Taxation and the allocation of risk inside the multinational firm

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Abstract

This paper provides the first theoretical and empirical analysis of how taxation shapes the joint allocation of risk and profits inside the multinational firm. Theoretically, we show that unconstrained firms optimally allocate all their risk to high-tax countries to maximize risk sharing with governments and all their profits to low-tax countries to minimize expected tax payments. However, transfer pricing rules requiring risk to be compensated with a higher expected return introduce a trade-off: the risk sharing motive to allocate risk to high-tax countries must be balanced against a profit shifting motive to allocate risk to low-tax countries. Empirically, we consistently find that multinational firms disproportionately allocate risk to low-tax countries. This suggests that the intra-firm allocation of risk and profits is effectively constrained by transfer pricing rules and that the profit shifting motive dominates the risk sharing motive. Finally, we show that within-firm differences in risk can account for a significant fraction of the well-established correlation between profits and tax rates suggesting that risk shifting is a quantitatively important channel for profit shifting.

1 Introduction

With an ever larger share of economic activity being performed by global firms with operations in many countries, the tax rules determining *where* profits are taxed have taken center stage in recent policy debates about business taxation. The key concern is that multinational firms shift profits to countries with low or no taxation of corporate income, thus causing erosion of tax bases in countries with high and moderate tax rates. To prevent this, tax rules stipulate that transactions between affiliates must take place at arm's length prices, which ensures that the taxable profits recorded by each affiliate is commensurate with the value it creates. Ultimately, an affiliate's taxable profits should be determined by the three value drivers: the *functions* it performs, the *assets* it employs and the *risk* it bears (OECD, 2017).

It is widely believed, however, that corporate tax systems remain vulnerable to base erosion for two reasons. First, firms may shift the functions, assets and risk that create value to countries with low tax rates and thus reduce the global tax bill in a manner that is fully consistent with arm's length pricing. Indeed, there is empirical evidence that multinational firms *shift functions*, such as manufacturing capacity (Mutti and Grubert, 2004) and headquarter functions (Voget, 2011), and *shift assets*, such as financial assets (Ruf and Weichenrieder, 2012), intangible assets (Dischinger and Riedel, 2011) and patents (Karkinsky and Riedel, 2012; Griffith et al, 2014), to affiliates facing low effective tax rates. Second, firms may misprice transactions between affiliates such that low-tax affiliates record a disproportionate share of firms' taxable profits given the value they create. Empirical studies find evidence that *transfer mispricing* occurs for trade in both goods (Cristea and Nguyen, 2016; Davies et al., 2018) and services (Hebous and Johannesen, 2015).

In this paper, we provide a first systematic analysis, theoretical and empirical, of how multinational firms *shift risk* in response to tax incentives. Our main premise is that firms face many types of risk - output prices may go down, input prices may go up, business partners may go bankrupt - and that firms are free to allocate these risks across affiliates through the contracts that govern intra-firm transactions. From this point of departure, we investigate how corporate taxes affect firms' choices regarding the allocation of risk and to what extent such risk shifting contributes to the erosion of tax bases in high-tax countries.

We first develop theoretical predictions in a simple model where two countries with different corporate tax rates each host a single enterprise. The enterprise in the low-tax country produces and sells an intermediate good to the enterprise in the high-tax country. The latter produces a consumer good and faces volatile output prices. By conditioning the price of the intermediate good on the stochastic output price, the two enterprises can obtain any allocation of risk that they may desire. At one extreme, a fixed input price makes the final good producer bear all the risk while, at the other extreme, an input price equal to the realized output price (less a constant) effectively shifts all the risk to the intermediate good producer.

Our main interest lies in the case where the two enterprises have the same risk-averse owner and thus form a multinational firm. As a theoretical benchmark, we show that, in the absence of regulatory constraints, the firm's optimal transfer price contract allocates all the risk to the high-tax country and all the profits to the low-tax country: the price of the intermediate good is fixed and such that the final good producer earns zero profit in expectation. Intuitively, the allocation of profits to the low-tax country minimizes expected tax payments whereas the allocation of risk to the high-tax country maximizes the insurance effectively provided by the government as a dormant partner (Domar and Musgrave, 1944).

Whereas this benchmark highlights the first-best allocation of risk and profits from the perspective of the multinational firm, such an allocation is generally not feasible when the transfer price contract must respect the arm's length principle. We show formally that when the two enterprises have different owners, they only accept a transfer price contract involving more risk if it also involves higher expected profits. This provides an underpinning for the arm's length rule that risk must be rewarded with higher profits in transactions between related parties and presents the multinational firm with a trade-off: allocating more risk to the high-tax country reduces the *volatility* of global (after-tax) profits, but requires that more profits are allocated to the high-tax country, which reduces the *expected level* of (after-tax) global profits. Our analysis shows that the second-best allocation of risk and profits generally depends on both policy and preference parameters: more risk is allocated to the high-tax country when the arm's length rules provide for a small compensation for risk in terms of higher expected profits and when the firm owners are relatively risk averse.

Starting from this theoretical understanding of the incentives underlying the allocation of risk and profits inside the multinational firm, we embark on an empirical analysis. We combine proprietary firm databases from Bureau Van Dijk to construct a dataset that covers the period 1995-2013. The dataset includes unconsolidated financial information about roughly 400.000 corporations with foreign affiliates as well as ownership information serving to identify corporations belonging to the same multinational firm. Following other recent studies of taxation and corporate risk (e.g. Langenmayr and Lester, 2018), our main measure of risk is the standard deviation of the annual return to equity taken over the sample period.

To empirically motivate the premise that multinational firms can shift risk across affiliates, we compare the correlation between tax rates and risk in two samples of entities: those *with* foreign affiliates (multinational firms) and those *without* foreign affiliates (national firms). The difference is striking. In the sample of national firms, we observe that entities facing higher tax rates exhibit more risk as predicted by standard theory (Domar and Musgrave, 1944) whereas in the sample of multinational firms we observe just the opposite. A possible explanation is that the overall risk of multinational firms responds to tax incentives in the same way as national firms, but that risk is shifted across borders from high-tax affiliates to low-tax affiliates to facilitate profit shifting.

In the main empirical analysis, we focus on the sample of multinational firms and identify the effect of corporate taxes on the allocation of risk across affiliates from within-firm variation. Controlling for observable characteristics at the country level (such as size and per capita income) and the affiliate level (such as size and industry), we effectively ask whether affiliates facing relatively low tax rates bear more or less risk than affiliates of the same firm facing relatively high tax rates. The results indicate that risk is allocated predominantly to low-tax countries: we estimate a coefficient of around -0.20 on the tax variable suggesting that an increase in the tax rate of 10 percentage points is associated with a decrease in the standard deviation of ROE of around 0.02 (corresponding to around 6% at the sample mean). In robustness checks, we find qualitatively very similar results when we employ alternative measures of risk.

The most obvious threat to identification in the main analysis is that the unobserved characteristics of affiliates or countries introduce a bias; for instance, if countries with low tax rates tended to have unobservable characteristics that attract particularly risky business activities (within industries and size groups), our main estimates would suffer from a negative bias. We address this concern by estimating a panel version of the baseline model: we split the sample period in two subperiods, calcute affiliate-level risk for each subperiod separately and estimate a panel model with time and affiliate fixed effects (nesting country fixed effects). Here, we identify exclusively from reform variation in tax rates and effectively ask whether affiliates facing a decrease in the corporate tax rate exhibit an increase or a decrease in risk relative to affiliates experiencing no change in the tax rate. While risk measures are based on fewer annual observations in the panel specification, which accentuates concerns about measurement error, it is reassuring that the results are similar to those from the cross-sectional specification although the point estimates, consistent with attenuation bias, are somewhat smaller.

Finally, having established that multinational firms allocate more risk to low-tax countries, we explore the importance of risk shifting as a channel for profit shifting. Consistent with a large number of existing studies, we find a strong correlation between reported profitability and tax rates within firms, which can be interpreted as an overall measure of profit shifting through all channels. However, we also document that within-firm differences in risk contributes significantly to the observed correlation between tax rates and profitability suggesting that risk shifting to low-tax countries plays a prominent role in the erosion of corporate tax bases in high-tax countries.

Our analysis relates to a large literature on taxation and risk (surveyed by Sandmo, 1985; Buchholz and Konrad, 2014). This literature emphasizes that taxation may increase the risk appetite of private agents when gains and losses are treated symmetrically for tax purposes (Domar and Musgrave, 1944) whereas asymmetries (Auerbach, 1986; Mayer, 1986), for instance in the form of imperfect loss offset (Altshuler and Auerbach, 1990; Devereux et al., 1994; Edgerton, 2010; Dressler and Overesch, 2013; Ljungqvist et al., 2016; Langenmayr and Lester, 2018) or tax rate progressivity (Gentry and Hubbard, 2000; Cullen and Gordon, 2007; Mukherjee et al., 2017) deter risk. While existing studies have also analyzed how risk decisions are shaped by mergers and acquisitions (Auerbach,

1986) and business group affiliation (Khanna and Yafeh, 2005; Gopalan et al., 2007), the literature is generally concerned with the overall risk of the firm and not with the distribution of risk across the various parts of the firm which is the focus of our paper. Our analysis also contributes to a growing literature on the techniques used by multinational firms to shift profits to low-tax environments (see papers cited above). While legal scholars have argued that risk shifting may serve as a channel for profit shifting (Schön, 2014), we are not aware of any formal theoretical nor empirical analysis of this tax avoidance technique.

