Size Does Matter: Firm Size Effects from Environmental Regulation on Employment using Quantile Regression

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Abstract: Does environmental regulation affect employment disproportionately in small or large firms? The present microeconometric analysis estimates the employment effect of a specific electricity tax on firm level employment. This analysis contributes to the literature by using a quantile regression approach. This allows taking a detailed look at where in the distribution of firms jobs are lost or generated by the environmental policy. The empirical analysis is based on the German production census which represents about 6 million employees. According to quantile regression results, overstaffed firms display a strong negative correlation between electricity consumption and employment while for understaffed firms this correlation is close to zero. This result holds for those firms that pay the full electricity tax. In contrast, for firms paying the reduced marginal tax rate, the correlation between electricity use and employment is slightly positive.

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1 Introduction

Environmental regulations have important repercussions on the labour market. One of these repercussions concerns employment and the question whether environmental policies destroy or generate employment. While the literature finds weak or zero effects, there might be important effect heterogeneities. This study looks at employment effects of environmental regulation along the firm size distribution by means of quantile regression. This allows analysing the following research question: Where in the firm size distribution are jobs lost or generated by environmental policy?

The idea that environmental policy might generate rather than destroy employment was brought up most prominently by Porter (Porter, 1991; Porter and van der Linde, 1995). Although the early literature found mixed evidence or no effect (see Jaffe et al., 1995), recent literature finds weak negative employment effects of the Clean Air Act on regulated industries (Deschênes, 2012; List et al., 2003; Greenstone, 2002; Berman and Bui, 2001). For Europe, the literature shows hardly any sign of a negative employment effect (Martin et al., 2014a,b; Petrick and Wagner, 2014; Cox et al., 2013). In order to study whether environmental regulation affects disproportionately small or large businesses, Becker et al. (2013) study Pollution Abatement Operating Costs (PAOC) and find that these rise weakly with increasing employment.

The present analysis contributes to the literature by explicitly analysing firm size heterogeneity. More specifically a quantile regression approach is employed to the estimation of employment effects of environmental regulation - for the first time, to the best of my knowledge. This approach allows answering the following research questions: Where are jobs lost or generated by environmental regulation when looking along the firm size dimension? Is it that larger or overstaffed firms show a stronger decline in employment? In turn, are smaller or understaffed firms less affected?

Why should there be heterogeneity with respect to firm size at all? Small firms have been found to be more flexible in terms of being more innovative,and being more flexible in hiring and firing employees. However, large firms may have more resources available than small firms in terms of capital and labour to react to policy changes. Moreover, there may be compliance asymmetries (Becker et al., 2013) which make environmental compliance more expensive per unit of output for small as compared to large businesses, e.g. due to high fixed costs of a regulation. Thus it is undetermined ex-ante whether small or large firms display stronger employment reactions to an environmental policy.

Why is this question relevant? Small and young firms are most important in creating employment (Haltiwanger et al., 2013). Also, there are often policy exemptions for very small or very large firms, e.g. in trying to protect international competitiveness of exporting firms.[1] Therefore, policy makers need to understand which type of firms is most affected in order to address policies to the desired target group of firms.

Germany is an interesting case to study because its environmental policies serve as a reference for the designing of environmental policies in other countries. Moreover, some of its environmental policies have been designed explicitly to gain the so-called double dividend, that is achieving ecological improvements and employment gains at the same time. In addition, Germany is the largest economy in the European Union and the fourth largest economy in the world.

There is a large public debate in Germany about the Renewable Energies Act (EEG) which is suspected of having destroyed many jobs, primarily in the solar industry (Frondel et al., 2010). A precursor to this policy is the electricity tax, introduced in 1999, which mandates all electricity users including firms to pay a tax on their electricity bought. This tax is currently at EUR 20.5 per MWh which is large in magnitude compared to the average yearly wholesale price for electricity that ranged between EUR 30 and EUR 65 per MWh between 2003 and 2010. However, tax reductions are possible under cer-

[1] An example where small firms are exempt from environmental regulation is the European Emissions Trading System (EU-ETS) which affects firms only from a minimal size onwards. Examples where large firms face less stringent environmental regulations are the German Renewable Energies Act (EEG) or the electricity tax.

tain conditions in particular for large firms in manufacturing industries, which allows analysing descriptively differences between firms that pay the full vs. the reduced marginal electricity tax rate. This will be implemented using a quantile regression framework.

