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# The downside of formula apportionment: evidence on factor demand distortions

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**Abstract** This paper investigates the impact of corporate taxes on the input factor choice of multi-jurisdictional entities (MJEs) under a formula apportionment (FA) regime. Our testing ground is the German local business tax that applies FA regulations with income apportionment according to the relative payroll share. Using unique data on the population of German firms, we find that MJEs distort their employment and payroll costs in favor of low-tax locations. On average, a 1-percentage-point-increase in the tax rate *differential* between an affiliate and foreign group members is found to lower the affiliate's payroll to capital ratio by 1.9%.

**Keywords** Corporate taxation · Formula apportionment · Micro data

**JEL Classification** H32 · H73

## 1 Introduction

The current taxation scheme for multinational enterprises has been perceived as a source of inefficiencies for some time (e.g. Eggert and Haufler 2006). According to its separate accounting (SA) legislation, multinationals must declare their pre-tax profits in the country where they accrue. Henceforth, internationally operating firms have an incentive to distort transfer prices for intra-firm trade and their debt-equity structure

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in order to shift paper profit from high-tax to low-tax jurisdictions and, thus, to reduce the group's overall tax payment. As countries compete for these shifty profits, they set inefficiently low corporate tax rates.

In 2001, the European Commission proposed to abolish the existing SA system within the borders of the European Union and to introduce an alternative taxation scheme called formula apportionment (FA) (European Commission 2001). Under FA, the corporate tax base of a multinational enterprise is consolidated at the group level and is apportioned to the affiliates on the basis of a formula that measures the relative corporate activity. Although FA has not been implemented at the international level yet, sub-national corporate tax regimes in the US, Canada and Germany have followed FA principles for decades. The system's main merit is thereby that profit shifting activities within the corporate group are abolished. On the downside, however, it is well known that FA may introduce new distortions that equally give rise to tax competition behavior between countries.

Whether multinational taxation should, from a normative point of view, follow FA or SA principles, depends on the relative size of corporate tax distortions and subsequent inefficiencies under the two tax regimes. Since source and mechanism of tax distortions fundamentally differ between SA and FA, theoretical papers are, however, largely restricted to the investigation of *qualitative* inefficiencies (for a literature survey see Eggert and Haufler 2006). Thus, a quantitative comparison requires empirical methodology whereas research effort has been rather asymmetrically distributed so far. While profit shifting activities under SA are empirically well-reported (e.g. Clausing 2003; Devereux and Maffini 2007), studies on distortions under FA are scarce.

The present paper contributes to this literature and empirically quantifies corporate tax distortions under FA based on an unique dataset of German firms. In Germany, part of the corporation tax is levied autonomously by local municipalities. The local business tax system thereby applies FA regulations, i.e. if firms operate affiliates in more than one community, their pre-tax profit is consolidated at the national level and apportioned to the affiliates according to the relative payroll share. Our data set comprises all German firms that are liable to local business taxation and allows us to identify every affiliate within a corporate group that is consolidated under FA regulations. Thus, our analysis takes into account that a multi-jurisdictional affiliate's activity may not only be distorted by the local corporate tax but may equally depend on the tax rate at other group locations.

We employ a simple theoretical model to receive guidance for the specification of the estimation equation. The analysis derives two main effects. First, we show that multi-jurisdictional enterprises (MJEs) have an incentive to distort their labor input towards low-tax communities since under payroll apportionment they may thus increase the share of the consolidated profit that is taxed at a low rate. Precisely, an affiliate's labor to capital ratio is suggested to be smaller the larger the average *tax rate differential* between an affiliate and all other group members. In a tax competition framework, this 'formula distortion' implies that corporate taxation exerts a positive fiscal externality on other jurisdictions' welfare and corporate tax rates are set inefficiently low.

Second, under FA each unit of corporate profit is effectively taxed at a weighted average of the affiliates' corporate tax rates. If we—in line with real world systems—

assume that payroll costs are fully deductible from the corporate tax base while capital costs are only partially deductible, we find that an increase in the average group tax reduces capital investment at all group locations. Thus, the labor to capital ratio is predicted to rise in the group's average tax rate. This 'investment distortion' implies that corporate taxation exerts a negative fiscal externality on other jurisdictions' welfare and corporate tax rates are set inefficiently high.

We test the predicted corporate tax effects on the affiliates' relative factor demand based on German firm data that is available for the years 1998 and 2001. Controlling for affiliate fixed effects and various time-varying determinants, we regress an affiliate's payroll to capital ratio on the average tax rate differential between the affiliate and other group locations to capture our model's 'formula distortion'. In line with the theoretical prediction, we find a negative and statistically significant impact which turns out to be stable across specifications and suggests that on average a rise in the tax rate differential by 1 percentage point leads to a drop in the affiliate's payroll to capital ratio by 1.9%. From a welfare point of view this gives rise to a sizable positive fiscal externality and inefficiently low corporate tax rates. Additionally, we estimate the effect of the average group tax rate on the MJE's relative factor demand to test for our model's 'investment distortion'. The coefficient estimates, however, do not gain statistical significance and hence we find no evidence for a negative fiscal externality under FA. Our results are moreover robust to various sensitivity checks. Most importantly, the size of the 'formula distortion' is not found to diminish in the average distance between group affiliates and hence the results do not turn out to be driven by the geographical proximity of German municipalities.

Our paper contributes to the debate on the appropriate corporate taxation scheme for MJEs. The broad theoretical literature in this field compares corporate tax distortions of multi-jurisdictional firm activity under SA and FA (e.g. Gordon and Wilson 1986; Nielsen et al. 2002; Kind et al. 2005; Riedel and Runkel 2007). Usually, the papers arrive at ambiguous results which indicate that the magnitude of the corporate tax distortions under SA and FA depends on the relative size of the MJEs' respective behavioral responses to corporate tax rate changes under the two systems. The quantification of these responses requires empirical methodology.

However, the focus of empirical research has so far strongly been biased towards an investigation of the international SA system. While evidence on profit shifting behavior under SA is conclusive (see e.g. Devereux and Maffini 2007), quantitative research on distortions under FA is thin. The small number of papers that investigates the impact of policy choices on investment and employment under subnational FA (e.g. Weiner 1994; Klassen and Shackelford 1998; Goolsbee and Maydew 2000; Mintz and Smart 2004) usually finds mixed and partly contradicting results. Since all these studies rely on aggregated data at the state or province level, the validity of their results, moreover, depends on the appropriate handling of simultaneity concerns. Our data set in contrast offers the opportunity to surmount these problems by testing the MJEs' corporate tax responses under FA based on firm level data.

Moreover, existing studies on FA account for the impact of *local* corporate taxes on capital investment and employment only. Theoretical models in contrast predict that factor demand distortions at the affiliate level are driven by the *tax rate differential* to other group locations and by the *group's average corporate tax rate*. To the best

of our knowledge, we are the first to account for these theoretically motivated tax measures and henceforth to provide empirical evidence on specific fiscal externalities of corporate taxation under FA.

Additionally, in contrast to most existing studies we investigate a FA system in the *European Union*. Given the differences in social and political institutions between Europe and North America, policy recommendations with respect to the European Commission's proposal should largely gain from the investigation of FA systems within EU borders. We are aware of only three other empirical studies that investigate FA in a European context. Büttner (2003) analyzes fiscal externalities of corporate taxation for the German local business tax. In contrast to our work, he relies on jurisdictional data and determines corporate tax effects on the aggregated tax revenues of geographically close neighboring communities. However, in contrast to our study he hardly finds any significant effect. We attribute the divergent results to the difference in the data's aggregation level. Precisely, our firm data shows that affiliates of a multi-jurisdictional group are usually not located in neighboring communities but are settled around 100 kilometers apart on average. Consequently, Büttner (2003) may not (fully) capture corporate tax effects at the intensive margin which we find to be a decisive driving force for fiscal externalities. Two other papers by Fuest et al. (2007) and Devereux and Loretz (2008) investigate short-run changes in corporate tax revenues if the EU decided to switch from SA to FA. They employ data on German and European multinationals respectively (which currently operate under SA regulations) to predict changes in the national tax revenues induced by the introduction of FA. Their analysis thereby builds on the assumption that multinationals do not adjust their capital investment and employment levels in the wake of the regime change and thus, they fully abstract from the behavioral distortions which define the center of our investigation.

