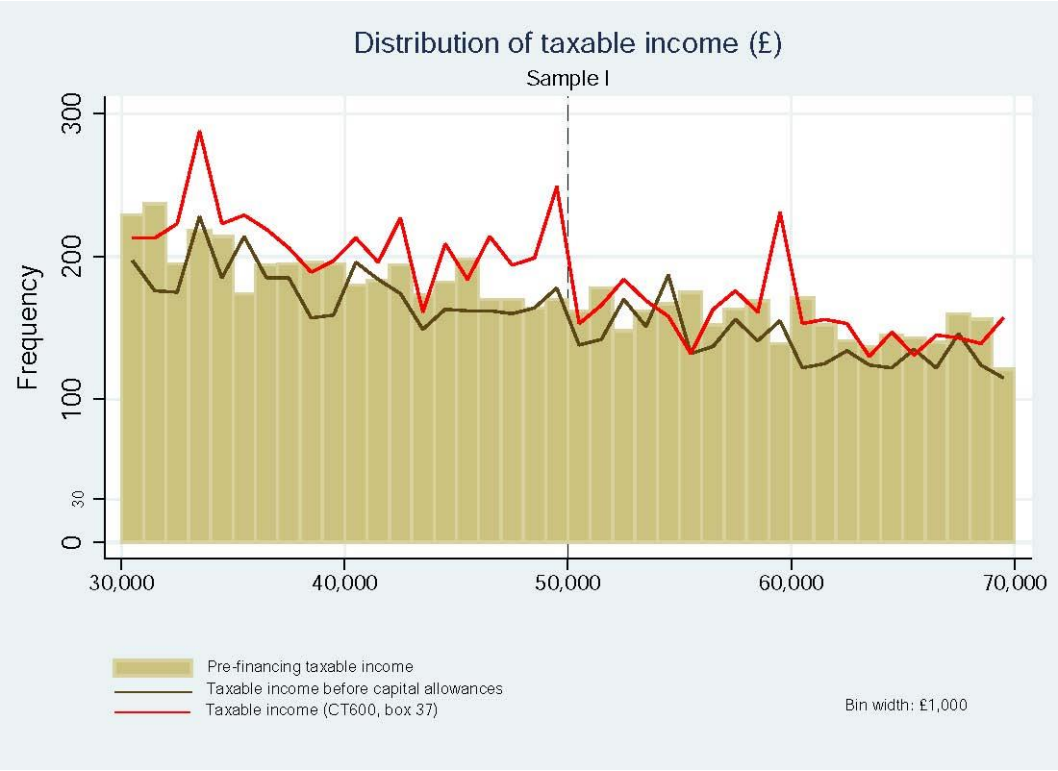



**Figure C.3 Distribution of taxable income around the £50,000 threshold (Sample I)**

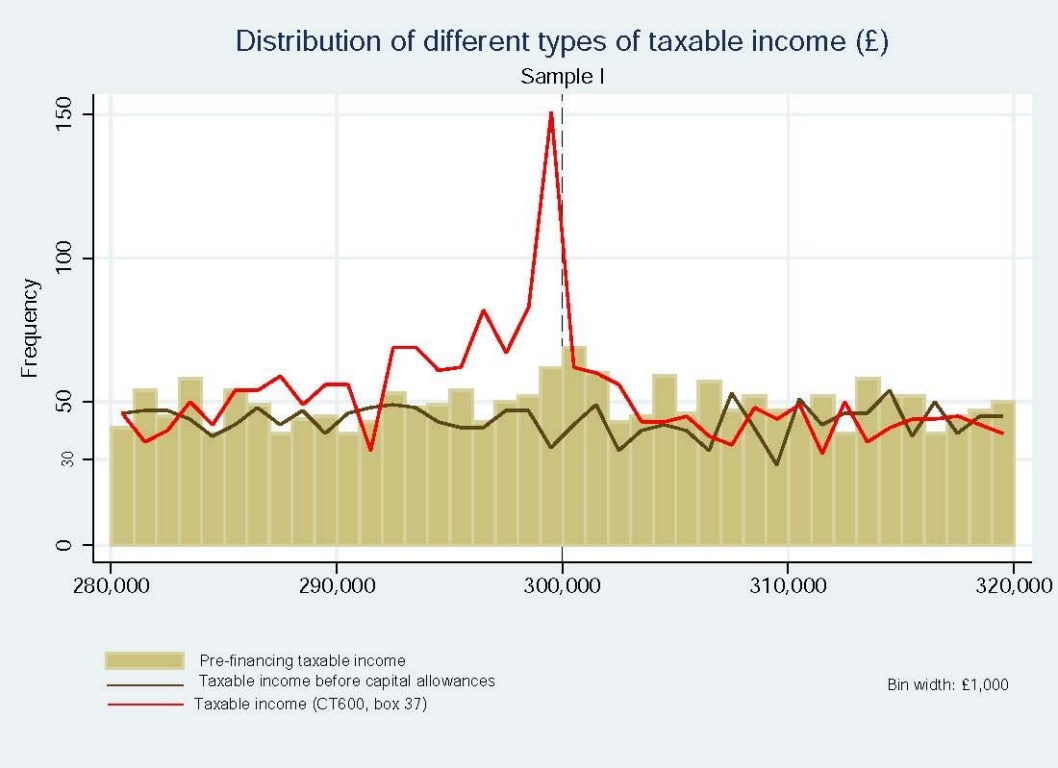



**Figure C.4 Distribution of taxable income around the £300,000 threshold (Sample I)**

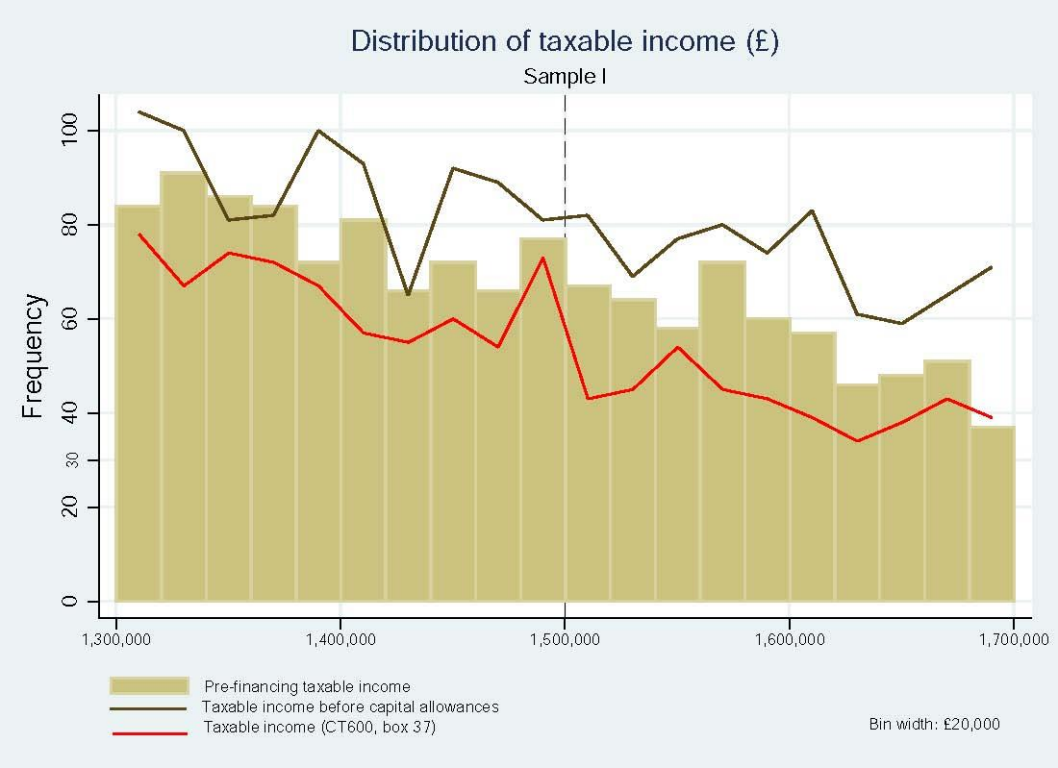



**Figure C.5 Distribution of taxable income around the £1,500,000 threshold (Sample I)**

## Appendix D: Construction of the perfect-foresight marginal tax rate

To construct the perfect-foresight marginal tax rate, we make the following assumptions. If the company is in a loss-making position in year *t-1* and year *t*, the company must carry forward its current taxable losses until year *t+s* when taxable profit becomes positive for the first time. In this case, we set the effective marginal tax rate to be $\mathrm{MTR}_{t+s}/(1+\mathrm{r})^{s}$, where $\mathrm{MTR}_{t+s}$ is the statutory after-financing marginal tax rate the company would face in year *t+s*. The discount rate r is set to be 7% which is the average interest rate for companies in our full sample.[58] If the company is instead able to carry backward its taxable losses to year *t-1*, we assume that it takes time for the company to obtain tax refund from the tax authority and set the marginal tax rate to be $\mathrm{MTR}_{t-1}/(1+\mathrm{r})$.

We need to make strong assumptions to calculate the perfect-foresight marginal tax rate as we only observe up to 9 years for each company. If the company makes losses every year we assume its marginal tax rate to be zero. This is a stronger assumption when imposed on the first and the last observations for each company. If the company makes a loss in the first year, we do not know whether the company can carry backward the current losses. If the last observation is in a loss-making position, we do not know whether the company carries forward its losses or not. As a result, there may be larger measurement errors in these cases. This is the rationale to omit the first and the last observations as a robustness check in our estimations.

[58] We experimented with a discount rate of 5% or 2% and the results are not affected.

## Appendix E: Distribution of the marginal tax rate by ownership

In this appendix, we provide histograms of the after-financing marginal tax rate for firms with different ownership types, for Sample I and Sample II, respectively. For Sample II, we provide the histograms for the after-financing MTR with and without loss-making firm-year observations, separately. We also calculate the number of tax status changes within each firm over time in Table E.