The empirical analysis is based on data from the German production census (AFiD; "Administrative Firm Data") provided by the Federal Statistical Office. The data set is a full sample of all establishments in manufacturing with a minimum number of employees and participation is mandatory by law. Overall, each year from 1995 to 2010 there are about 50,000 establishments in the data covering more than 6 million employees. Manufacturing is an interesting case to study because it makes up about 26% of gross value added and uses about 46% of electricity. Therefore it is particularly important in this sector to detect and correct potential inefficiencies.

The results show a strong and significant negative correlation between electricity bought and employment for firms paying the full electricity tax. In contrast, for firms paying the reduced marginal tax rate, the correlation with electricity consumption is slightly positive, but they display lower employment levels. For firms paying the reduced electricity tax rate these results remain qualitatively the same when looking along the firm size distribution by means of quantile regression. But for firms paying the full electricity tax rate, the quantile regression results show a very interesting heterogeneity along the conditional firm size distribution. According to these results, overstaffed firms display a strong negative correlation between electricity consumption and employment while for understaffed firms this correlation is close to zero. Firms that benefit from the reduced marginal tax rate do not display the negative employment effect found for firms paying the full rate. Thus, introducing a reduced electricity tax rate may have helped to overcome the otherwise negative employment effects of higher electricity consumption.

The outline of this paper is as follows. The following section discusses the existing literature. Then, section 3 presents the data and descriptive statistics. Section 4 explains the econometric approach. Next, section 5 presents and discusses the empirical results. The final section concludes.

2 Literature

Environmental policies can have positive or negative effects on employment as a side effect. On the one hand, traditionally, environmental stringency is seen as a cost factor to firms hence increasing production costs and thus threatening employment (e.g. Gray et al., 2014). On the other hand, there is a view that environmental stringency increases the competitive advantage of those firms which are subject to the regulation. This is known as the Porter Hypothesis (Porter, 1991; Porter and van der Linde, 1995), according to which environmental stringency can enhance productivity and innovation in several ways (Ambec et al., 2013). Firms subject to well-designed environmental regulations will be more informed about potential technical improvements and effective utilisation of resources. Regulations which focus on data collection may raise corporate awareness of firms. Regulation can also spur innovation and productivity, and it balances out the playing field for all firms subject to the regulation.

The biggest criticism of the Porter Hypothesis is that it assumes that firms do not fully take advantage of profitable opportunities (Palmer et al., 1995). Also, it must be noted that the Porter Hypothesis claims that only well-designed environmental regulations may have such positive effects. The Porter Hypothesis has often been divided into the "weak'" version and the "strong" version. The "weak version" claims that environmental regulation enhances innovation, but still regulated firms pay a price in terms of reduced profits (Jaffe and Palmer, 1997). The "strong" version indicates that the regulation has benefits which overcompensate the costs to firms leading, in turn, to increased competitiveness (Ambec et al., 2013), which might result in increasing employment. In their thorough analysis of the Porter Hypothesis, Ambec et al. (2013) review the empirical evidence from the last 20 years. They show that there is strong empirical support for the "weak" version of the Porter Hypothesis, whereas support for the "strong" version is mixed. In any case the positive effects of environmental regulation as stated by the Porter Hypothesis do not seem to hold generally but always depend on the specific conditions of a regulation (**?**).

Based on these thoughts, there is a large literature investigating whether the employment effect of environmental regulation is positive or negative. The early literature found inconclusive results on employment effects of the Clean Air Act or a zero employment effect (see Jaffe et al., 1995 for an overview). In contrast, recent US literature points to weakly negative employment effects (Deschênes, 2012; List et al., 2003; Greenstone, 2002; Berman and Bui, 2001). Moreover, there is also a growing interest and literature on how the Clean Air Act affects other outcomes, such as income (Isen et al., 2014; Walker, 2013), location decisions (Kahn and Mansur, 2013; Becker and Henderson, 2000), Total Factor Productivity (TFP; Greenstone et al., 2012), Foreign Direct Investments (FDI; Henderson and Millimet, 2007; List and Co, 2000) and emissions (Fowlie et al., 2012; Auffhammer and Kellogg, 2011; Fowlie, 2010; Greenstone, 2004). Further interesting outcomes of other environmental policies include worker productivity (Chang et al., 2014; Graff Zivin and Neidell, 2012) and health (Currie et al., 2014; Lavaine and Neidell, 2013; Schlenker and Walker, 2011).