The paper is structured as follows: Sect. 2 presents a simple theoretical model to motivate our estimation equation. Sections 3 to 5 provide information on the German local business tax system, on our data set and on the estimation methodology. The empirical results are described in Sect. 6, Sect. 7 concludes.

## 2 A simple theoretical model

We consider a standard model of corporate taxation under FA (see e.g. Gordon and Wilson 1986 and Nielsen et al. 2002). The model comprises two symmetric countries $a$ and $b$ which host one affiliate of a representative multi-jurisdictional enterprise (MJE). The MJE produces a homogeneous good using labor $L_i$ and capital $K_i$ as input factors, with $i \in \{a, b\}$. A fixed production factor $G_i$ gives rise to positive profits which are taxed at rate $t_i$ with $i \in \{a, b\}$. The production function carries the standard properties with $F' > 0$ and $F'' < 0$. We assume perfect competition on the product market and normalize the price of the good to 1. Workers receive a wage rate $w_i$ which is fixed from the MJE's perspective and which we equally normalize to 1 for all jurisdictions.[1] The capital costs are denoted by the interest rate $r$ and are assumed to

[1] For various reasons, we do not consider the assumption of a fixed wage rate to be critical in the context of our theoretical and empirical analysis. For a thorough discussion, see Sect. 6.2.4.

be partially deductible from the corporate tax base, whereas the deduction parameter is given by $\gamma$ and is assumed to be equal across jurisdictions.[2]

Under FA, the MJE's profit is consolidated at the group level and apportioned according to a formula that measures the affiliates' relative corporate activity. In line with the German local business tax legislation, we will in the following assume that the consolidated profit is apportioned to the affiliates according to their relative payroll shares. Thus, the group's consolidated pre-tax profit is taxed at a payroll weighted average corporate tax rate $\bar{t}$ that reads

$$\bar{t} = t_a \frac{L_a}{L_a + L_b} + t_b \frac{L_b}{L_a + L_b}. \tag{1}$$

The MJE's after-tax profit is therefore defined as

$$\Pi = \sum_i \left[(1-\bar{t})\big(F(K_i, L_i, G_i) - L_i - \gamma r K_i\big) - (1-\gamma) r K_i\right], \quad i \in \{a, b\}. \tag{2}$$

The multi-jurisdictional firm maximizes (2) by choosing its optimal labor demand $L_i$ and the capital stock $K_i$. This leads to the following first-order conditions

$$\frac{\partial F}{\partial L_i} = 1 + \frac{(t_i - t_j)}{(1-\bar{t})} \frac{L_j}{(L_a + L_b)^2} (\Pi_{Pa} + \Pi_{Pb}), \tag{3}$$

$$\frac{\partial F}{\partial K_i} = \frac{(1-\bar{t}\gamma) r}{1-\bar{t}}, \tag{4}$$

for $i, j \in \{a, b\}$ and $i \neq j$; $\Pi_{Pi} = (F(K_i, L_i, G_i) - L_i - \gamma r K_i)$ represents the MJE's tax base in jurisdiction $i$. According to (3), the MJE's labor demand is distorted by corporate profit taxes. If $t_i > t_j$, the MJE has an incentive to reduce its labor demand in jurisdiction $i$ since it thus lowers the share of consolidated profit which is apportioned to $i$ and taxed at the high corporate tax rate. If $t_i < t_j$, the MJE has an incentive to distort labor demand in favor of jurisdiction $i$ since this increases the fraction of the consolidated tax base that is taxed in jurisdiction $i$ at the relatively low tax rate $t_i$. In the following, we will refer to this effect as 'formula distortion'. Moreover, according to (4), optimal capital demand is also adversely affected by corporate taxation, precisely by the group's average corporate tax rate, if capital costs are partially deductible from the corporate tax base ($0 \leq \gamma < 1$).[3] In the following, we will refer to this effect as 'investment distortion'.[4] Note, that formula and investment distortion are unique to the FA system. In an analogous model set up for a taxation system with

[2]This assumption reflects the German local business tax legislation since the tax base definition is set at the national level while each municipality may autonomously decide on the business tax rate.

[3]Under partial deductibility, the group's profit tax rate $\bar{t}$ effectively becomes a tax on the capital input factor. In contrast, with full deductibility ($\gamma = 1$), the firm's capital demand remains undistorted by corporate taxation. Since the German local business tax system does not allow full deduction of capital costs from the corporate tax base, we assume $0 \leq \gamma < 1$.

[4]Note, that (3) and (4) are not in reduced form. Nevertheless, it can be easily shown that the described 'formula' and 'investment distortion' prevail in a comparative static analysis.

SA principles, neither the corporate labor demand nor the capital demand would be affected by the tax burden at other group affiliates (see e.g. Riedel and Runkel 2007).

The derived tax distortions under FA can easily be translated into welfare effects. Assuming that each jurisdiction autonomously chooses its corporate tax rate by maximizing a social welfare function and that it does not take into account the effect of its tax rate choice on foreign welfare, the fiscal externality of corporate taxation on foreign jurisdictions' welfare reflects the inefficiency of the corporate taxation scheme. In our framework, changes in the foreign corporate tax rate $t_j$ influence the domestic firm's input factor choice through two channels. First, the 'formula distortion' implies that an increase in $t_j$ will reduce the tax rate differential $t_i - t_j$ and will thus tend to increase labor demand and welfare in jurisdiction $i$ (see (3)). This gives rise to a positive fiscal externality and inefficiently low tax rates. Second, the 'investment distortion' implies that an increase in the foreign tax rate $t_j$ raises the average group tax $\overline{t}$ and therefore lowers capital investment at *all* group affiliates, including location $i$ (see (4)). This in turn establishes a negative fiscal externality and inefficiently high tax rates. The overall effect is ambiguous, i.e. tax rates may be set inefficiently high or low. For a formal derivation of the described externalities see an earlier working paper version of this paper or Nielsen et al. (2002).

To receive guidance for the specification of the estimation equation, we assume a Cobb–Douglas production function of the following form

$$F(L_i, K_i, G_i) = L_i^{\alpha} K_i^{\beta} G_i^{1-\alpha-\beta}, \quad i \in \{a, b\}, \tag{5}$$

whereas $G_i$ represents a fixed production factor. Dividing (3) by (4) and accounting for the Cobb–Douglas technology gives

$$\frac{L_i}{K_i} = \frac{\alpha}{\beta} \cdot \frac{(1-\overline{t}\gamma)r/(1-\overline{t})}{1 + (t_i - t_j)/(1-\overline{t}) \cdot L_j/(L_a + L_b)^2 \cdot (\Pi_{Pa} + \Pi_{Pb})}, \quad i \in \{a, b\}, i \neq j. \tag{6}$$