Our results are relevant for current policy discussions about base erosion and profit shifting. While governments have recently attempted to enhance the protection of corporate tax bases in high-tax countries within the framework of the arm's length principle (OECD, 2015), the *risk-cum-profit-shifting* identified in this paper highlights the limitations of this approach. The disconnection of profitable risk taking from core business activities and the subsequent migration of risk to low-tax environments appears to contribute significantly to base erosion; yet it is perfectly legitimate under the prevailing approach to taxing multinational firms.

The paper proceeds in the following way. Section 2 provides some background on the literature and the institutional framework in international taxation. Section 3 lays out the theory. Section 4 describes the data. Section 5 presents the empirical results. Section 6 concludes.

2 Background

When firms operate in several countries, they must decide not only how much risk to take but also how to allocate risk across affiliates. The key instrument to shift risk within the firm is the contracts that determine which affiliates claim residual revenue and incur residual costs. As a concrete example, consider a manufacturer in one country, which produces and sells a single good to a distributor in another country belonging to the same firm. At one extreme, the *ex ante* contract between the two may fix the transfer price at production costs (plus a mark-up), which effectively allocates all the risk related to fluctuating prices in the market for final goods to the distributor. At the other extreme, it may set the transfer price at the sales price that is realized *ex post* in the market for final goods (minus a mark-up), which allocates all the risk to the manufacturer. Any intermediate allocation of risk can be achieved by letting the transfer price have two components: one that is fixed and another that varies with the sales price.

While the above example describes the risk allocation decision in the context of a transaction of substance, i.e. the transfer of final goods from a manufacturer in one country to a distributor in another, multinational firms often undertake transactions that serve primarily, or even exclusively, to achieve a specific intra-firm allocation of risk. This is most obvious when firms operate captive insurance companies whose sole activity is to insure affiliates against various types of risk. Cost-sharing arrangements, under which a specialized entity acquires the right to future intangible assets in exchange for a fixed payment to the affiliates undertaking research and development, may also serve primarily as risk shifting devices (Schön, 2014).

The intra-firm allocation of risk has direct tax implications, by determining how taxable profits are distributed across countries with high and low tax rates in the various states of the world, but also indirect ones because the transfer pricing rules impose a link between the chosen allocation of risk and the appropriate allocation of expected profits. Specifically, the OECD Transfer Pricing Guidelines generally require that transactions between related parties be priced as if they were unrelated. Since "*in the open market, the assumption of increased risk would also be compensated by an increase in the expected return*" (OECD, 2017, p. 53), a firm is required to allocate more expected profits to affiliates that assume more of the group's risk holding other factors constant. In the example above, the transfer price received by the manufacturer, averaged across all states of the world, should be higher the more it varies with the uncertain sales price.

While this is conceptually a straightforward application of the arm's length principle. it is complicated by the fact that neither risk nor expected profits are directly observable in firms' financial accounts. The risk analysis should therefore analyze the written contracts that define rights, obligations and contingencies in intra-group transactions in order to "*...determine how specific, economically significant risks are contractually assumed by the associated enterprises*" (OECD, 2017, p. 54). The analysis of the contractual arrangements should serve to establish the effective allocation of risk provided that "*...the associated enterprises follow the contractual terms*" (OECD, 2017, p. 54) and that these terms are consistent with the economic substance of the transaction. Specifically, if "*the associated entreprise assuming the risk [...] does not exercise control over the risk or does not have the financial capacity to assume the risk, then the risk should be allocated to the enterprise exercising control and having the financial capacity to assume the risk*" (OECD, 2017, p. 70).

Based on these considerations, we draw up four stylized assumptions that will guide our theoretical and empirical investigation. First, absent transfer pricing rules, multinational firms can implement any allocation of risk and profits with the appropriate use of intra-firm contracts. Second, the feasible set of allocations is restricted by transfer pricing rules requiring that an increase in risk is compensated by an increase in expected profits similar to the one observed in transactions between unrelated parties. Third, given that transfer pricing rules require that the allocation of risk be sustained by an appropriate allocation of economic substance, transaction costs may also affect firms' choice of risk allocation. Fourth, given the practical difficulties associated with measurement of risk and expected profits, firms may be able to reduce their global tax bill by mispricing risk (i.e. apply a risk premium differing from the one applied by unrelated parties).

3 Theory

In this section, we develop a theoretical framework to study the impact of taxation on the allocation of risk and profits inside the multinational firm. We first characterize the arm's length standard for pricing of risk and then determine how risk and profits are allocated in the two polar cases where the multinational firm is unconstrained and constrained by this standard. Finally, we derive an empirical test to determine whether the dominating motive in the allocation of risk is profit shifting to low-tax locations or risk sharing with governments through risk shifting to high-tax locations.

3.1 Framework

Consider a world with two countries, a low-tax location (L) and a high-tax location (H). In each of the two countries, there is an enterprise. The enterprise in location H purchases an input good from the enterprise in L at the price q and produces one unit of an output good which is sold to consumers at the price p. The latter is subject to a shock ε; hence the realized price is given by:

$$p(\varepsilon) = \bar{p} + \varepsilon$$

where $E(\varepsilon) = 0$ such that $\bar{p}$ is the expected price. We assume that both enterprises know the expected price and the distribution of the shock *ex ante* and that both observe the realized price *ex post*.

With this information structure, the two enterprises may agree to condition the input price on the shock to the final price. Specifically, assume that the two enterprises *ex ante* agree on a transfer price of the following form:

$$q(\varepsilon) = \bar{q} + \alpha\varepsilon$$

The contract between the two enterprises specifies two parameters each with a specific function: α shifts risk from the enterprise in H to the enterprise in L while leaving the expected profits of both enterprises unchanged and $\bar{q}$ shifts expected profit from the enterprise in H to the enterprise in L while leaving the allocation of risk unchanged. When $\alpha = 0$, the enterprise in L receives a certain outcome (which makes it a "*contract manufacturer*" in the OECD jargon) and all the risk is borne by the enterprise in H (which becomes a "*full-fledged manufacturer*"). When $\alpha = 1$, the roles are reversed. When $\bar{q} = \bar{p}$, the enterprise in L appropriates all the expected profits and the enterprise in H just breaks even. When $\bar{q} = 0$, the roles are reversed. The parameter space between these extreme values encompasses any linear allocation of risk and expected profits across the two enterprises. For later use, we note that the after-tax profits of the two enterprises are given by:

$$\begin{aligned} \pi_H(\varepsilon) &= (p(\varepsilon) - q(\varepsilon))(1 - t_H) \\ \pi_L(\varepsilon) &= q(\varepsilon)(1 - t_L) \end{aligned}$$

The preferences of enterprise owners over their uncertain incomes can be represented by a von Neumann-Morgenstern utility function $u(\pi)$ with $u'(.) > 0$, $u''(.) < 0$ and $u'''(.) > 0$ (decreasing absolute risk aversion). Expected utility is denoted by $U^E = E[u(\pi(\varepsilon))]$.

3.2 Risk shifting between unrelated parties

To establish the properties of the arm's length standard, we first assume that the two enterprises have distinct owners (they are "*unrelated parties*" in the OECD jargon) and ask under which conditions risk is shifted between them.

We first note that the owners' expected utility depends solely on the two parameters of the transfer price contract: for the owner of the enterprise in L expected utility is increasing in expected income $\bar{q}$ (for given α) and decreasing in α (for given $\bar{q}$); the opposite is true for the owner of the enterprise in H. This implies that owners are only willing to take on more risk (for the owner in L an increase in α) if compensated with an increase in expected profits (for the owner in L an increase in $\bar{q}$). Formally, we differentiate expected utility with respect to the two parameters to obtain:

$$\left(\frac{d\bar{q}_i}{d\alpha}|d\bar{U}_i^E = 0\right) = -\frac{E[u'(\pi_i(\varepsilon)) \cdot \varepsilon]}{E[u'(\pi_i(\varepsilon))]} \text{ for } i = H, L$$

The right-hand side of the equation expresses the slope of the indifference curve in the $\bar{q}$-α space: the denominator is the expected marginal utility, which is strictly positive, and the numerator is the expected product of marginal utility and the price shock, which is strictly negative except when the firm bears no risk at all (in which case it is zero). The finding resonates with the OECD transfer pricing guidelines that risk is accompanied by expected profits in transactions between unrelated parties. We summarize this finding in the following proposition

Proposition 1 *When the two enterprises are unrelated parties, an increase in risk taking is accompanied by an increase in expected profits.*

3.3 Risk shifting within the multinational firm: without regulation

Next, we turn to the case where the two enterprises belong to the same multinational firm (the enterprises are "*related parties*" in the OECD jargon). Now, risk and profits are allocated across the two enterprises with the aim of maximizing the expected utility of the sole owner. Note that, in this case, the transfer price contract has no economic meaning: the owner is essentially transferring resources from the left to the right hand, and is entirely unconsequential except for its effect on taxes paid in various states of the world. The global after-tax income of the multinational firm is given by:

$$\pi = p(\varepsilon)(1 - t_H) + (t_H - t_L)(\bar{q} + \alpha\varepsilon) \tag{1}$$

We first describe the optimal transfer price contract under the assumption that transfer prices are unregulated so that the parameters of the contract can be set freely. It follows directly from eq. (1) that when the tax rates in the two locations are equal, $t_H = t_L$, the transfer price contract has no bearing on expected utility: global after-tax income equals $p(\varepsilon)(1 - t_H)$ regardless of the parameters of the contract. However, with $t_H > t_L$, the picture changes. An increase in $\bar{q}$ raises global after-tax profits in all states of the world; a clear expected utility gain for the owner. A decrease in α lowers global after-tax profits in good states of the world ($\varepsilon > 0$), but does the opposite in bad states of the world ($\varepsilon < 0$); also an expected utility gain for the owner under the assumption of risk aversion. Hence, assuming that both affiliates must have a non-negative expected tax base, the firm optimally chooses $\bar{q} = \bar{p}$ and $\alpha = 0$: all expected profits are allocated to L and all risk is allocated to H.