Due to differences in regulations and in the labour market, the results for the US cannot be directly transferred to the European case. In contrast to those weakly negative employment effects in the US, the current literature for Europe finds hardly any indication for negative employment effects (Martin et al., 2014a,b; Petrick and Wagner, 2014; Licht and Peters, 2014; Cox et al., 2013). On the basis of firm level data, the studies by Martin et al. (2014a) and Petrick and Wagner (2014) find hardly significant effects of environmental regulation in the UK or in Germany on employment or other economic outcome variables. Petrick and Wagner study the European Emission Trading System (EU-ETS), but they cannot separate the estimated effects from those of the German Renewable Energies Act. The study by Cox et al. (2013) tries to estimate the effect of the German renewable energy surcharge on the basis of data from the LIAB. It concludes by pointing to weak negative employment effects of the surcharge, which hit in particular medium and highly qualified employees.

As discussed above, the so-called Porter Hypothesis can trigger down into the firms by stimulating innovation, i.e. R&D as well as innovation adoption. The early study by Jaffe and Palmer (1997) finds moderate positive effects of compliance expenditures on R&D, but no direct effect on inventive output as measured by patents. However, when the analysis is restricted to environmentally successful patents, there seems to exist a positive effect from environmental regulation (Ambec et al., 2013 and the literature therein). When investigating the link from innovation to employment, the literature usually points to a weakly positive employment effect from "green" innovation (Licht and Peters, 2014; Horbach and Rennings, 2013; Rennings and Rammer, 2011; Rennings and Zwick, 2002; Pfeiffer and Rennings, 2001). More precisely, integrated "green" process innovations tend to generate employment whereas end-of-pipe technologies tend to reduce employment (Horbach and Rennings, 2013; Pfeiffer and Rennings, 2001; Rennings and Zwick, 2002; Licht and Peters, 2014), which is in line with the Porter Hypothesis. The recent study by Rexhäuser and Rammer (2014) distinguishes between regulation-induced and non-regulation induced innovations and finds no difference such that both may have positive effects on profitability. Furthermore, it finds that resource-saving innovations display a positive effect whereas other innovations may have weak adverse effects.

There is a small literature on firm size effects of environmental regulation on employment (Becker et al., 2013 and the literature therein). Most of this literature uses aggregate, i.e. industry level, data. Pashigian (1984) finds increasing plant size and a reduced number of plants per industry from environmental compliance which he interprets as a sign for a higher burden on smaller firms (similar result by Millimet, 2003). In contrast, Evans (1986) finds diseconomies of scale in pollution abatement. Dean et al. (2000) find less business formations within industries with higher pollution abatement costs. Studies using microeconometric data find economies of scale in pollution abatement (Hartman et al., 1997) or mixed evidence depending on the air pollutant considered (Becker, 2005). The study by Becker et al. (2013) investigates explicitly the relation between plant size and pollution abatement operating costs (PAOC), that is abatement costs per unit of output. Based on establishment-level survey data they find that small establishments and firms pay slightly less abatement costs than large firms and are thus affected less rather than more by environmental regulation. For Europe, the study by Martin et al. (2014a) indicates that small firms tend to show negative employment effects whereas for large firms the tendency of the employment effect is positive, though the differences are not significantly different. Thus, the contribution of this paper to the literature will be to explicitly consider the heterogeneity of employment effects from environmental regulation along the firm size distribution by means of quantile regression. This allows identifying whether small or large firms are winners or losers of environmental regulation.

Quantile regressions have hardly been used in the field of environmental economics, so far. The study by DeLeire et al. (2014) is the closest to this present study which uses quantile regressions. It analyses worker flows in reaction to shale gas drilling in the US and suggests larger job gains in the upper part of the job flow distribution. Further examples of studies in environmental economics using quantile regressions are Yaduma et al. (2013); Frondel et al. (2012); Kesidou and Demirel (2012) and Du and Ng (2011). However, these studies are only related methodologically, but not to the content of this present analysis.