This expression is a modified version of the well-known relation between the labor to capital demand and the relative factor price in the Cobb–Douglas case. Taking the logarithm on both sides of (6), we arrive at

$$\log \frac{L_i}{K_i} = \log \alpha - \log \beta - \log\big(1 + \kappa(t_i - t_j)\big) + \log \frac{(1-\overline{t}\gamma)r}{(1-\overline{t})} \tag{7}$$

$$\approx \log \alpha - \log \beta - \kappa(t_i - t_j) + \log \frac{(1-\overline{t}\gamma)r}{(1-\overline{t})} \tag{8}$$

with

$$\kappa = \frac{1}{(1-\overline{t})} \frac{L_j}{(L_a + L_b)^2} (\Pi_{Pa} + \Pi_{Pb}) \tag{9}$$

and $i \in \{a, b\}, i \neq j$. Thus, (8) suggests to regress the logarithm of the labor to capital ratio on the parameters $\alpha$ and $\beta$ which capture the relative importance of labor and capital in the firm's production function. Moreover, the third term on the right-hand-side reflects our model's 'formula distortion' and hence indicates that the logarithm of the labor to capital ratio depends on the tax rate *differential* between a considered

affiliate $i$ and the other group location $j$. As described above, increases in the tax rate differential $t_i - t_j$ reduce affiliate $i$'s labor demand under payroll apportionment. With labor and capital being complements (by the Cobb–Douglas specification), the reduced labor demand translates in a reduced capital demand. However, the effect on capital falls short from the initial labor adjustment (see (8)) and thus, the model predicts an inverse relation between affiliate $i$'s labor to capital ratio and the tax differential to the foreign location.

Moreover, (8) includes the MJE's average corporate tax rate $\bar{t}$ to account for our model's 'investment distortion'. Increases in the local tax rates $t_a$ and $t_b$ raise the MJE's average tax $\bar{t}$ and thereby increase the term $(1-\bar{t}\gamma)r/(1-\bar{t})$. As described above, raising the tax rate at either group location, will tend to diminish capital demand at all affiliates whereas again labor demand is affected by its complementary relation to the capital factor only. Consequently, the labor to capital ratio is predicted to increase in the group's average corporate tax rate.

One complication of (8), which is common to all models on FA, is that the $\kappa$-term depends on the endogenous variables $L_i$ and $K_i$. Thus, strictly speaking (8) is not a neat closed-form solution for the payroll to capital ratio in location $i$. Determining the marginal effect of the tax differential to other group locations on an affiliate's payroll to capital ratio reads

$$\frac{d(L_i/K_i)}{d(t_i - t_j)} = -\frac{\kappa}{1 + (t_i - t_j) \cdot \partial\kappa/\partial(L_i/K_i)}, \tag{10}$$

for $i, j \in \{a, b\}$ and $i \neq j$. It can easily be shown that the sign of $\partial\kappa/\partial(L_i/K_i)$ and henceforth the sign of (10) is ambiguous. Theoretical papers throughout the FA literature circumvent this problem by assuming a symmetric tax competition equilibrium since for $t_i = t_j$ (10) simplifies to $d(L_i/K_i)/d(t_i - t_j) = -\kappa < 0$ (see e.g. Nielsen et al. 2002; Kind et al. 2005; Riedel and Runkel 2007). The analysis then centers around the investigation of marginal deviations of the corporate tax rate differential from the symmetric equilibrium. Adjustments of $\kappa$ driven by changes in the endogenous variable thus are assumed to play no role in the analysis. The specification of our empirical model will follow the theoretical literature and hence we assume the $\kappa$-term in (8) to be unaffected by changes in the tax rate differential. However, Sect. 6.2 will present sensitivity checks on this assumption.

## 3 The German local business tax

Following our theoretical considerations, our paper empirically determines corporate tax effects on MJEs' relative factor demand under a FA regime. Our testing ground is the German local business tax that is levied on corporate profit and is raised autonomously by the 12,544 German communities. The tax base definition, in contrast, is set at the national level. Our empirical investigation comprises the years 1998 and 2001 during which the average municipality levied a local business tax rate of 16.25%. The tax rate thereby exhibits a considerable cross-sectional variation between a minimum rate of 0% and a maximum rate of 45%. Moreover, from a longitudinal point of view, two thirds of the communities changed their business tax rate

between 1998 and 2001. Usually, the wide spread and variability in the business tax measure is accredited to the fact that the local business tax constitutes the only major revenue instrument at communities' discretion and therefore is often adjusted to local budget needs.

Liable to the business tax are individual enterprises, non-incorporated and incorporated firms. The former two groups benefit from tax allowances and hence face a progressive tax scheme. If a firm operates affiliates in more than one community, a FA system applies. Thus, the MJE's income is consolidated at the national level and is apportioned to the single entities according to the relative payroll share. Only in seldom cases, German law regulates that apportionment may be based on other factors if the payroll shares do not reflect the actual business activity of a corporate group in a proper way.[5]

## 4 Data and sample statistics

Our estimations are based on unique data provided by the German tax authorities in cooperation with the German Federal and State Statistical Offices. The data contains tax reports for all German firms that are subject to local business taxation and is available for the years 1998 and 2001 ('Gewerbesteuerstatistik'; for a detailed description of the data set, see Statistisches Bundesamt 2005). In total, we observe data for around 1.3 million corporations per cross section. Since our study is interested in determining corporate tax effects on *multi-jurisdictional* firms' relative factor input, we restrict our analysis to the MJEs included in the data set. Moreover, our estimations account for incorporated groups only since non-incorporated firms face a progressive taxation scheme which would introduce unnecessary complication to the analysis.

The unique advantage of our data is that it provides accounting information at the affiliate level and allows us to identify *all* entities within a MJE that are taxed according to FA principles. Moreover, the cross-sectional affiliate information can be linked to a panel. The identifier variable in the data is the MJE's tax account number which happens to be identical for all affiliates in a corporate group and which is determined by the location of the corporate headquarter. Accounting for the group's tax identification number and the affiliate's hosting jurisdiction, we can link the affiliate information between the observation years.[6] However, as the tax account number may potentially change over time in the course of tax office restructuring or headquarters relocation to different municipalities (or in large cities even by a move to another quarter), the cross-section information can only be connected for 20% of the affiliates in our data.

[5] Our theoretical predictions are derived for a payroll apportionment system and consequently do not apply to firms whose profit is apportioned according to other factors. Although we will not be able to identify individual groups' apportionment factors, the non-payroll-apportionment firms will introduce noise to our estimations and will, hence, bias our results against us.

[6] If an MJE observes more than one affiliate in a municipality, we aggregate the accounting information and treat the entities as one single affiliate.

However, we consider our panel data to be representative for the population of incorporated MJEs. According to German tax authorities, the restructuring of tax offices in the time period between 1998 and 2001 was arbitrary and did not follow any underlying systematic. Location changes of the corporate headquarter might equally considered to be random.[7] As a cross check, we compared the sample means for all relevant variables of our analysis and did not find statistically significant differences between the subgroups of affiliates with and without panel information. Since a Hausman-Test suggests to include affiliate fixed effects in our estimation model, we restrict our analysis to MJEs for which panel information is available. Moreover, 99% of the MJEs in our data comprise less than 50 entities which are consolidated under FA regulations. Since the computational estimation effort convexly increases in the number of corporate affiliates, we focus our analysis on groups with 50 entities at maximum.

Our data comprises a rich set of accounting information at the affiliate level. Thus, we obtain information on capital investment (in stocks), annual payroll cost and taxable profit as well as information on the group's industry, legal form (individual enterprise, incorporated firm, non-incorporated firm) and hosting municipalities. Since our data does, unfortunately, not include information on employment numbers but on payroll costs only, our regressions will employ the *payroll* to capital ratio as dependent variable (not the theoretically motivated labor to capital ratio). Possible implications of this modification are discussed in Sect. 6.2.