The result is very intuitive: the owner desires high expected income, which introduces a *profit shifting motive* to shift profits to the low-tax location, and low variability of income, which introduces an *risk sharing motive* to shift risk to the high-tax location where a larger part of the risk is effectively borne by the government.

Proposition 2 *When transfer pricing is unregulated, the firm allocates all risk to the high-tax location due to the risk sharing motive ($\alpha = 0$) and all expected profit to the low-tax location due to the profit shifting ($\bar{q} = \bar{p}$).*

3.4 Risk shifting within the multinational firm: with regulation

Most countries adhere to the arm's length principle under which transactions between related enterprises must be priced as if the enterprises were unrelated. Guided by our finding above that unrelated enterprises only agree to assume more risk if compensated with higher expected profits, we therefore introduce the assumption that for a given amount of risk borne by the affiliate in the low-tax location, α, the tax rules specify an appropriate level of the expected transfer price, $\bar{\theta}(\alpha)$. Hence, the multinational firm is facing the following regulatory constraint when formulating its transfer pricing contract: $\bar{q} = \bar{\theta}(\alpha)$.

Inserting this constraint into eq. (1), we obtain the following first-order condition for α (assuming an interior solution):

$$\underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot\bar{\theta}'\left(\alpha\right)}_{\text{profit shifting}}+\underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\cdot\varepsilon\right]}_{\text{risk sharing}} \quad = \quad 0 \tag{2}$$

Transferring more risk to the low-tax location by raising α now has two opposing effects on expected utility: a direct negative effect by reducing the risk sharing provided by the tax system (second term) and an indirect positive effect by allowing for more profits to be realized in the low-tax location (first term). The optimal amount of risk shifting depends on two factors: the risk premium imposed by the regulation and the degree of risk aversion of the firm owner. If the transfer pricing rules stipulate a large compensation for taking risk ($\bar{\theta}'\left(\alpha\right)$ large), it is relatively attractive to shift risk to the low-tax location so that alpha is optimally large (and vice versa). If the firm owner is highly risk averse ($u''(\pi)$ large), it is relatively unattractive to shift risk to the low-tax location so that alpha is optimally small (and vice versa).

Proposition 3 *When transfer pricing is regulated and the tax base in each country must be non-negative in expectation, the firm balances the risk sharing motive and the profit shifting motive and allocates more risk to the low-tax location when (i) the risk premium stipulated by the regulation is larger (when $\bar{\theta}'\left(\alpha\right)$ is large) and (ii) when the firm owner is less risk averse (when $u''(\pi)$ is small).*

3.5 Testable predictions

The simple model developed above serves to illustrate the key mechanisms through which taxation shapes the allocation of risk: the profit shifting motive and the risk sharing motive respectively. However, the model delivers knife-edge results, which are not well suited to derive testable predictions: the first-order condition that governs the allocation of risk, eq. (2), implies that the risk allocation is unaffected by the size of the tax differential as long as $t_H > t_L$, but changes discontinuously at $t_H = t_L$. To derive testable predictions, we develop an extended model that includes non-tax factors. The non-tax factors could take many forms, for instance there could be differences in the labor costs associated with risk management or corporate governance motives for preferring one allocation of risk over another.

Formally, we introduce transaction costs in the broadest sense of the word, which also encompasses agency costs and other frictions inside of the firm (Williamson, 1981). We then assume that there exists an allocation of risk, which minimizes the firm's transaction costs, and that transaction costs are increasing in the distance from this risk allocation. Specifically, we describe the transaction costs by the convex function $c(\alpha)$ and assume that the firm maximizes profits net of taxes and transaction costs. With this extension, we obtain the following first-order condition for the optimal allocation of risk:

$$(t_H - t_L)\left(\underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot\bar{\theta}'\left(\alpha\right)}_{\text{profit shifting}} + \underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\cdot\varepsilon\right]}_{\text{risk sharing}}\right) - \underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot c'(\alpha)}_{\text{transaction cost}} = 0 \tag{3}$$

Now, denote by α^T the value of α that is optimal for profit shifting and risk sharing purposes disregarding transaction costs and denote by α^C the value of α that minimizes transaction costs disregarding the consequences for profit shifting and risk sharing. Thus, $c'(\alpha)$ has the same sign as $\left(\alpha - \alpha^C\right)$. Generally, we can have either $\alpha^C > \alpha^T$ or $\alpha^C < \alpha^T$. In any case, assuming that π is strictly concave in α, the firm optimally chooses a value of α between α^C and α^T. When $\alpha^T > \alpha > \alpha^C$ we say that the profit shifting motive dominates because the firm is incurring transaction costs to shift risk, and as a result profits, to the low-tax location. Conversely, when $\alpha^C > \alpha > \alpha^T$ we say that the risk sharing motive dominates because the firm is incurring transaction costs to shift risk to the high-tax location with the aim of equalizing after-tax profits across good and bad states of the world.

This framework allows us to identify empirically which of the two motives is dominating by estimating the marginal effect of a tax change on the allocation of risk. To see this, note that an increase in $t_H - t_L$ induces the firm to move α closer to α^T whereas a decrease in $t_H - t_L$ induces it to move α closer to α^C. Hence, if the profit shifting motive dominates ($\alpha^T > \alpha > \alpha^C$), both an increase in t^H and a decrease in t^L should be associated with an increase in α, that is less risk in H and more risk in L, and we should observe a negative correlation between the tax rate in a location and the share of the firm's risk allocated to that location. Conversely, if the risk sharing motive dominates ($\alpha^C > \alpha > \alpha^T$), both an increase in t^H and a decrease in t^L should be associated with a decrease in α, that is more risk in H and less risk in L, and the correlation between the tax rate in a location and the share of risk allocated to the location should be positive.

3.6 Extensions

First, we investigate if the findings are robust to the use of other profit shifting techniques. Assume that the firm may set a transfer price that deviates from the arm's length price $\bar{\theta}(\alpha)$. Specifically, let $\delta \equiv \overline{q} - \bar{\theta}(\alpha)$ denote the deviation from the arm's length price and assume that the firm incurs a convex concealment cost $f(\delta)$ with $f(0) = 0$, $f'(0) = 0$, and $f''(\delta) > 0$. The firm now chooses two parameters: α which captures the allocation of risk and δ which captures the deviation from the transfer price stipulated by the tax rules. The global after-tax income of the multinational firm is given by:

$$\pi = (\bar{p} + \varepsilon)(1 - t_H) + (t_H - t_L)\left(\bar{\theta}(\alpha) + \delta + \alpha\varepsilon\right) - c(\alpha) - f(\delta)$$

We show in the Appendix that, in line with standard models of profit shifting, the firm optimally uses transfer mispricing to allocate profits to the low-tax country ($\delta > 0$) and that mispricing is increasing in the tax differential. While profit shifting creates a rent for the firm, the choice of α is still determined by (3) and thus (qualitatively) unaffected by the profit shifting opportunities.

Second, we have assumed so far that transaction costs are not tax deductible. We introduce tax deductibility while assuming that the share of transaction costs that is deductible in a location equals the share of the risk that is allocated to that location: α in L and $1-\alpha$ in H. These assumptions imply that the after-tax transaction costs are given by:

$$c(\alpha)[(1-\alpha)\left(1-t^{H}\right)+\alpha\left(1-t_{L}\right)]$$

We show in the Appendix that tax deductibility of transaction costs creates an incentive for the firm to allocate more risk to an affiliate the higher the tax rate it is facing because the tax value of deductions is increasing in the tax rate. Hence, in the model with tax deductibility of transaction costs, a positive empirical correlation between the tax and risk implies that the combined risk sharing and deduction motive dominates whereas a negative correlation implies that the profit shifting motive dominates.

Last, our analysis so far has been based on the assumption of unlimited loss offset implying that a loss L triggers an immediate cash payment tL to the firm. However, in many tax systems, loss offsets are limited so that the expected present value of the loss is less than tL. We do not explicitly model limited loss offset, but just note that if loss offset limitations are present in one location, placing risk there is (weakly) less attractive (depending on the variability of ε). Hence, we should expect that multinational firms allocate less risk to countries with imperfect loss offset holding other factors constant.

4 Data

The empirical analysis uses unconsolidated financial information and ownership links between corporations from the databases Amadeus and Orbis maintained by Bureau Van Dijk. The sample of European corporations was drawn from the online version of Amadeus in August 2014 (accounting years: 2003-2013) and from historical versions of

Amadeus (for accounting years prior to 2003).[1] The sample of non-European corporations was drawn from the online version of Orbis in August 2014 (accounting years: 2003-2013).[2] While the sample period spans almost two decades, 1995-2013, the coverage is relatively poor in the early years and improves sharply in the early 2000s.

In the main analysis, we study the allocation of risk inside the multinational firm and therefore restrict the sample to corporations with either a foreign parent company, a foreign sister company or a foreign subsidiary.[3] This yields a sample of around 400,000 affiliates of multinational firms, for which financial information is available. While these affiliates are spread out across 129 countries, most of them are located in Europe and very few are located in developing countries, as shown in Table 1. In the empirical analysis, we assess the robustness of our findings to excluding countries with poor coverage.