3 Data and Descriptive Statistics

The empirical analysis is based on data from the German production census (AFiD; "Administrative Firm Data") provided by the Federal Statistical Office. The data set is a full sample of all establishments in manufacturing with a minimum number of 20 employees[2] and participation is mandatory by law. Overall, each year from 1995 to 2010 there are about 50,000 establishments in the data covering more than 6 million employees. The establishment data are aggregated to the firm level for two reasons. First, this allows merging the data with an additional module to the data which provides detailed information on

[2]For a part of the survey this minimum number was increased to 50 employees in 2007. However, due to the modular structure of the data set this only affects a few variables.

energy use.

The second reason for aggregating the data to the firm level is that electricity tax exemption rules apply on this level. Tax reductions apply to firms that exceed a certain threshold of electricity bought. Note that all power that is bought below the threshold is fully taxed. Note that only electricity bought is taxed, leaving own production of electricity untaxed. This study analyses electricity bought, exclusively, but the term will be used interchangeably with the term electricity consumption for ease of reading. This threshold has varied over time and the amount of the tax and of the reduction also varied, as can be seen in table 1. The identification of firms paying the full vs. the reduced tax rate follows straight from the data because electricity bought is provided.

Table 1: Marginal electricity tax rate

Electricity tax	Marginal electricity tax rate in EUR per MWh						
	Until 1999	1999	2000	2001	2002	2003	Until 2010
Full rate	0	10	12.5	15	17.9	20.5	20.5
Reduced rate	0	2	2.5	3	3.6	12.3	12.3
Threshold	n.a.	50 MWh	40 MWh	33 MWh	28.6 MWh	25 MWh	25 MWh

Which share of firms benefits from the reduced electricity tax rate? Interestingly, about 95.6% do. The left part of figure 1 in the appendix shows how the share of firms paying the full vs. reduced tax rate varies over the deciles of the unconditional employment distribution. The share of firms paying the reduced marginal tax varies from 87.5% at the lowest decile to 99.8% at the highest decile. This makes a quantile regression of the reduced tax-dummy on the whole sample infeasible. For this reason, the estimation sample is reduced to contain only those observations which lie within a range of 25 MWh around the threshold. Hence, the remaining firms are very well comparable in that their electricity consumption varies only within a small range. In addition, the data is limited to those observations starting in 1999 in order to include only those years in which the electricity tax is in place. This way firms paying the full vs. the reduced tax rate can be compared. Within this selected sample, the share of firms paying the reduced marginal electricity tax rate is 58.9% and its distribution over the employment distribution can be found in the right panel of figure 1.

Additional control variables used in this study are: Investment as a proxy for capital, federal state and industry.[3] In an additional specification, the following variables will be added to the regression: Share of turnover abroad, material use and unemployment rate as a proxy for the business cycle.

Descriptive Statistics can be found in table 3 and 4 in the appendix. They show that average employment in this selected sample is 37.4 employees. The average electricity consumption is 34.1 MWh. The three largest industries within this sample are the manufacturing of metals, metal products and electrical equipment. The pooled sample contains more than 35,000 observations while within each year there are between 2000 and 4400 observations. In consequence, it is meaningful to do the analysis on a year-by-year basis to circumvent this structural break in the data. The changes over time (table 4) in the share of firms paying the reduced tax rate and in the average electricity consumption are explained by the institutional changes over time (table 1).

4 Econometric Approach

Let us start by imagining an KLEM production function which we rearrange such that employment is the dependent variable. A very intuitive way to estimate the effect of the policy on employment would be to add a "treatment"-dummy indicating whether a specific firm i pays the full or the reduced marginal electricity tax rate. However, as treatment status is a direct function of electricity bought, i.e. whether a firm consumes electricity above or below the threshold, the "treatment effect" from such a model would simply reflect high vs. low electricity consumption. This problem is solved by adding electricity bought to the model and interacting it with the treatment dummy. Thus, the

[3] The European Statistical Classification of Economic Activities (NACE) is used continuously in its 2003 classification. Using the 2008 classification, instead, for all years produces a large systematic break in the year 2008.