Moreover, we ran plausibility tests on the accounting variables in our data set and followed previous studies (e.g. Zwick 2007) in excluding observations in the 1st and 99th percentile of the capital investment and payroll expense distribution. The exclusion, however, is neither qualitatively nor quantitatively decisive for our results. Moreover, we restrict the regressions to multi-jurisdictional groups that on average observed a positive profit in the two sample years. The restriction is justified since our model's relative factor demand distortions critically depend on a positive multi-jurisdictional group profit. Accounting for all mentioned sample adjustments, we remain with 22,540 affiliates being included in our estimation analysis.

Table 1 contains basic sample statistics. The average corporate payroll expenses and capital investment amount to 20.6 million DM and 14.1 million DM respectively. The average payroll to capital ratio is calculated with 3983.4 which is excessively large. However, a detailed look at the data reveals that this mean calculation is driven by a few very large observations since the median of the distribution is calculated with 2.2 and the 95th percentile of the distribution is 39.8. We therefore ran sensitivity checks on all our regressions excluding observations in the upper percentile of the payroll to capital distribution from the estimation which turned out to have no effect on our results. Additionally, we obtain detailed information on the industry of a corporate group and classify 20 categories that broadly correspond to the NACE two-digit level.

We augment our data by municipality characteristics at the affiliate location which were gathered from the REGIOSTAT data base of the German Federal Statistical Office. Theoretically motivated, the community variables of central interest comprise

[7] Note that we cannot identify the headquarter within a corporate group since the original tax account number was removed due to confidentiality requirements.

**Table 1** Descriptive statistics for multi-jurisdictional affiliates

| Variables | Average | Median | Std. Dev. |
|---|---|---|---|
| Payroll Cost (in Millions of DM) | 20.6 | 0.6 | 60.9 |
| Capital Invested (in Millions of DM) | 14.1 | 0.4 | 53.2 |
| Payroll to Capital Ratio | 3983.4 | 2.2 | 134,725.2 |
| Integrated Group | 0.3 | 0 | 0.5 |
| Tax Difference to Other Group Affiliates (Capital Weighted Average, in %) | 0.19 | −0.16 | 2.94 |
| Tax Difference to Other Group Affiliates (Unweighted Average, in %) | 0.02 | 0.00 | 2.78 |
| Average Group Tax Rate (Capital Weighted Average, in %) | 18.94 | 18.92 | 2.33 |
| Average Group Tax Rate (Unweighted Average, in %) | 18.30 | 18.12 | 2.14 |
| Distance to Other Group Affiliates (Capital Weighted Average, in Kilometers) | 107.8 | 37.34 | 131.5 |
| Distance to Other Group Affiliates (Unweighted Average, in Kilometers) | 108.2 | 42.43 | 127.2 |
| Municipality Inhabitants | 116,117.0 | 20,012 | 256,240.8 |
| Municipality Employees | 54,945.5 | 6,831 | 129,816.8 |
| Municipality Unemployment Rate | 0.13 | 0.11 | 0.06 |

the corporate tax difference between the affiliate and other group members, and the group's average tax rate. The average tax rate difference between an affiliate and other group members is small (−0.185% and 0.02% based on a capital weighted and unweighted difference measure respectively[8]) but exhibits a considerable variation across observations. The average group tax rate is calculated with 18.94% and 18.30% based on a capital weighted and unweighted mean calculation respectively and equally features a sufficient variation across observations. Besides these corporate tax measures, we add the hosting municipality's number of inhabitants, the number of employees and the local unemployment rate to our analysis. The community variables are equally summarized in Table 1 and point to a pronounced heterogeneity across German municipalities. The average population size at the affiliate location is measured with 116,117 inhabitants but exhibits a strong variation across affiliates. Moreover, the economic situation of the municipalities differs and is proxied by the unemployment rate in our empirical analysis. The average unemployment rate is calculated with 13%, while again the variation is strong and thus, some communities observe low unemployment rates of less than 1%, others face an unemployment rate of over 50%.

Moreover, we add Gauss–Krueger coordinates to our data and can thereby calculate the distance between an MJE's affiliates. As a result we obtain that the average

[8]The rationale for employing capital weighted and unweighted average calculations will be explained in detail in Sect. 5.

distance of one affiliate to all other group members amounts to 107.8 kilometers (capital weighted mean calculation) and 108.2 kilometer (unweighted mean calculation) respectively. Furthermore, 50% of the affiliates are located more than 37.3 (capital weighted mean calculation) and more than 42.4 (unweighted mean calculation) kilometers apart from other group locations respectively. Intuitively, the average distance between the corporate affiliates increases in the group's affiliate number. While corporate groups with two subsidiaries observe a distance of 65.23 kilometers on average, the (unweighted) average distance between corporate groups with 10 to 50 subsidiaries is calculated with 132.39 kilometers. As mentioned in the introduction, this implies that studies which test fiscal externalities of corporate taxation based on the tax rate information of *geographically* close neighbors may only insufficiently capture corporate tax distortions at the intensive margin.

## 5 Estimation methodology

Based on our considerations in Sect. 2, we estimate the following model

$$\log W_{i,\tau} = \beta_0 + \beta_1(t_{i,\tau} - \tilde{t}_{i,\tau}) + \beta_2 \log \overline{t}_{i,\tau} + \beta_3 x_{i,\tau} + \beta_4 \tilde{x}_{i,\tau} + \phi_i + \mu_\tau + \epsilon_{i,\tau} \quad (11)$$

whereas $W_{i,\tau}$ denotes the ratio of payroll cost to capital employed by multi-jurisdictional plant $i$ at time $\tau$. The explanatory variables of central interest comprise the difference between the corporate tax rate of affiliate $i$ at time $\tau$ $t_{i,\tau}$ and the average tax rate at the foreign group locations $\tilde{t}_{i,\tau}$. Moreover, we include the logarithm of the multi-jurisdictional group's average corporate tax $\overline{t}_{i,\tau}$.[9] Our theory predicts $\beta_1 < 0$ and $\beta_2 > 0$. Since our data comprises two time periods, the estimation approach controls for affiliate fixed effects $\phi_i$ that capture unobserved time-constant plant-characteristics. Note, that these firm fixed effects nest group effects and equally capture time-constant characteristics of the hosting jurisdiction since we include one dummy variable for each affiliate. Using fixed effects is reasonable in our analysis since an affiliate's labor intensity is likely to be mainly driven by internal firm–specific factors (see e.g. the parameters $\alpha$ and $\beta$ in (8)) which are impossible to be captured by observable control variables available in our database. The fixed effects model is also preferred to a random effects approach by a Hausman-Test. Moreover, we control for time-varying locational and industry characteristics at the home and foreign location $x_{i,\tau}$ and $\tilde{x}_{i,\tau}$. The time-varying locational characteristics thereby include the local unemployment rate, the municipality's number of inhabitants and the municipality's number of employees. Last, we include a year dummy $\mu_\tau$ to capture shocks over time which are common to all affiliates in our data set. $\epsilon_{i,\tau}$ describes the error term.