Following other papers in the recent literature on corporate risk (John et al., 2008; Armstrong and Vashishtha, 2012; Langenmayr and Lester, 2018), our main risk measure is the standard deviation of the annual return to equity (ROE) over the sample period (all years with non-missing ROE); however, because of our specific interest in the within-firm allocation of risk, we measure risk at the affiliate-level. To limit the influence of extreme

[1] The current and historic versions of Amadeus can be linked by a unique firm identifier. In most cases, this identifier is constant over time and we account for changes when they occur achieving very high match rates between database versions.

[2] Our version of Amadeus comprises the full set of European firms known to Bureau van Dijk whereas our version of Orbis includes firms from all countries satisfying one of the following three criteria: (i) operating revenue exceeding €1 million; (ii) total assets exceeding €2 million EUR; (iii) the number of employees exceeding 15. As coverage is relatively poor for small non-European companies in any case, we lose few observations due to the size restriction in our version of Orbis.

[3] To delimit the sample of corporations belonging to a multinational firm, we proceed in the following steps. First, if the corporation's global ultimate owner (GUO) is itself a corporation, we identify the GUO's (directly and indirectly) majority-owned subsidiaries and augment this list by the (directly and indirectly) majority-owned subsidiaries of the corporation itself (in case they do not overlap). In doing so, we account for 10 levels of indirect ownership chains. Corporations are considered to belong to a multinational firm if either the GUO or one of the majority-owned subsidiaries is located in a foreign country. Second, if the GUO is an individual or a family, we identify all corporations that are directly and majority owned by these individuals and families and define them as 'top-level corporate owners'. Their (directly and indirectly) majority-owned subsidiaries constitute the set of affiliates. All corporations in this set (as well as the 'top-level corporate owners' themselves) are considered to be part of a multinational firm if at least two of them are located in different countries. Third, if information on the GUO is missing but information on the immediate majority shareholder (ISH) is available, we identify the 'highest' corporate ISH of the corporation by constructing direct majority shareholder-chains (10 levels upwards). The subsidiary list of the 'highest' corporate ISH augmented by the list of majority-owned subsidiaries of the corporation itself constitute the set of affiliates. All corporations in this set are considered to be part of a multinational firm if at least two of them are located in different countries. Fourth, if the firm is a GUO or information on both ISH and GUO are missing, it is classified as a multinational if it majority-owns (directly or indirectly) at least one foreign subsidiary.

observations and reduce measurement error, we winsorize ROE at the 5% level before calculating the standard deviation and drop years with negative shareholder funds. We also construct a corresponding affiliate-level measure of profitability as the average ROE taken over the sample period. Table 2 provides descriptive statistics for these measures of risk and profitability.

For robustness, we also employ a number of alternative risk measures. First, we use binary measures of highly volatile returns: a dummy variable indicating that an affiliate has realized values of ROE both below the 10th percentile *and* above the 90th percentile during the sample period (and a similar measure indicating ROEs both below the 25th percentile *and* above the 75th percentile). Second, we use the variance of the annual ROEs (the square of the standard deviation), which places more weight on extreme observations. Table 2 includes descriptive statistics of the alternative risk measures. Table 3 reports a correlation matrix for all the risk measures.[4]

Finally, we include the following country-level variables that characterize the tax system as well as the general economic and institutional environment: statutory corporate tax rates (from KPMG's global corporate tax guides); information about loss-offset provisions (from IBFD's European and Global Tax Handbooks); GDP, GDP per capita and the unemployment rate (from World Development Indicators) and a range of governance indicators (from World Governance Indicators). For all the country-level variables, we construct affiliate-level variables corresponding to the value in the base year (the first year with non-missing ROE) as well as the average value and the standard deviation taken over the sample period (all years with non-missing ROE). Descriptive statistics of these variables are reported in Table 2.

5 Empirical results

5.1 A first pass: multinational vs national firms

Before embarking on the main empirical analysis, we provide suggestive evidence that the tax incentives specific to multinational firms have a significant impact on the allocation of

[4] In the literature, risk is measured by a whole range of alternative measures including leverage (Acharya et al. 2011, Coles et al. 2006), business focus (Coles et al. 2006), the incidence of losses (Cullen and Gordon 2007) and diversifying acquisitions (Acharya et al. 2011).

risk. We estimate the correlation between corporate tax rates and our preferred measure of risk in two distinct samples: affiliates belonging to multinational firms and purely national firms. In the former sample, the observed correlation between taxation and risk reflects the conflicting incentives created by intra-firm tax differences. In the latter sample, these incentives are entirely absent by construction.

Specifically, we estimate the following model for each of the two samples separately:

$$risk_{ic} = \alpha_1 + \alpha_2 tax_c + \alpha_3' X_i + \alpha_4' W_c + \varepsilon_{ic}$$

where $risk_{ic}$ measures the standard deviation of ROE at the level of affiliate i located in country c and tax_c is the mean statutory corporate tax rate in country c over the sample period. The vector X_i controls for affiliate characteristics that may affect risk: industry (ten industry dummies), size (ten dummies for deciles of total assets) and sample period (dummies for the first year in the sample). The vector W_c controls for country characteristics: size (GDP in logs), productivity (GDP / capita in logs) and labor market conditions (unemployment).

We present the results of the two regressions in the form of binned scatterplots. Figure 1 documents a positive relation between risk and taxation for purely national firms: an increase in the corporate tax rate of 10 percentage points is associated with an increase in the standard deviation of ROE of around 0.05, which corresponds to around 10 percent at the sample mean (which is at just below 0.5). The effect is tightly estimated (the data points are relatively close to the regression line) and the linear functional form imposed by the regression model appears appropriate (there is no obvious non-linear relation between the data points). The estimated positive relation between taxation and risk is consistent with canonical theory (Domar and Musgrave, 1944) and with recent empirical evidence (Langenmayr and Lester, 2018).

Turning to affiliates belonging to multinational firms, Figure 2 documents a strikingly different relation between risk and taxation: an increase in the corporate tax rate of 10 percentage points is associated with a decrease in the standard deviation of ROE of around 0.05, which corresponds to around 15 percent at the sample mean just above 0.3. It should be emphasized that the negative correlation is not inconsistent with the positive correlation in the sample of national firms or with the canonical theory of taxation and risk. Assuming that also multinational firms exhibit a positive firm-level correlation between taxation and risk, that is multinational firms operating predominantly in high-tax environments take more risk than those operating predominantly in low-tax environments, we might still observe a negative affiliate-level correlation if the within-firm allocation of risk is tilted toward low-tax countries. In the remainder of the paper, we explore how corporate taxes shape the allocation of risk inside multinational firms.

- Figures 1 and 2 around here -

5.2 Baseline results

Our main research question concerns the relation between taxation and the allocation of risk inside the multinational firm. The theoretical analysis pointed to two conflicting incentives: given the firm's overall level of risk, the risk sharing motive makes it attractive to allocate more of the risk to high-tax countries while the profit shifting motive makes it attractive to allocate more of the risk to low-tax countries. Guided by the theory, we determine which motive dominates by estimating the effect of a country's corporate tax rate on the risk of the affiliates operating in the country conditional on the risk of the multinational firm to which they belong:

$$risk_{ijc} = \beta_1 + \beta_2 tax_c + \beta_3' X_i + \beta_4' W_c + \rho_j + \varepsilon_{ijc}$$

where $risk_{ijc}$ measures the standard deviation of ROE at the level of affiliate i located in country c belonging to multinational firm j and tax_c is the statutory corporate tax rate in country c. The vectors X_i and W_c represent affiliate and country characteristics respectively and ρ_j represents firm fixed effects. The effect of taxation on the intra-firm allocation of risk is identified from cross-sectional differences in the corporate tax rates faced by affiliates belonging to the same firm: we effectively ask whether affiliates facing higher taxes (compared to other affiliates of the same firm) exhibit more or less volatile returns (again compared to other affiliates of the same firm), holding constant observable affiliate and country characteristics.

The results are reported in Table 4. In the first four columns, both the tax variable and the controls are measured by their mean across all the years where information about ROE is available for a given affiliate. These are also the observations that enter the risk measure. In the most parsimonious specification where the only controls are firm dummies and time dummies indicating the year in which an affiliate enters the sample, we estimate a coefficient of around -0.25 suggesting that a decrease in the tax rate of 10 percentage points is associated with an increase in ROE of around 0.025 (Column 1) corresponding to around 8% at the sample mean. When adding macro-economic controls, GDP, GDP per capita and unemployment, the estimated coefficient drops to around -0.35 (Column 2). Controlling for the level of institutional development by including six standard indicators for governance and for the business cycles by including the standard deviation of the three macro-economic controls (Column 3) has little effect on the estimate. Finally, restricting the time period to 2001-2012 and limiting the sample to affiliates with non-missing values of ROE in all of these years leaves the estimated coefficient almost unchanged (Column 4).