estimated regression model reads as follows:

$$\begin{aligned}(1)\quad empl_{it} &= \beta_0 + \beta_1 D_{it}(reduced\ tax) + \beta_2 Electr.\ consumpt._{it} \\ &+ \beta_3 D_{it}(reduced\ tax) * Electr.\ consumpt._{it} \\ &+ \beta_4 Turnover_{it} + \beta_5 Investments_{it} \\ &+ \sum_{j=2}^{16} \gamma_j D_{it}(Federal\ state = j) + \sum_{k=2}^{20} \delta_k D_{it}(Industry = k) + \epsilon_{it}\end{aligned}$$

where $empl_{it}$ refers to employment in firm i at time t, $D_{it}(reduced\ tax)$ is a dummy variable indicating whether firm i pays the reduced tax rate in t, and *Electr. consumpt.* refers to the electricity bought by firm i (a continuous variable). Next, the interaction term $D_{it}(reduced\ tax) * Electr.\ consumpt._{it}$ is zero for firms paying the full tax rate and gives the value of electricity consumption for those firms paying the reduced rate. This will be important to interpret carefully. Additional control variables are turnover, investments as a proxy for capital, federal state dummies and industry dummies. Model (1) refers to the case of year-by-year regressions. When, instead, a pooled specification over all years is used, an additional set of year dummies is added to the regression. Moreover, some specifications will include additional controls for turnover abroad, material use and unemployment rate as a proxy for the business cycle.

In order to interpret the results in a meaningful manner, particular attention has to be paid to the interaction term and its coefficient β_3. More precisely, the marginal effect of the electricity consumption on employment is:

$$(2)\quad \frac{\delta empl_{it}}{\delta Electr.\ consumpt._{it}} = \beta_2 + \beta_3 * D_{it}(reduced\ tax)$$

Thus, for firms paying the full tax rate, equation (2) reduces to β_2 and for firms paying the reduced marginal tax rate it reduces to $\beta_2 + \beta_3$. The corresponding estimation results will be displayed later graphically.

The regression model in equation (1) will be estimated first by OLS and second by quantile regression (QR, Koenker and Bassett, 1978; Koenker and Hallock, 2001; Koenker, 2005). Quantile regression is based on a weighted regression where weighting is done by the so-called check function $\rho(\tau)$ which implements an asymmetric weighting which varies with the considered quantile τ. The τth percentile of the employment function depending on a set of covariates X is specified as:

$$(3) \quad q(\tau|X) = X'\beta(\tau)$$

The minimising problem is solved by linear programming and this results in quantile-specific coefficient estimators. Hence, the effect of a covariate can vary over the distribution of the conditional distribution of the outcome variable, here employment. In the present application, this means that the employment effect of electricity consumption can vary with the conditional employment size, i.e. large firms can display different employment effects as compared to small firms. More precisely, as quantile regression provides a comparison along the *conditional* employment distribution, it is more precise to speak of understaffed and overstaffed firms (i.e. conditional on the covariates). It should be noted that quantile regression has to be considered in analogy to least squares regression (OLS) in the sense that this method alone provides descriptive rather than causal effects. Despite being merely descriptive, these estimates can be very interesting.

5 Empirical Results

Does higher electricity consumption go along with higher or lower employment? How is this correlation affected by the electricity tax? Table 5 and figure 2 show the results of estimating model (1). Each line represents one year-specific regression.[4] Let us start by looking at the estimated coefficients for electricity consumption. The estimated coefficients are mostly negative,

[4]The results for the additional control variables are not displayed, but are available upon request.

but not always significantly different from zero. This implies a negative correlation of electricity consumption with employment for those firms that pay the full electricity tax rate (cp. equation 2). For this group of firms the results imply that electricity and labour are substitutes rather than complements in the production function. In contrast, for firms paying the reduced marginal electricity tax the coefficients have to be interpreted jointly. In order to gauge the marginal effect of electricity consumption on employment, we have to keep in mind equation (2) and add the coefficients for electricity consumption and for the interaction term. This is what is displayed in figure 2. This results in small positive terms meaning that in firms paying the reduced marginal tax rate a higher electricity consumption goes along with slightly growing employment. However, note that the employment level is significantly lower for firms paying the reduced marginal tax rate and this effect is on the order of up to about one dozen employees (see column 1 of table 5) and figure 3.

Qualitatively, these results remain the same when additional covariates are added (see table 6 in the appendix). The magnitude of all effects remains the same meaning that these results are robust to the inclusion or exclusion of the additional variables.

Next, we turn to the quantile regression results so as to look at how the effects change along the firm size distribution. These results are displayed graphically to ease visibility. Figure 4 shows the marginal effects of electricity consumption on employment for firms paying the full vs. reduced marginal electricity tax rate as defined in equation (2). The underlying numbers can also be found in tabular form in table 7 in the appendix.