One advantage of our study lies in the possibility to connect affiliates of the same corporate group. This enables us to determine the impact of the corporate tax rate at

[9] Equation (8) suggests to regress the logarithm of the payroll to capital ratio on $\log[(1-\overline{t}\gamma)r/(1-\overline{t})]$. The deductibility parameter $\gamma$ thereby does not vary across the affiliates in our data set. Moreover, we do not observe information on individual firms' capital costs $r$ but presume these to be captured by an affiliate fixed effect and a year effect.

foreign locations on the payroll to capital ratio as suggested by the theoretical model. Since MJEs comprise several affiliates, we follow previous micro-data studies on SA (see Huizinga and Laeven 2008) and apply a weighting scheme for the calculation of our average tax variables $\tilde{t}_{i,\tau}$ and $\overline{t}_{i,\tau}$. Formally, the average tax rate calculation reads

$$\tilde{t}_{i,\tau} = \sum_{j} w_{i,j} \cdot t_{j,\tau}, \quad i \neq j, \tag{12}$$

$$\overline{t}_{i,\tau} = \sum_{\ell} w_{i,\ell} \cdot t_{\ell,\tau}, \quad \ell \in \{i, j\},\ i \neq j, \tag{13}$$

whereas $w_{i,j}$ and $w_{i,\ell}$ denote the weighting scheme. Remember that $\tilde{t}_{i,\tau}$ represents the average corporate tax rate for all group affiliates *excluding* the considered affiliate $i$. Hence, $t_{j,\tau}$ denotes the corporate tax rate of a *foreign* group location $j$ at time $\tau$; accordingly, $w_{i,j}$ stands for the weight attached to the tax rate in jurisdiction $j$ when calculating the average $\tilde{t}_{i,\tau}$. In contrast, $\overline{t}_{i,\tau}$ represents the average corporate tax rate for all group affiliates *including* the considered affiliate $i$. Hence, $t_{\ell,\tau}$ denotes the corporate tax rate of a group location $\ell$ at time $\tau$; accordingly, $w_{i,\ell}$ stands for the weight attached to the tax rate in jurisdiction $\ell$ when calculating the average $\overline{t}_{i,\tau}$. The calculation of averages for other jurisdictional characteristics at foreign group locations $\tilde{x}_{i,\tau}$ methodologically follows the calculation of the average foreign tax rate $\tilde{t}_{i,\tau}$.

Our theoretical model suggests to employ the affiliates' relative payroll shares as weighting schemes $w_{i,j}$ and $w_{i,\ell}$.[10] This, however, may introduce endogeneity problems to our estimation strategy since variations in the corporate tax rate induce adjustments in the payroll cost distribution within a group and hence alter the relative payroll shares that are used as a weighting measure in the calculation of the average corporate tax rates $\overline{t}_{i,\tau}$ and $\tilde{t}_{i,\tau}$. Consequently, the coefficient estimates for $\beta_1$ and $\beta_2$ may be biased.

One way to overcome this endogeneity concern is to construct the weighting matrix on the basis of the affiliates' relative capital shares. As described above, the tax rate distribution within the corporate group may affect the MJE's employment decision and payroll costs location. However, if the complementary relation between labor and capital input is sufficiently low, this will not translate into relevant adjustments of the affiliates' capital investment. As pointed out by Hellerstein and McLure (2004), MJEs may for example adjust their relative labor demand to the intra-firm tax rate distribution by hiring independent contractors whose compensation is not included in the payroll factor at high-tax locations and hiring dependent affiliate workers at low-tax locations. The affiliates' capital investment plausibly remains unaffected by these labor adjustments. Moreover, changes in the average group tax rate are equally predicted to leave the relative capital investment shares unchanged. If the

[10] As described above, the group's average tax rate $\overline{t}_{i,\tau}$ is calculated according to a payroll weighting scheme under the German local business tax law. $\tilde{t}_{i,\tau}$ represents the corporate tax rate that is levied if a unit of group profit is not taxed at location $i$ but at the foreign group affiliates instead. Intuitively, the average actual tax burden of the foreign affiliates thereby equally depends on a payroll weighted average of their statutory corporate tax rates.

group tax is increased due to an enlarged business tax rate at one affiliate, capital investment is predicted to go down proportionally at all locations and hence the relative capital shares are unaffected. This makes a weighting scheme according to the affiliates' relative capital shares an excellent alternative to the payroll weighting scheme since it captures the relative size of the affiliates but is not prone to endogeneity concerns.

As a sensitivity check, we additionally employ an unweighted calculation for the average corporate tax measures. Since the unweighted tax averages do not reflect the affiliates' relative size, we introduce measurement error to our average tax variables. However, as long as this measurement error is unsystematic, it will just bias our coefficient estimates towards zero. In the context of our OLS framework with affiliate fixed effects, the measurement error is unsystematic if the probability to observe a change in the corporate tax rate between 1998 and 2001 is uncorrelated with affiliate size.

To illustrate that imagine an affiliate which observes a change in the corporate tax rate at one of its foreign locations. If this foreign affiliate is large in comparison to other locations, the use of an unweighted average tax measure implies that the average tax change is understated and consequently, the effect of the average tax rates on the considered affiliate's payroll to capital ratio is overestimated. The opposite picture emerges if the affiliate with the increased tax is small compared to other group locations. Then the application of an unweighted mean calculation implies that the change in the average corporate tax measure is overstated which leads to an underestimation of the average tax effects on the considered affiliate's payroll to capital ratio.

Since our data does not exhibit a significant correlation between affiliate size and the probability to observe a change in the local business tax rate between 1998 and 2001, we presume that the application of an unweighted mean calculation to determine our analysis' average tax measures introduces noise to our estimation that just biases the coefficient estimates towards zero.

## 6 Results

The following section presents our estimation results whereas we first describe the baseline estimations and second sketch various sensitivity checks to our results. All upcoming regressions include a year dummy. Heteroscedasticity robust standard errors adjusted for firm clusters are calculated and displayed in parentheses below the coefficient estimates in the result tables. As described in the previous section, the observational units are the multi-jurisdictional affiliates.

### 6.1 Baseline results

Our baseline estimation results are presented in Table 2. The dependent variable is the logarithm of the payroll to capital ratio. In Specification (1), we focus on the 'formula distortion' and include the tax rate differential between the affiliate and other members of the same corporate group as explanatory variable whereas the tax

**Table 2** OLS estimation with affiliate fixed effects—capital weighted tax measures

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Tax Rate Difference / 100 | −2.8428*** | −2.5732*** | −1.9324*** | −1.9504*** | −2.4916*** | −2.4806*** | −1.8702*** | −1.8624** |
| | (0.6598) | (0.6626) | (0.7648) | (0.7680) | (0.7320) | (0.7298) | (0.7664) | (0.8338) |
| Log Avg. Group Tax Rate | | | | | 0.1840 | 0.0509 | 0.0520 | 0.0682 |
| | | | | | (0.1382) | (0.1421) | (0.1955) | (0.1986) |
| Log Inhabitants | | | −0.2422** | −0.2677** | | | −0.2412* | −0.2671** |
| | | | (0.1216) | (0.1260) | | | (0.1351) | (0.1261) |
| Log Employment | | | 0.1971*** | 0.1914*** | | | 0.1973*** | 0.1912*** |
| | | | (0.0519) | (0.0534) | | | (0.0617) | (0.0534) |
| Unemployment Rate | | | −0.4526 | −0.6097 | | | −0.4611 | −0.6144* |
| | | | (0.3438) | (0.3772) | | | (0.3744) | (0.3774) |
| Log Inhabitants FGA | | | 0.0879** | 0.0956*** | | | 0.0860** | 0.0935*** |
| | | | (0.0377) | (0.0381) | | | (0.0394) | (0.0386) |
| Log Employment FGA | | | −0.0566* | −0.0610* | | | −0.0559* | −0.0603* |
| | | | (0.0333) | (0.0335) | | | (0.0331) | (0.0335) |
| Unemployment Rate FGA | | | −1.0446*** | −1.1250*** | | | −1.0537*** | −1.1337*** |
| | | | (0.3902) | (0.4041) | | | (0.3739) | (0.4045) |
| Industry-Year Dummies | | √ | √ | √ | | √ | √ | √ |
| State-Year Dummies | | | | √ | | | | √ |
| Number of Observations | 44,106 | 44,106 | 43,796 | 43,796 | 44,106 | 44,106 | 43,796 | 43,796 |
| Number of Affiliates | 22,053 | 22,053 | 21,898 | 21,898 | 22,053 | 22,053 | 21,898 | 21,898 |
| R Squared | 0.9046 | 0.9060 | 0.9199 | 0.9202 | 0.9046 | 0.9060 | 0.9199 | 0.9202 |