- Table 4 around here -

While explaining the risk measured over a time period with the mean tax rate observed over that period is an intuitive approach, it also raises concerns about endogeneity. For instance, an adverse shock to corporate profitability in year t is likely to increase the volatility of returns taken over the sample period (an increase in risk) and may also induce a policy response in the form of a change in the corporate tax rate in year $t+1$ or later (a change in the mean tax rate). To address this concern, we reestimate the model while letting the independent variables take the value observed in the first year where information about ROE is available for a given affiliate. As shown in the last four columns of Table 4, using first-year values of the independent variables yields slightly smaller estimates (in absolute terms) than using mean values: in all four specifications, we estimate a coefficient of around -0.20 suggesting that an increase in the tax rate of 10 percentage points is associated with a decrease in ROE of around 0.02 (Columns 5-8) corresponding to around 6% at the sample mean. For the purposes of the robustness tests and model extensions in the remainder of the paper, we adopt the prudent approach using first-year values of independent variables and including corporate and macro-economic controls (Column 6) as our preferred specification.

While the standard errors reported above allow for correlation in the error terms across all affiliates belonging to the same multinational firm, one may be concerned that error terms also correlate along other dimensions, which requires multi-dimensional clustering of standard errors. As illustrated in the left side of Figure 3, standard errors widen slightly when we also allow for correlation across affiliates belonging to the same industries and widen considerably more when allowing for correlation across affiliates located in the same country. However, even in the latter case, the estimated effect of the tax rate on risk is statistically significant with a t-value around 2.6.

- Figure 3 around here -

We report a number of additional robustness checks in Table A1 in the Appendix. We obtain the same qualitative results as in the baseline (Columns 1 and 6) when restricting the sample to affiliates located in the European Union where the coverage is particularly good (Columns 2 and 7); restricting the sample to core industries by eliminating firms in the insurance and banking industry that are often subject to specific tax rules and firms in the public sector with limited profit shifting incentives (Columns 3 and 8); excluding extreme affiliate-year values of ROE rather than winsorizing (Columns 4 and 9); and restricting the sample to affiliates with at least 5 annual observations over the sample period (Columns 5 and 10).

5.3 Alternative measures of risk and tax

In a next step, we reestimate the baseline model using three alternative measures of risk and report the results in Table 5. The first measure is a dummy variable indicating that an affiliate has realized values of ROE below the 10th percentile *and* above the 90th percentile during the sample period. As shown in Column (1), this binary measure of return volatility yields results that are qualitatively similar to the baseline measure: an increase in the corporate tax rate of 10 percentage points lowers the propensity to realize returns in both the upper and lower decile of the ROE distribution by around 1.3 percentage points (corresponding to around 8% at the sample mean). Moreover, as shown in Column (2), these results are qualitatively unchanged when we set the thresholds for extreme returns at the 25th percentile and the 75th percentile: the same tax increase of 10 percentage points lowers the propensity to realize returns in both the upper and lower quartiles by around 2.0 percentage points (around 5% at the sample mean). Finally, as shown in Column (3), this pattern also emerges when we use the variance of the annual ROEs as a risk measure: an increase in the corporate tax rate of 10 percentage points lowers the variance of ROE by around 0.014 (around 8% at the sample mean).

- Table 5 around here -

5.4 Panel model

The identifying assumption underlying the cross-sectional results reported in Table 4 is that there are no unobserved characteristics of affiliates or countries that drive both risk and taxation. To relax that assumption, we exploit the time dimension of the data to estimate a panel model:

$$risk_{ijct} = \theta_1 + \theta_2 tax_{ct} + \theta_3' W_{ct} + \mu_c + \delta_t + v_{ijct}$$

where $risk_{ijct}$ measures the standard deviation of ROE at the level of affiliate i located in country c belonging to multinational firm j in period t and tax_{ct} is the statutory corporate tax rate in country c in period t . The vector W_{tc} controls for time-varying country characteristics; μ_c represents affiliate fixed effects (nesting both firm and country fixed effects).

The panel model allows us to fully control for time invariant characteristics of multinational firms and countries and, thus, to identify the effect of taxation on risk from corporate tax *reforms*. We effectively compare affiliates belonging to the same firm located in different countries and ask whether affiliates facing a differential tax change relative to affiliates of the same firm exhibit a differential change in risk. The identifying assumption in the panel model is that *tax changes* do not correlate with changes in unobserved determinants of the intrafirm allocation of risk (conditional on controls). The main disadvantage of the panel model is that risk measures are based on fewer annual observations, which is likely to increase measurement error and, thus, attenuation bias.

To implement the model, we restrict the sample to affiliates with non-missing ROE in all the years between 2001 and 2012, the years with the best sample coverage, to obtain a balanced sample. We then split the sample into two subperiods, 2001-2006 and 2007-2012, and define risk in each period as the standard deviation of ROE over the six years, respectively. To address concerns about endogeneity, we use the values of tax rates and other control variables in the first year of each subperiod. The set of controls includes country-level economic variables with significant time variation that may contribute to explain risk, but not governance variables that tend to be highly persistent over time and therefore add little to the model once fixed effects are included.

As shown in Table 6, the effect of the corporate tax rate on risk remains negative and statistically significant when identified by tax *reforms*. However, the coefficient increases from around -0.2 to around -0.12 (Column 1), which is consistent with attenuation bias. The result is robust to adding interactions between size and time, which controls flexibly for differential trends in risk across the size distribution (Column 2); interactions between industry and time, which further controls for differential trends in risk across industries (Column 3); and both of these controls jointly (Column 4).

Like in the cross-sectional model, the standard errors reported in Table 6 allow for correlation in the error terms within firms. As illustrated in the right side of Figure 3, estimates become less precise when we also cluster on industry-time and country-time. In the latter case, the estimated effect of the tax rate on risk is only marginally significant with a t-value around 1.85.

- Table 6 around here -

5.5 Loss offset provisions

Next, we estimate how loss-offset rules, the ability to offset taxable profits against losses incurred in other tax years, shapes the allocation of risk inside the multinational firms and how these rules interact with the corporate tax rate. As argued in the theory section, we should expect less generous loss offset rules in a country to deter firms from allocating risk to that country because, even if the expected gross return is zero, the expected value of the tax base is positive. Therefore, we should expect the deterrence effect to be increasing in the tax rate.

We construct two measures of the generosity of loss offset provisions. First, following Lester and Langenmayr (2018), we define a continuous measure as the sum of years losses can be carried forward or backward where indefinite carry-forward provisions are coded as a loss carry forward of 20 years. Second, we define a binary measure of whether losses can be carried forward or backward at least 20 years, which is roughly the median value in our sample.

The results are presented in Table 7. As shown in Column (1), affiliates that are allowed to carry forward or backward losses for more than 20 years exhibit a standard deviation of ROE that is around 0.0052 percentage points larger on average than affiliates that are allowed to carry losses less than 20 years. This is the same magnitude as the effect of a decrease in the corporate tax rate of around 2 percentage points. As shown in Column (2), the effect of loss offset provisions is increasing in the corporate tax rate. At a tax rate of around 25 percent, the standard deviation of ROE is roughly the same regardless of the generosity of the loss offset provisions while at a tax rate of around 35 percent, the difference between affiliates allowed to carry losses more and less than 20 years is around 0.01. The estimates with the continuous measure of loss offset generosity, reported in Column (4) and (5), are qualitatively similar: allowing losses to be carried for 10 additional years raises the standard deviation of ROE by around 0.006 and the effect is increasing in the level of the tax rate.

- Table 7 around here -

5.6 Risk and profits

Our empirical results so far have shown that multinational firms allocate more risk to low-tax countries. This suggests that risk shifting serves as a channel for profit shifting in the following sense. Since transfer pricing rules require that affiliates taking more risk are remunerated with higher expected returns, one way to reduce the global tax bill is to jointly allocate risk and profits to low-tax countries. In principle, this is fully legitimate under the current international tax rules. In this section, we attempt to quantify the importance of risk shifting as a profit shifting channel.

In a first step, we estimate the within-firm correlation between corporate tax rates and profitability while disregarding risk:

$$profits_{ijc} = \gamma_1 + \gamma_2 tax_c + \gamma_3' X_c + \rho_j + \phi_{ijc}$$

where $profits_{ijc}$ denotes the average ROE of affiliate i located in country c and belonging to multinational firm j over the sample period and tax_c is the first-year corporate tax rate. In the spirit of many earlier papers, γ_2 identifies the full extent of profit shifting, occurring through well-documented channels such as transfer mispricing and debt shifting as well as risk shifting, as the difference in reported profitability across affiliates facing different tax rates (e.g. Huizinga and Laeven, 2008; Johannesen et al, 2016). As shown in Column 1 of Table 8, the estimates suggest that an increase in the corporate tax rate of 10 percentage points lowers ROE by around 0.018. At the sample mean, this is equivalent to a semi-elasticity of around 1.0, which is roughly consistent with a recent estimate from a meta-study of 0.8 (Heckemeyer and Overesch, 2017).

In a second step, we estimate the same equation but conditioning on risk:

$$profits_{ijc} = \delta_1 + \delta_2 tax_c + \delta_3' X_c + \delta_4 risk_{ijc} + \rho_j + \kappa_{ijc}$$

where $risk_{ijct}$ measures the standard deviation of ROE at the level of affiliate i located in country c belonging to multinational firm j in period t. By comparing the reported profitability of affiliates facing different tax rates but with a comparable level of risk, δ_2 identifies profit shifting through other channels than risk shifting. As shown in Column 2, the estimates suggest that an increase in the corporate tax rate of 10 percentage points lowers ROE by around 0.01 when holding risk constant. A simple comparison of $\widehat{\gamma}_2$ and $\widehat{\delta}_2$ shows that differences in risk can account for around 40% of the intra-firm correlation between tax rates and reported profits suggesting that risk shifting is a quantitatively important channel for profit shifting.