**Figure E.1: Distribution of the after-financing MTR by ownership, Sample I**

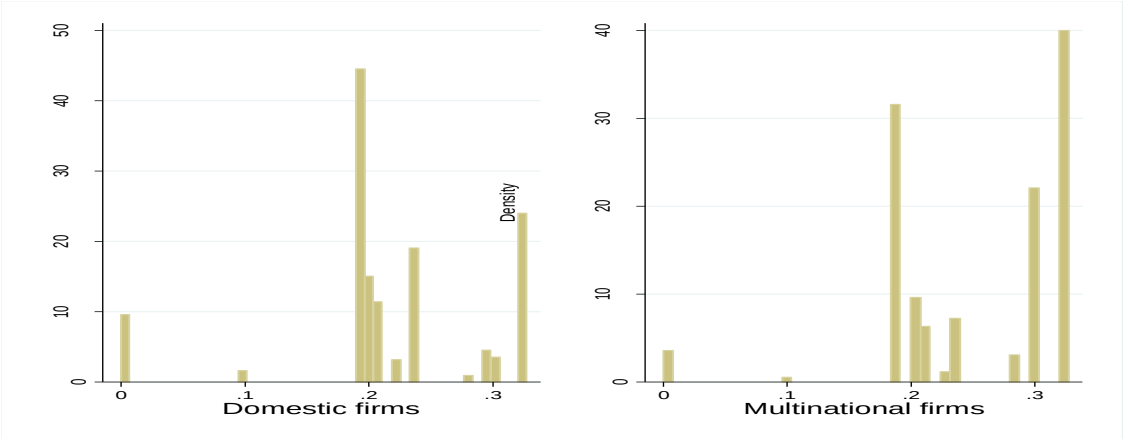



**Figure E.2: Distribution of the after-financing MTR by ownership, Sample II**

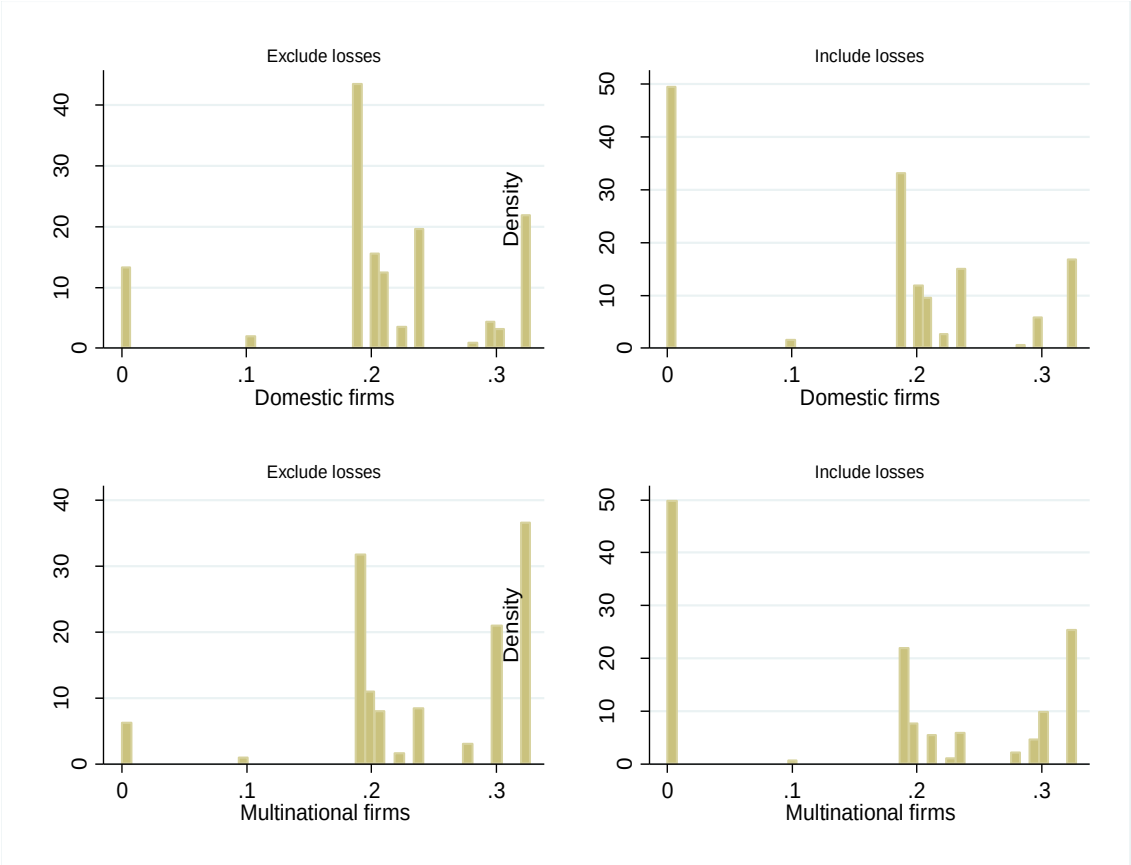


**Table E: Number of Tax Changes within Companies, by ownership**

**Sample I: Total number of moving in and out of the £300,000 tax bracket**

| Number of changes | Number of companies | Percent of total companies | Number of observations | Percent of total observations |
|---|---|---|---|---|
| **Multinational companies** | | | | |
| 0 | 1,273 | 51.79% | 6,750 | 49.69% |
| 1 | 578 | 23.52% | 3,111 | 22.90% |
| 2 | 384 | 15.62% | 2,160 | 15.90% |
| >=3 | 223 | 9.08% | 1,564 | 11.51% |
| Total | 2,458 | 100% | 13,585 | 100% |
| **Domestic companies** | | | | |
| 0 | 4,894 | 70.1% | 25,251 | 67.40% |
| 1 | 928 | 13.29% | 5,062 | 13.51% |
| 2 | 761 | 10.90% | 4,348 | 11.61% |
| >=3 | 549 | 5.70% | 2,805 | 7.00% |
| Total | 6,981 | 100% | 37,466 | 100% |
| **Sample II: Total number of moving in and out of losses** | | | | |
| **Multinational companies** | | | | |
| 0 | 2,155 | 46.88% | 12,081 | 44.08% |
| 1 | 1,185 | 25.78% | 6,817 | 24.87% |
| 2 | 803 | 17.47% | 5,106 | 18.63% |
| >=3 | 454 | 9.87% | 3,404 | 12.42% |
| Total | 4,597 | 100% | 27,408 | 100% |
| **Domestic companies** | | | | |
| 0 | 5,908 | 51.25% | 31,960 | 48.53% |
| 1 | 2,792 | 24.22% | 15,597 | 23.69% |
| 2 | 1,897 | 16.46% | 11,599 | 17.61% |
| >=3 | 930 | 8.07% | 6,695 | 10.17% |
| Total | 11,527 | 100% | 65,851 | 100% |