Dependent variable: logarithm of the payroll to capital ratio. The tax measures are calculated on the basis of a capital weighting scheme. Robust standard errors adjusted for firm clusters in parentheses. *** / ** / * indicates statistical significance at the 1% / 5% / 10% level. All Specifications include a dummy variable for the year 2001. Specifications (2)–(4) and (6)–(8) include a dummy that indicates whether the affiliate belongs to an integrated group. The abbreviation 'FGA' denotes (capital weighted) average characteristics of foreign group affiliates

measure is calculated on the basis of a capital weighting scheme. The specification additionally accounts for a full set of affiliate fixed effects and thus, we employ a simple difference estimator to determine how changes in the tax measure between 1998 and 2001 affect the logarithm of an affiliate's payroll to capital ratio. In line with our theory, the coefficient estimate for the tax rate differential exerts a significantly negative impact on the payroll to capital ratio. The estimated semi-elasticity is −2.8 and hence an increase in the tax rate difference by 1 percentage point is suggested to reduce the payroll to capital ratio, on average, by 2.8%. Thus, a rise in the tax rate differential induces the MJE to relocate labor demand and payroll costs towards low-tax municipalities and therefore, we provide evidence for a quantitatively relevant 'formula distortion'.

Specifications (2) to (4) account for various control variables. An F-test of no significance of these additional controls is rejected. Specification (2) adds a full set of industry-year effects whereas the industry definition broadly corresponds to the NACE two-digit level. Moreover, the specification accounts for a dummy variable that indicates whether an affiliate belongs to an integrated corporate group. 'Integrated' thereby means that the group does not only comprise dependent production units but also independent subsidiaries (e.g. subsidiaries in which the group holds less than 50% of ownership shares). The regression yields a semi-elasticity of the payroll to capital ratio with respect to the corporate tax rate difference of −2.6.

Additionally, we hedge against potential concerns that our results may be driven by an unobserved correlation between the local business tax rate and other time-varying hosting community characteristics. Our analysis accounts for both, characteristics of an affiliate's hosting municipality as well as average characteristics of hosting communities of other group members.[11] Precisely, we add the number of inhabitants, the number of employees and the unemployment rate to absorb sales market characteristics, labor market characteristics and the municipalities' general economic situation. The control variables on inhabitants and employees enter in log-form although this is neither qualitatively nor quantitatively relevant for our results. In this and in all following specifications, the weighting scheme for the average municipality characteristics at foreign group affiliates corresponds to the weighting scheme employed for the calculation of the average tax measures. Thus, in Specification (3) the average municipality characteristics for foreign group members are calculated on the basis of a capital weighting scheme. The inclusion of the community controls causes a slight drop in the coefficient estimate for the tax difference variable and suggests that an increase in the tax difference by 1 percentage point reduces the payroll to capital ratio by 1.9%. This quantitative result is confirmed by Specification (4) which additionally accounts for state specific shocks by including a set of state-year dummies.[12]

[11] The abbreviation 'FGA' in our result tables denotes 'Foreign Group Affiliates' and indicates the average jurisdictional characteristics for hosting communities of foreign group affiliates.

[12] Note, that the coefficient estimates for the community characteristics exhibit the expected signs. The results indicate that the payroll to capital ratio tends to decrease in the relative size of the local sales market proxied by the number of local inhabitants and the number of inhabitants at foreign group locations. This may reflect the corporate incentive to locate capital intensive final production in large sales market to save transport costs. The estimates moreover suggest that the corporate payroll to capital ratio increases in the local jurisdiction's number of employees and decreases in the foreign jurisdictions' numbers of

Besides the 'formula distortion' our empirical analysis intends to test for the theoretically derived 'investment distortion'. In Specifications (5) to (8) we thus reestimate the regressions (1) to (4) and additionally include the multi-jurisdictional group's average tax rate (calculated on the basis of a capital weighting scheme). Controlling for affiliate fixed effects, Specification (5) suggests that the average group tax does not exert a statistically significant effect on the affiliates' payroll to capital ratio.[13] Thus, the 'investment distortion' and consequently the negative 'investment externality' do not seem to play a major role in the German FA system. The coefficient for the tax difference variable, in contrast, is estimated with −2.49 and remains statistically significant. The results are robust against the inclusion of industry-year effects (Specification (6)), time-varying locational characteristics (Specification (7)) and state-year effects (Specification (8)). Specification (8) suggests that raising the tax difference to foreign group members by 1 percentage point decreases an affiliate's payroll to capital ratio by 1.9% on average.

There may be concerns that we do not find evidence for an 'investment distortion' since corporate tax effects on capital investments take some time to materialize and our analysis comprises only two time periods. Note, however, that the stickiness of corporate activity should affect both, capital investment levels and the corporate labor demand since dynamic labor demand models and dynamic investment models have shown a comparable dependency on past activity levels (see e.g. Navaretti et al. 2003; Becker and Riedel 2008). Although the model may thus underestimate the absolute importance of the corporate tax effects on affiliate activity, we are confident that the formula distortion prevails to be relatively more important than the investment distortion in a panel analysis comprising a longer time period.

### 6.2 Robustness checks and discussion

In the following, we will employ various robustness checks to our results which mainly address the underlying assumptions of our estimation model.

employees. Thus, corporations tend to locate their labor intensive production at affiliates which are hosted by municipalities with a well-developed and large labor market. Last, the local unemployment rate does not exert any significant effect on the payroll to capital ratio while the unemployment rate at foreign group affiliates exhibits a negative effect. Although stumbling at first sight, this result is well explained by two countervailing effects. On the one hand, a low local unemployment rate may cause local wages to rise which will induce an increase in the affiliates' payroll cost variable. On the other hand, a high local wage rate provides the incentive to decrease the affiliate's labor demand which will in turn reduce the payroll cost variable. If the two effects counterbalance each other, this may well explain the insignificant coefficient estimate for the local unemployment rate. In contrast, if the unemployment rate at foreign affiliates is reduced, this causes a rise in the foreign wage rate and foreign labor demand will decrease. If the labor demand at different affiliates of a corporate group is characterized by a substitutive relation, this will increase labor demand and payroll cost at the considered affiliate and will thus justify the negative correlation between foreign unemployment and the local payroll to capital ratio.

[13] Note that the correlation between the average group tax rate and the tax rate differential is weak which is also reflected by the fact that the inclusion of average group tax variable into the estimation equation hardly changes the coefficient estimate for the tax differential variable.

### 6.2.1 Endogeneity of the weighting scheme

As described in Sect. 5, applying a payroll weighting scheme for the average tax measure calculation may introduce endogeneity problems to our analysis. Our baseline estimations therefore employ capital weighted averages which are not prone to endogeneity concerns. As a sensitivity check, we reestimate the regression model with tax rate measures based on an unweighted mean calculation. Following our discussion in Sect. 5, we presume that the use of unweighted averages introduces unsystematic noise to our estimation and hence biases the coefficient estimates towards zero.

The regression results are displayed in Table 3 whereas the Specifications (1) to (8) correspond to the baseline Specifications in Table 2. The results confirm our previous findings and the methodological considerations in Sect. 5. The coefficient estimates for the tax difference variable exhibit a negative sign in all Specifications but are smaller in absolute size and of slightly lower statistical significance than the baseline results. Specification (4) suggests a semi-elasticity of the payroll to capital ratio with respect to the tax rate differential of $-1.7$. Moreover, in line with the baseline results, the coefficient estimates for the average group tax in Specifications (5) to (8) do not gain statistical significance and therefore, the 'investment distortion' is confirmed to exert no statistically significant effect on the payroll to capital ratio.