The results displayed in figure 4 show, just like the previous OLS results, the negative correlation of electricity consumption with employment for firms paying the full electricity tax and the corresponding slightly positive effect for firms paying the reduced rate. What is new and highly interesting here is to look at the shape of the effect along the conditional employment distribution on the x-axis. In quantile regression, the effects have to be interpreted along the conditional distribution of the outcome variable, i.e. here along the conditional employment distribution after after controlling for turnover, investments, industry, capital etc. Thus, when speaking of small or large firms along the conditional firm size distribution one should rather think of under- or overstaffed firms after conditioning on the covariates.

Figure 4 shows how the marginal effect decreases over the distribution for firms paying the full tax rate. This means that for overstaffed firms the negative correlation of electricity consumption with employment is much more pronounced than for understaffed firms – under the condition that they pay the full marginal tax rate. Put differently, for overstaffed firms there is a negative correlation of energy consumption with employment whereas for understaffed firms this relation is close to zero. In contrast, for firms paying the reduced marginal tax rate, the marginal effect of electricity consumption on employment is slightly increasing over the distribution and is mostly statistically significant. Keep in mind that the employment level is much lower for firms paying the reduced marginal tax rate due to the large negative coefficient on the dummy variable.

In order to check the level effect, figure 5 displays the estimated employment level for firms paying the full vs. reduced tax rate over the conditional employment distribution. These estimated effects hold for the hypothetical case of a firm with zero turnover and zero electricity consumption in the manufacturing of metal products located in North-Rhine Westfalia (i.e., the reference group). Not surprisingly, the results show a growing level of employment over the distribution. What is interesting is that the employment level is lower for firms paying the reduced tax rate as compared to firms paying the full tax rate. The difference in employment levels between these two types of firms grows continuously over the distribution and reaches 8.3 at the 9^{th} decile.

Summing up, the quantile regression results unmask a highly interesting heterogeneity along the firm size distribution – at least for firms paying the full electricity tax. In a next step, these estimations are repeated for every year separately. Figure 6 and 7 in the appendix display the marginal effect of electricity bought on employment from year-specific quantile regressions.

There are two caveats with respect to the results presented here. First, the present analysis is limited to firms within a certain range of electricity consumption around the threshold for the electricity tax. This limits the results to a very specific group of firms. Second, the assignment of firms to paying the full vs. the reduced marginal electricity tax rate is not random but instead strongly tied to firm size.[5] Therefore, firms below the threshold tend to be small while firms above the threshold tend to be large. Comparing the results between firms paying the full vs. the reduced tax rate is hence also a comparison between small and large firms. However, the check for overlap in figures 8 and 9 reveals that at every point in time there is sufficient overlap of firms paying the full vs. reduced marginal tax rate over the unconditional employment distribution. Still, one also sees how the two distributions are diverging over time as the threshold for paying the reduced marginal tax rate decreases.

6 Discussion

Employment effects are a very important side effect of environmental regulation as exemplified by lively public debates about the question of whether environmental policies are a job killer or a job machine. This paper investigates the employment effects related to electricity consumption and the electricity tax in Germany. Germany is an interesting case to study as its environmental policies are taken as a reference for policy implementation in other countries of the world. The electricity tax, a predecessor to the Renewable Energy Sources Act in Germany, is important because it is large in magnitude and currently contributes about seven billion Euro to the budget.

The present analysis employs a full sample of German firms in manufacturing above a certain minimum number of employees. The analysis employs data for the years 1999 to 2010. The empirical analysis compares firms paying the full vs. the reduced electricity tax rate. The reduced marginal tax rate applies to firms with an electricity consumption above a certain threshold which is itself time-varying. Using quantile regressions the questions addressed are: Is

[5] The underlying reason is a strong positive bivariate i.e. unconditional correlation between electricity consumption and employment as both are indicators for firm size.

it that larger or overstaffed firms show a stronger decline in employment? In turn, are smaller or understaffed firms less affected? The short answer is: yes, if the pay the full electricity tax.

The microeconometric results show a strong and significant negative correlation between electricity consumption and employment for firms paying the full electricity tax. Firms paying the reduced marginal tax rate display lower employment levels, but the correlation with electricity consumption is slightly positive. The quantile regression results point to a very interesting heterogeneity along the conditional firm size distribution. According to these results, overstaffed firms display a strong negative correlation between electricity consumption and employment while for understaffed firms this correlation is close to zero. This result holds for those firms that pay the full tax rate. In contrast, for firms paying the reduced marginal tax rate, the correlation between electricity use and employment is slightly positive, but employment is at a much lower level.