We finally note that, under the relatively strong assumption that our risk measure is orthogonal to other determinants of reported profits (conditional on the controls), δ_4 can be interpreted as a measure of the within-firm "risk price": it captures the average compensation in terms of expected profits for taking on an additional unit of risk. We provide a simple test of "risk mispricing" by including the interaction between the corporate tax rate and the risk measure in the model. If multinational firms misprice risk to lower the global tax bill, we should expect affiliates in high-tax countries to receive less compensation for the same amount of risk than affiliates of the same firm in low-tax countries so that the coefficient on the risk term should be closer to zero when affiliates face relatively high tax rates. As shown in Column 3, we find only weak evidence of such "risk mispricing": the interaction term is statistically insignificant and the estimated coefficient suggests that increasing the corporate tax rate by 10 percentage points reduces the coefficient on the risk term by a modest 6%.

- Table 8 around here -

6 Concluding remarks

This paper studies the effect of taxes on the allocation of risk inside the multinational firm. Theoretically, we show that unconstrained firms optimally allocate all their risk to high-tax countries to maximize risk sharing with governments and all their profits to low-tax countries to minimize expected tax payments. However, when transfer pricing rules require risk to be compensated with a higher expected return, firms face a trade-off: the risk sharing motive to allocate risk to high-tax countries must be balanced against a profit shifting motive to allocate risk to low-tax countries. Empirically, we consistently find that multinational firms disproportionately allocate risk to low-tax countries suggesting that the profit shifting motive dominates the risk sharing motive. Moreover, we show that within-firm differences in risk can account for a significant part of the well-established correlation between profits and tax rates suggesting that risk shifting is a quantitatively important channel for profit shifting.

The analysis has important policy implications. In particular, the *risk-cum-profit-shifting* identified in this paper highlights the limitations of the arm's length principle and international transfer pricing regulation. The migration of profitable risk taking to low-tax environments appears to contribute significantly to base erosion, but is perfectly legitimate under the prevailing approach to taxing multinational firms as long as risk is appropriately priced and substance requirements are observed.

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Appendix

Other profit shifting:

The first-order condition for δ is:

$$(t_H - t_L) = f'(\delta)$$

Let δ^* denote the level of δ that satisfies this first-order condition. Because $f'(\delta)$ is positive only when δ is positive, this implies that $\delta^* > 0$: the affiliate in the low-tax country receives more expected profits and the affiliate in the high-tax country less expected profits than implied by the transfer pricing rules given the allocation of risk. Moreover, since $f'(\delta)$ is increasing in δ, it also implies that δ^* is higher for larger tax differentials.

Using the definition of δ^*, we can rewrite the after-tax profits of the firm in the following way:

$$\pi = (\bar{p} + \varepsilon)(1 - t_H) + (t_H - t_L)\left(\bar{\theta}(\alpha) + \alpha\varepsilon\right) - c(\alpha) + \{(t_H - t_L)\,\delta^* - f(\delta^*)\}$$

The last term in curly brackets is the rent created by profit shifting, which is independent of α. The firm thus chooses α to maximize the other terms. The first-order condition to this problem is identical to the first-order condition in the model without profit shifting (3).

Deductible transaction costs:

These assumptions imply that the first-order condition of the firm is given by:

$$\begin{aligned} 0 &= (t_H - t_L)\left(\underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot\bar{\theta}'\left(\alpha\right)}_{\text{profit shifting}} + \underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\cdot\varepsilon\right]}_{\text{risk sharing}} - \underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot c(\alpha)}_{\text{tax deductibility}}\right) \\ &- \underbrace{E\left[u'\left(\pi_i\left(\varepsilon\right)\right)\right]\cdot c'(\alpha)(1-t)}_{\text{transaction cost}} \end{aligned}$$

where

$$(1-t) = (1-\alpha)\left(1-t^H\right) + \alpha\left(1-t_L\right)$$

Compared to the baseline model, the value of α that minimizes transaction costs, α^C, is unchanged whereas the value that is optimal for tax and risk sharing purposes, α^T is unambiguously lower because of tax deductibility (as an increase in α reduces the value of tax deductibility).

Figure 1: Tax and risk - corporations belonging to national firms

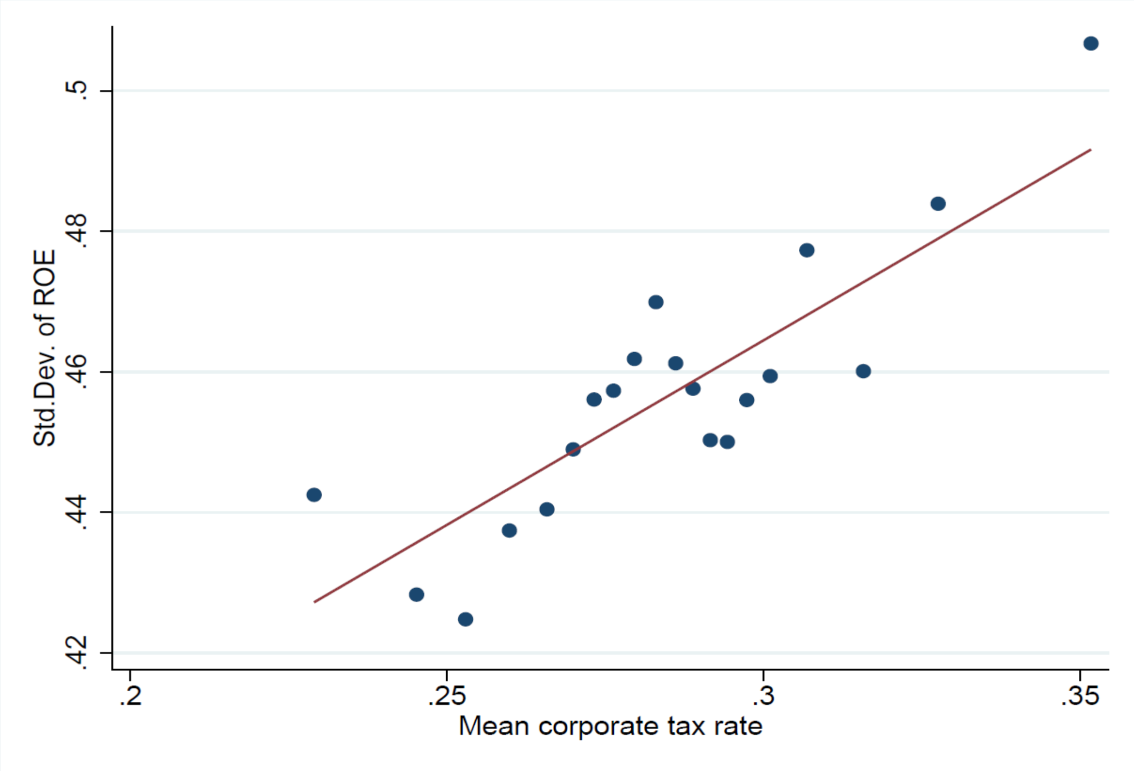
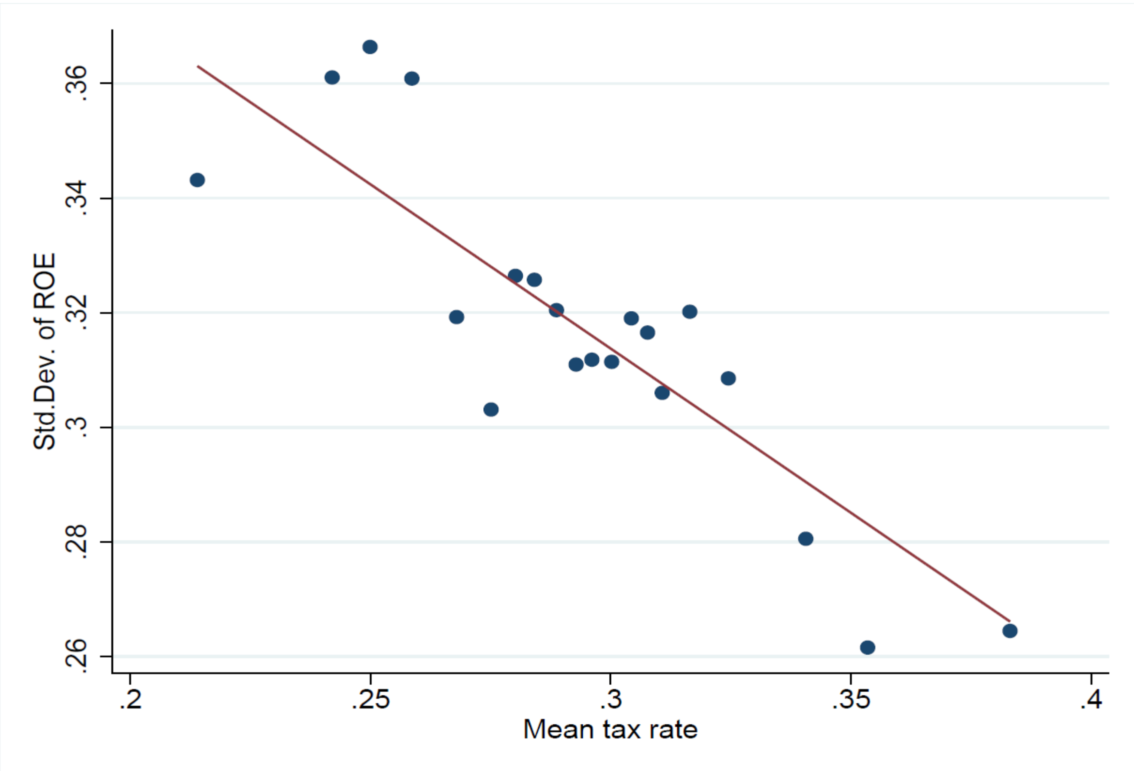
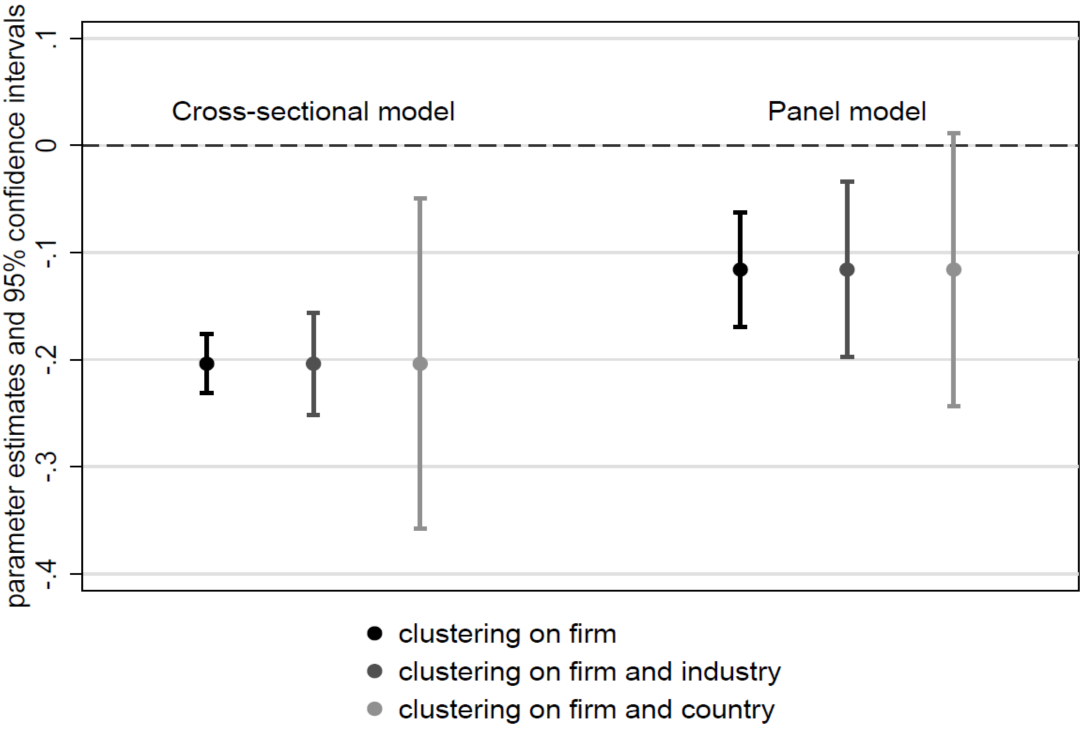