### 6.2.2 Symmetric tax rate assumption

In Sect. 2, we derived our estimation equation on the basis of the assumption that the tax rate differential to foreign group members is sufficiently small (see (10)). This implies that our estimation equation may be misspecified for variations in a non-zero tax rate differential whereas this misspecification might, a priori, lead to an under- or overestimation of the tax difference coefficient $\beta_1$. Since (10) indicates that the distortion is small if the absolute size of the tax rate differential is small, we rerun our baseline regressions for a subgroup of affiliates that observes a relatively small average tax difference to foreign group members. Precisely, we account for multi-jurisdictional affiliates in the second and third quartile of the pooled capital weighted average tax difference distribution since these affiliates observe a tax rate difference to foreign group members near zero in both observation years. This most closely resembles a marginal variation in the tax difference from a symmetric equilibrium.[14]

The results are presented in Table 4. Controlling for affiliate fixed effects, Specification (1) confirms the qualitative baseline results and indicates that the corporate tax rate difference to other group members exerts a statistically significant and negative impact on the affiliate's payroll to capital ratio while the average group tax rate does not exhibit any significant effect. First and foremost, this result indicates that our qualitative findings are not driven by a misspecification of the estimation equation.

[14] According to this subgroup definitions, affiliates are included in the regression analysis if they observe a capital weighted tax difference to foreign group members larger than $-1.7\%$ and smaller than $1.3\%$ in both observation years. As this subgroup definition is ad hoc, we accounted for other cut-off rates around the tax rate difference of 0 which led to comparable results.

**Table 3** OLS estimation with affiliate fixed effects—unweighted tax measures

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Tax Rate Difference / 100 | −2.4074*** | −2.4230*** | −1.6122* | −1.6854** | −2.0110*** | −2.0958*** | −1.4324* | −1.4360* |
| | (0.7734) | (0.7708) | (0.8566) | (0.8670) | (0.8094) | (0.8086) | (0.8658) | (0.8880) |
| Log Avg. Group Tax Rate | | | | | 0.3031 | 0.2564 | 0.2521 | 0.3058 |
| | | | | | (0.2338) | (0.2598) | (0.2845) | (0.3169) |
| Log Inhabitants | | | −0.2496** | −0.2773** | | | −0.2449** | −0.2740** |
| | | | (0.1200) | (0.1246) | | | (0.1204) | (0.1249) |
| Log Employment | | | 0.1914*** | 0.1897*** | | | 0.1925*** | 0.1892*** |
| | | | (0.0524) | (0.0541) | | | (0.0524) | (0.0541) |
| Unemployment Rate | | | −0.4353 | −0.6869* | | | −0.4702 | −0.7053* |
| | | | (0.3532) | (0.3838) | | | (0.3541) | (0.3840) |
| Log Inhabitants FGA | | | 0.0561 | 0.0626* | | | 0.0480 | 0.0543 |
| | | | (0.0379) | (0.0380) | | | (0.0386) | (0.0385) |
| Log Employment FGA | | | −0.0178 | −0.0221 | | | −0.0154 | −0.0200 |
| | | | (0.0353) | (0.0351) | | | (0.0353) | (0.0351) |
| Log Unemployment FGA | | | −0.8854** | −1.0089** | | | −0.9358** | −1.0507*** |
| | | | (0.4104) | (0.4278) | | | (0.4099) | (0.4259) |
| Industry-Year Dummies | | √ | √ | √ | | √ | √ | √ |
| State-Year Dummies | | | | √ | | | | √ |
| Number of Observations | 45,080 | 45,080 | 44,786 | 44,786 | 45,080 | 45,080 | 44,786 | 44,786 |
| Number of Affiliates | 22,540 | 22,540 | 22,393 | 22,393 | 22,540 | 22,540 | 22,393 | 22,393 |
| R Squared | 0.9019 | 0.9033 | 0.9034 | 0.9034 | 0.9019 | 0.9033 | 0.9041 | 0.9068 |

Dependent variable: logarithm of the payroll to capital ratio. The tax measures are calculated on the basis of an unweighted mean calculation. Robust standard errors adjusted for firm clusters in parentheses. *** / ** / * indicates statistical significance at the 1% / 5% / 10% level. All Specifications include a dummy variable for the year 2001. Specifications (2)–(4) and (6)–(8) include a dummy that indicates whether the affiliate belongs to an integrated group. The abbreviation 'FGA' denotes (unweighted) average characteristics of foreign group affiliates

**Table 4** OLS estimation with affiliate fixed effects—small tax differences

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Tax Rate Difference / 100 | −6.6910*** | −5.6860*** | −4.9270** | −5.1542*** |
| | (2.1454) | (2.1130) | (2.0394) | (2.0632) |
| Log Avg. Group Tax Rate | 0.1659 | 0.0987 | −0.0948 | −0.2480 |
| | (0.3840) | (0.4071) | (0.3929) | (0.4505) |
| Log Inhabitants | | | −0.1387 | −0.1454 |
| | | | (0.1720) | (0.1761) |
| Log Employment | | | 0.2292*** | 0.2375*** |
| | | | (0.0739) | (0.0757) |
| Unemployment Rate | | | −0.4496 | −0.7142 |
| | | | (0.5076) | (0.5134) |
| Log Inhabitants FGA | | | 0.2635*** | 0.2701*** |
| | | | (0.0941) | (0.0951) |
| Log Employment FGA | | | −0.1639** | −0.1649** |
| | | | (0.0773) | (0.0778) |
| Unemployment FGA | | | −1.2310* | −1.4172** |
| | | | (0.7185) | (0.7733) |
| Industry-Year Dummies | | √ | √ | √ |
| State-Year Dummies | | | | √ |
| Number of Observations | 19,726 | 19,726 | 19,554 | 19,554 |
| Number of Affiliates | 9,863 | 9,863 | 9,777 | 9,777 |
| R Squared | 0.9078 | 0.9097 | 0.9105 | 0.9105 |

Dependent variable: logarithm of the payroll to capital ratio. Robust standard errors adjusted for firm clusters in parentheses. *** / ** / * indicates statistical significance at the 1% / 5% / 10% level. All Specifications include a dummy variable for the year 2001. Specifications (2)–(4) include a dummy that indicates whether the affiliate belongs to an integrated group. The tax measures are calculated based on a capital weighting scheme. The abbreviation 'FGA' denotes the (capital weighted) average characteristics of foreign group affiliates. The estimations comprise affiliates in the second and third quartile of the distribution of the capital weighted average tax rate difference to foreign group members

Interestingly, the absolute size of the coefficient estimate for the tax difference variable substantially increases with a semi-elasticity estimate of −6.7. This quantitative result is robust against the inclusion of industry-year effects (Specification (2)), time-varying community characteristics (Specification (3)) and state-year effects (Specification (4)). Specification (4) derives a semi-elasticity estimate of −5.2. While this surge in the coefficient estimate may partly reflect that the specification problem described above leads to an underestimation of the tax difference effect on the payroll to capital ratio, this is unlikely to be the only driving force. Besides, the results also point to a convex relation between the absolute corporate tax rate differential and the costs of relocating factor endowments for tax purposes. Starting from an optimal factor allocation across affiliates in the absence of corporate tax rate differences, small deviations from the symmetric equilibrium imply that MJEs can easily adjust their affiliates' labor endowment, e.g. by altering the relation of dependent workers and independent contractors newly hired at the affiliate locations. However, adapting

to larger deviations in the corporate tax distribution might require more fundamental changes in the payroll cost distribution, like e.g. the relocation of workers and functional units to different production sites which is likely to be associated with substantially larger costs. Consequently, deviations in the tax rate differential plausibly have a larger impact on the payroll to capital ratio if the initial tax rate difference is small.