Figure 2: Tax and risk - corporations belonging to multinational firms



Note: The figures show binned scatterplots of the corporate tax rate and the standard deviation of ROE for the sample of corporations with no foreign affiliates (Figure 1) and the sample of corporations with foreign affiliates (Figure 2) respectively. The standard deviation of ROE is taken over all years for which non-missing values are available. The corporate tax rate is measured as the mean value over the same years. The set of controls includes dummies indicating the year of the first observation of ROE, dummies indicating the deciles of total assets and three macro-economic variables: GDP, GDP per capital and the unemployment rate (means over the years with non-missing values of ROE).

Figure 3: Clustering of standard errors



Note: The figure shows estimated point estimates on the corporate tax rate as well as 95% confidence bands for these estimates from the preferred cross-sectional specifation (Table 4, Column 6) on the left side and from the preferred panel specification (Table 6, Column 1) on the right side under different assumptions about the error structure. The black line represents one-dimensional clustering at the firm-level; the dark gray line represents two-dimensional clusering at the firm-level and industry-level (industry-time level in the panel case); the light gray line represents two-dimensional clusering at the firm-level and country-level country-time level in the panel case).

Table 1: Country distribution

Country	Host	Home	Country	Host	Home
Argentina	341	64	Kazakhstan	88	38
Australia	771	1.879	South Korea	2.152	1.621
Austria	4.603	8.868	Latvia	2.078	751
Belgium	18.247	15.612	Lithuania	992	653
Bermuda	88	1.346	Luxembourg	2.912	13.315
Bosnia and Herzegovina	494	178	Malaysia	43	239
Brazil	986	416	Malta	995	1.385
British Virgin Islands	2	218	Mexico	600	544
Bulgaria	2.048	689	Montenegro	55	59
Canada	26	1.397	Netherlands	9.765	17.209
Cayman Islands	17	587	New Zealand	454	196
Chile	216	237	Norway	10.238	9.076
China	4.860	1.673	Peru	130	28
Colombia	897	235	Philippines	747	230
Croatia	2.981	1.189	Poland	10.822	3.177
Curacao	-	114	Portugal	10.115	6.959
Cyprus	104	10.370	Romania	7.323	526
Czech Republic	11.065	4.557	Russia	12.206	2.443
Denmark	14.902	17.082	Serbia	1.773	371
Estonia	3.189	1.887	Singapore	1.307	748
Finland	4.875	5.378	Slovakia	5.214	1.493
France	44.653	43.127	Slovenia	1.756	1.943
Germany	28.488	35.484	South Africa	15	537
Greece	2.172	1.311	Spain	29.341	24.144
Hong Kong	40	363	Sweden	23.390	24.745
Hungary	2.145	1.325	Switzerland	76	4.287
Iceland	456	515	Taiwan	857	1.130
India	2.733	2.751	Thailand	27	142
Ireland	4.465	3.609	Turkey	663	713
Israel	16	534	Ukraine	2.205	50
Italy	43.678	38.003	United Kingdom	48.176	37.350
Japan	10.818	17.358	United States of America	906	23.059

Note: The table indicates for each country the number of corporations belonging to multinational firms located in the country (Host) and owned by a parent corporation in the country (Home). We only report countries for which the sum of the two columns exceed 100.

Table 2: Summary statistics

	Obs.	Mean	Std.dev.	Min.	Max.
Risk and return:					
Standard deviation of ROE	398.374	0,318	0,250	0	1,519
Extreme ROEs (deciles)	398.374	0,152	0,359	0	1,000
Extreme ROEs (quartiles)	398.374	0,376	0,484	0	1,000
Variance of ROE	398.374	0,163	0,245	0	2,308
Mean of ROE	398.374	0,186	0,361	-0,867	1,282
Taxation:					
Corporate tax rate	398.374	0,317	0,075	0	0,597
Macro-economic controls:					
GDP (in logs)	379.702	27,282	1,343	21,859	30,280
GDP per capita (in logs)	379.702	10,093	0,797	5,520	11,674
Unemployment rate	376.046	8,416	3,648	0,100	37,600
Governance:					
Control over corruption	380.272	1,200	0,915	-1,488	2,586
Government effectiveness	380.272	1,265	0,718	-1,673	2,430
Political stability	380.272	0,666	0,598	-2,812	1,668
Regulatory quality	380.272	1,170	0,558	-2,098	2,077
Voice	380.272	1,111	0,583	-1,885	1,826
Rule of Law	380.272	1,149	0,720	-1,842	2,000

Note: The table reports summary statistics for the variables used in the regression analysis. The *standard deviation of ROE* is taken over non-missing and winsorized (95% level) values of ROE for each corporation separately; *Extreme ROEs (deciles)* indicates that the corporation has realized ROE-values in the upper and in the lower decile of the ROE-distribution during the sample period; *Extreme ROEs (quartiles)* indicates that the corporation has realized ROE-values in the upper and in the lower quartile of the ROE-distribution during the sample period; the *Variance of ROE* is taken over non-missing and winsorized (95% level) values of ROE for each corporation separately; the *Corporate tax rate* is the statutory corporate tax rate in the country where a corporation is located; *GDP (in logs)* is the Gross Domestic Product (in logs); *GDP per capital* is the Gross Domestic Product per capita (in logs); *Unemployment rate* is the unemployment rate. *Control over corruption, Government effectivenes, Political stability, regulatory quality, Voice* and *Rule of Law* are indicators of governance, which are standardized (mean zero and unit standard deviation) in the global sample of countries. Variables related to tax, macro-economics and governance refer to the value in the first year where we observe a non-missing value of ROE.

Table 3: Correlation between alternative risk measures

	Std. dev. of ROE	Extreme ROEs (deciles)	Extreme ROEs (quartiles)	Var. of ROE
Std. dev. of ROE	1			
Extreme ROEs (deciles)	0,645	1		
Extreme ROEs (quartiles)	0,556	0,426	1	
Var. of ROE	0,949	0,681	0,475	1

Note: The table shows the correlation between the four alternative measures of risk: (i) the standard deviation of ROE taken over all years with non-missing values of ROE; (ii) an indicator that the corporation has realized ROE-values in the upper and in the lower decile of the ROE-distribution during the sample period; (iii) an indicator that the corporation has realized ROE-values in the upper and in the lower quartile of the ROE-distribution during the sample period; (iv) the variance of ROE taken over years with non-missing observations of ROE.

Table 4: Baseline results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	standard deviation of ROE							
	mean values on RHS				first-year values on RHS			
	full sample	full sample	full sample	balanced	full sample	full sample	full sample	balanced
corporate tax rate	-0.2504***	-0.3677***	-0.4338***	-0.4263***	-0.2025***	-0.2038***	-0.1988***	-0.1956***
	(0.0148)	(0.0195)	(0.0232)	(0.0452)	(0.0114)	(0.0141)	(0.0145)	(0.0381)
Observations	398,557	372,682	367,760	86,609	398,374	355,016	355,016	86,447
R-squared	0.3240	0.3594	0.3585	0.4715	0.3239	0.3620	0.3632	0.4678
time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
macro-economic controls	NO	YES	YES	YES	NO	YES	YES	YES
corporate controls	NO	YES	YES	YES	NO	YES	YES	YES
governance controls	NO	NO	YES	YES	NO	NO	YES	YES
business cycle controls	NO	NO	YES	YES	NO	NO	YES	YES

Note: The table shows regression results from the cross-sectional model with various sets of controls. The dependent variable is the standard deviation of ROE taken over all years with non-missing values of ROE. In Columns (1)-(4), all explanatory variables take the mean value across all years where a corporation has non-missing values of ROE. In Columns (5)-(8), all explanatory variables take the value of the first year with non-missing values of ROE. In Columns (1)-(3) and (5)-(7), the sample includes all corporations with foreign affiliates. In Columns (4) and (8), the sample includes corporations with foreign affiliates with non-missing values of ROE in all of the years 2001-2012. The main explanatory variable is the statutory corporate tax rate. Control variables: *time fixed effects* are dummy variables indicating the first year where a non-missing values of ROE is observed; *firm fixed effects* are dummy variables indicating the ultimate owner of the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *corporate controls* are dummy variables indicating the deciles of the distribution of total assets and dummy variables indicating the industry of the firm (1-digit NACE); *governance controls* are control over corruption, government effectivenes, political stability, regulatory quality, voice and rule of Law; *busines cycle controls* are the standard deviation of the macro-economic controls taken over all the years with non-missing values of ROE.

Table 5: Alternative risk measures

	(1) **ROE in top and bottom decile**	(2) **ROE in top and bottom quartile**	(3) **variance of ROE**
corporate tax rate	-0.1335***	-0.1977***	-0.1399***
Observations	387,507	387,507	355,016
R-squared	0.3002	0.3647	0.3472
time fixed effects	YES	YES	YES
firm fixed effects	YES	YES	YES
macro-economic controls	YES	YES	YES
corporate controls	YES	YES	YES

Note: The table shows regression results from the cross-sectional model with alternative measures of risk as dependent variable: an indicator that the corporation has realized ROE-values in the upper and in the lower decile of the ROE-distribution during the sample period (Column 1); an indicator that the corporation has realized ROE-values in the upper and in the lower quartile of the ROE-distribution during the sample period (Column 2); the variance of ROE taken over years with non-missing observations of ROE (Colunmn 3). The main explanatory variable is the statutory corporate tax rate. Control variables: *time fixed effects* are dummy variables indicating the first year where a non-missing value of ROE is observed; *firm fixed effects* are dummy variables indicating the ultimate owner of the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *corporate controls* are dummy variables indicating the deciles of the distribution of total assets and dummy variables indicating the industry of the firm (1-digit NACE). All explanatory variables take the value of the first year with a non-missing observation of ROE.

Table 6: Panel model

	(1)	(2)	(3)	(4)
	standard deviation of ROE			
corporate tax rate	-0.1159***	-0.1064***	-0.0875***	-0.0850***
	(0.0272)	(0.0274)	(0.0274)	(0.0275)
Observations	172,892	172,892	172,892	172,892
R-squared	0.6810	0.6825	0.6818	0.6830
corporation fixed effects	YES	YES	YES	YES
macro-economic controls	YES	YES	YES	YES
size decile × time	NO	YES	NO	YES
industry × time	NO	NO	YES	YES

Note: The table shows regression results from the panel model with various sets of controls. The sample includes all corporations with foreign affiliates and non-missing values of ROE in each of the years 2001-2012. There are two time periods: 2001-2006 and 2007-2012. The dependent variable is the standard deviation of ROE taken over a time period. Control variables: *corporation fixed effects* are dummy variables indicating the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *size decile × time* are interactions between dummies indicating the decile of the size distribution and dummies indicating the period; *industry × time* are interactions between dummies indicating the industry of the firm (1-digit NACE) and dummies indicating the time period. All explanatory variables take the value of the first year in the time period.

Table 7: Loss offset provisions

	(1)	(2)	(3)	(4)
	standard deviation of ROE			
	loss offset generosity: > 20 years		loss offset generosity: number of years	
corporate tax rate	-0.3060***	-0.3715***	-0.3030***	-0.4192***
	(0.0189)	(0.0242)	(0.0189)	(0.0325)
loss offset generosity	0.0052**	-0.0370***	0.0006***	-0.0021***
	(0.0025)	(0.0100)	(0.0002)	(0.0006)
corporate tax rate × loss offset generosity		0.1350***		0.0087***
		(0.0321)		(0.0020)
Observations	280,197	280,197	280,197	280,197
R-squared	0.3862	0.3863	0.3862	0.3863
time fixed effects	YES	YES	YES	YES
firm fixed effects	YES	YES	YES	YES
macro-economic controls	YES	YES	YES	YES
corporate controls	YES	YES	YES	YES

Note: The table shows regression results from the cross-sectional model with controls for loss offset provisions. The dependent variable is the standard deviation of ROE taken over all years with non-missing values of ROE. The variable *corporate tax rate* is the statutory tax rate in the first year with a non-missing value of ROE. The variable *loss offset generosity* is an indicator that the number of years that losses can be carried forward or backwards for corporate tax purposes (Columns 1-2) or a continuous variable indicating the number of years that losses can be carried forward or backwards for corporate tax purposes exceeds 20 (Columns 3-4). Control variables: *time fixed effects* are dummy variables indicating the first year where a non-missing value of ROE is observed; *firm fixed effects* are dummy variables indicating the ultimate owner of the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *corporate controls* are dummy variables indicating the deciles of the distribution of total assets and dummy variables indicating the industry of the firm (1-digit NACE). All explanatory variables take the value of the first year with a non-missing observation of ROE.

Table 8: Risk and profits

	(1)	(2)	(3)
		mean ROE	
corporate tax rate	-0.1760***	-0.1011***	-0.0790***
	(0.0288)	(0.0243)	(0.0298)
standard deviation of ROE		0.0893***	0.1116***
		(0.0059)	(0.0162)
corporate tax rate ×			-0.0724
standard deviation of ROE			(0.0530)
Observations	387,507	355,016	355,016
R-squared	0.3599	0.3671	0.3671
time fixed effects	YES	YES	YES
firm fixed effects	YES	YES	YES
macro-economic controls	YES	YES	YES
corporate controls	YES	YES	YES

Note: The table shows regression results from a cross-sectional model where the dependent variable is the mean of ROE taken over all years with non-missing values of ROE and the main explanatory variables are the standard deviation of ROE taken over all years with non-missing values of ROE and the corporate tax rate in the first year with non-missing values of ROE. Control variables: *time fixed effects* are dummy variables indicating the first year where a non-missing value of ROE is observed; *firm fixed effects* are dummy variables indicating the ultimate owner of the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *corporate controls* are dummy variables indicating the deciles of the distribution of total assets and dummy variables indicating the industry of the firm (1-digit NACE). All explanatory variables take the value of the first year with a non-missing observation of ROE.

Table A1: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	standard deviation of ROE									
	mean values on RHS					first-year values on RHS				
	baseline	EU27	core industries	exclude outliers	min 5 observations	baseline	EU27	core industries	exclude outliers	min 5 observations
corporate tax rate	-0.3677***	-0.2302***	-0.3637***	-0.2590***	-0.2686***	-0.2038***	-0.1450***	-0.1970***	-0.1238***	-0.1344***
	(0.0195)	(0.0252)	(0.0215)	(0.0144)	(0.0207)	(0.0141)	(0.0156)	(0.0151)	(0.0104)	(0.0146)
Observations	372,682	315,344	332,460	351,207	279,172	355,016	300,714	316,058	333,719	263,120
R-squared	0.3594	0.3434	0.3684	0.3599	0.3928	0.3620	0.3476	0.3711	0.3630	0.3972
time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
macro-economic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
corporate controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
governance controls	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
business cycle controls	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Note: The table shows regression results from the cross-sectional model with various sample restrictions. The dependent variable is the standard deviation of ROE taken over all years with non-missing values of ROE. In Columns (1)-(5), all explanatory variables take the mean value across all years where a corporation has non-missing values of ROE. In Columns (6)-(10), all explanatory variables take the value of the first year with non-missing values of ROE. Columns (1) and (6) correspond to the baseline specifications in Table 4. Columns (2) and (7) exclude corporations located outside of the European Union (27 countries). Columns (3) and (8) exclude firms in the financial and government sector. Columns (4) and (9) exclude corporations with ROE below the 2.5th percentile and above the 97.5th percentile. Columns (5) and (10) exclude corporations with less than 5 non-missing observations of ROE. The main explanatory variable is the statutory corporate tax rate. Control variables: *time fixed effects* are dummy variables indicating the first year where a non-missing value of ROE is observed; *firm fixed effects* are dummy variables indicating the ultimate owner of the corporation; *macro-economic controls* are GDP, GDP per capita and unemployment; *corporate controls* are dummy variables indicating the deciles of the distribution of total assets and dummy variables indicating the industry of the firm (1-digit NACE); *governance controls* are control over corruption, government effectivenes, political stability, regulatory quality, voice and rule of Law; *busines cycle controls* are the standard deviation of the macro-economic controls taken over all the years with non-missing values of ROE.