#### *6.2.3 Geographical proximity between affiliates*

Our evidence on tax distortions under FA is derived for the subnational local business tax system in Germany and cannot necessarily be transferred to an international context. Most importantly, German communities comprise a substantially smaller territory than nation states. Thus, group affiliates whose locations are geographically close may nevertheless be located in different communities.

It is therefore useful to determine to what degree our results are driven by this geographical proximity of tax setting jurisdictions. If two production sites of an MJE are located near each other, workers could easily change their workplace between the two affiliates in the wake of local business tax rate changes without the necessity to move their location of residence and without the MJE having to bear hiring and firing costs. If our findings are, however, dominated by geographical proximity, they could hardly be carried forward to the international (European) context since multinational entities usually observe large distances between their production locations.

To investigate this question, we reestimate our model for the subgroup of affiliates which observe a distance of 100 kilometers or more to other members of the same corporate group. The results are displayed in Table 5. The semi-elasticity of the payroll to capital ratio with respect to the tax rate difference to foreign group members is negative and statistically significant indicating that a large distance between corporate affiliates does not abolish multi-jurisdictional activities to save taxes by adjusting the intra-group factor location. In contrast, the semi-elasticity amounts to $-3.56$ and is thus even larger in absolute terms than the coefficient estimate of our baseline regression. This result is stable against the inclusion of various control variables in Specifications (2) to (4). The larger coefficient estimate is rationalized by a positive correlation between an MJE's size (measured in affiliate numbers or group profit, see also Sect. 4) and the average distance between the group's affiliates. Since our theoretical model predicts the 'formula distortion' to rise in the overall group profit (see (8) and (9)), this finding is in line with the theoretical considerations.

#### *6.2.4 Payroll to capital ratio as dependent variable*

Due to data limitations, our empirical analysis employs the *payroll* to capital ratio as dependent variable instead of the theoretically motivated labor to capital ratio. This does not alter the interpretation of our results if changes in the local business tax rate do not affect multi-jurisdictional workers' wages. The coefficient estimates for our tax measures are then predicted to be identical irrespective of the payroll to capital ratio or the labor to capital ratio being employed as dependent variable.

**Table 5** OLS estimation with affiliate fixed effects—distance > 100 km

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Tax Rate Difference / 100 | −3.5596*** | −2.8542** | −3.0390** | −3.3332** |
| | (1.2668) | (1.2636) | (1.4984) | (1.5798) |
| Log Avg. Group Tax Rate | 0.2381 | −0.1139 | −0.1974 | −0.2457 |
| | (0.2008) | (0.1974) | (0.3577) | (0.3732) |
| Log Inhabitants | | | −0.0349 | −0.0135 |
| | | | (0.2547) | (0.2734) |
| Log Employment | | | 0.0502 | 0.0495 |
| | | | (0.1637) | (0.1728) |
| Unemployment Rate | | | 0.1088 | −0.3396 |
| | | | (0.6490) | (0.7196) |
| Log Inhabitants FGA | | | 0.2499*** | 0.2418*** |
| | | | (0.0853) | (0.0851) |
| Log Employment FGA | | | −0.2230*** | −0.2195*** |
| | | | (0.0762) | (0.0758) |
| Unemployment FGA | | | −2.3778*** | −2.3612*** |
| | | | (0.7183) | (0.7127) |
| Industry-Year Dummies | | √ | √ | √ |
| State-Year Dummies | | | | √ |
| Number of Observations | 11,300 | 11,300 | 11,248 | 11,248 |
| Number of Affiliates | 5,650 | 5,650 | 5,624 | 5,624 |
| R Squared | 0.8894 | 0.8942 | 0.8799 | 0.8800 |

Dependent variable: logarithm of the payroll to capital ratio. Robust standard errors adjusted for firm clusters in parentheses. *** / ** / * indicates statistical significance at the 1% / 5% / 10% level. All Specifications include a dummy variable for the year 2001. Specifications (2)–(4) include a dummy that indicates whether the affiliate belongs to an integrated group. The tax measures are calculated based on a capital weighting scheme. The abbreviation 'FGA' denotes the (capital weighted) average characteristics of foreign group affiliates. The estimations comprise affiliates that observe an unweighted average distance to other group members of 100 kilometer or more

We consider this to hold for two reasons. Firstly, workers in Germany can plausibly be assumed to be mobile across jurisdictions since German communities comprise small geographic areas and language and cultural barriers to mobility do not exist. With worker mobility and perfectly competitive labor markets, changes in the corporate tax rate and consequent adjustments in labor demand between jurisdictions do not exert any impact on workers' wages since arbitrage of workers cancels out potential wage effects. Workers consequently geographically "follow" labor demand adjustments. Secondly, wage determination in Germany is largely characterized by union wage bargaining which takes place at the sector level in most industries. Consequently, bargaining outcomes are determined by the overall labor demand in a sector but not by the distribution of labor demand across jurisdictions. Since changes in the local business tax rate largely affect the latter while leaving the overall labor demand

unchanged, we consider it plausible to assume workers' wages to be independent from the distribution of local business taxes.[15]

## 7 Conclusion

Using a new and unique data set on German firms, our paper provides evidence for a quantitatively relevant distortion of firm behavior by corporate taxation under FA. The results indicate that multi-jurisdictional firms possess a substantial flexibility to adjust their payroll costs at the intensive margin in order to reduce their corporate tax burden under the German payroll apportionment system. Precisely, a 1-percentage-point-increase in an affiliate's local business tax difference to other group members is estimated to reduce the affiliate's payroll to capital ratio by 1.9% on average. This distortion of payroll costs towards low-tax affiliates enlarges the share of the consolidated pre-tax profit that is apportioned to low-tax communities and consequently, gives rise to a positive fiscal externality and a race-to-the-bottom in corporate tax rates.

Thus, our results suggest that some caution is warranted with respect to the European Commission's proposal to introduce FA in the European Union. Although the results are not directly comparable to micro data studies on profit shifting under SA since those exclusively investigate international settings and follow different identification strategies, our paper nevertheless suggests that tax distortions under FA may not fall very short from their SA counterparts. A recent paper by Huizinga and Laeven (2008), for example, captures profit shifting activities in the European Union by regressing an affiliate's pre-tax profits on an intra-group tax difference measure and finds semi-elasticities of $-0.8$ to $-3.7$. Quantitatively similar results are reported in other papers on profit shifting activities (for a survey see Devereux and Maffini 2007). We in contrast derive a semi-elasticity of an affiliate's payroll to capital ratio with respect to the tax rate differential to foreign group members of $-1.9$. Thus, conditional on the capital input choice, an increase in the tax rate difference by 1 percentage point reduces the payroll input, and consequently the pre-tax profit, at an affiliate by 1.9%.

It goes without saying that part of this rather large distortive effect may well be attributed to the subnational character of the German FA system that might provide a higher flexibility to adjust payroll costs than a multinational context within the EU (since for example cultural and language barriers that restrict the relocation of input factors in an international context are not decisive at the subnational level). Moreover, if the European Union introduced FA within its borders, it is likely to rely on a three-factor formula which includes capital and sales beyond the payroll factor. The corporate adjustment flexibility in the former two factors may well be smaller than the reported results for the payroll apportionment system, although we consider that to be somewhat unlikely. Here, more empirical research is needed. Nevertheless, given the

[15] Note here, that corporate tax effects on labor demand run mainly through the 'formula distortion'. Thus, changes in the tax rate differential between group members lead to a relocation of labor demand between jurisdictions but likely induce no major changes in the affected firms' overall labor demand within German borders.

strong distortive effects under the payroll apportionment system, our findings should in any case cast some doubt on the hope that the introduction of FA will substantially reduce tax competition behavior between European countries.

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