The current results suggest that firms with a high electricity consumption which benefit from a reduced marginal tax rate display lower employment levels that increase only slightly with rising electricity consumption. The reason could be that electricity-intensive firms are very capital-intensive and require little labour in the production process. In contrast, firms with low electricity consumption paying the full tax rate have higher employment levels which are, however, strongly decreasing with higher electricity consumption. This effect is even stronger the larger these firms are. This result is in line with a story that the electricity tax has negative employment effects for those firms that have to pay the full tax rate.

These preliminary results require further investigation. Therefore, in a next step I will investigate which further modern microeconometric methods can give meaningful answers to the research question and what we can learn from using the full sample of firms. Moreover I will find out which other policies can be meaningfully investigated.

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Appendix

Figure 1: Share of firms with reduced tax rate, sample pooled over all years

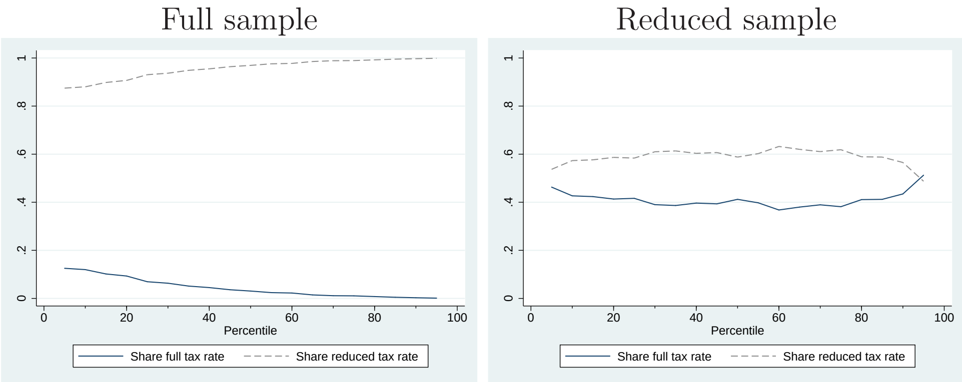

Table 2: List of covariates

	Variable	Description
	Employment	Average annual employment of the firm
	D(reduced tax)	Dummy-variable = 1 if firm pays the reduced marginal electricity tax rate
	Electr. consumpt. in MWh	Electricity consumption of the firm in MWh
	Turnover	Turnover of the firm in thousands of Euro
	Investment	Investments of the firm in thousands of Euro
Industry codes		
Code	Label	Description
15+16	Food	Manufacturing of food products, beverages, and tobacco
17	Textiles	Manufacturing of textiles
18	Clothes	Manufacturing of textile products
19	Leather	Manufacturing of leather and leather products
20	Wood	Manufacturing of wood and wood products (without furniture)
21	Paper	Manufacturing of paper
22	Publishing, printing	Publishing, printing and reproduction of recorded media
23+24	Chemicals	Manufacturing of chemicals and chemical products and petroleum products
25	Rubber, plastic	Manufacturing of rubber and plastic products
26	Non-metallic	Manufacturing of other non-metallic mineral products, glass and ceramics
27	Metals	Manufacturing of basic metals
28	Metal products	Manufacturing of fabricated metal products, except for machinery and equipment
29	Machinery	Manufacturing of machinery and equipment
30	Electr. machinery	Manufacturing of electrical machinery and apparatus
31	Electricity	Manufacturing of machinery for electricity generation and distribution
32	Electr. equipment	Manufacturing of electrical & optical equipment; radio, TV, & communication equipment & apparatus
33	Instruments	Manufacturing of medical, precision and optical instruments, watches and clocks
34	Transport car	Manufacturing of car transport and equipment
35	Transport other	Manufacturing of other transport and equipment
36	Manufact: n.e.c.	Manufacturing not elsewhere classified
37	Recycling	Recycling
Additional covariates		
	Material use in KWh	Material use in KWh
	Share of turnover abroad	Share of turnover abroad (between 0 and 1)
	Unemployment rate x 100	Unemployment rate x 100 (between 0 an 100)

Table 3: Descriptive Statistics on reduced sample, pooled over all years

Variable	Mean	(Std. dev.)
Employment (dep. var.)	37.449	(31.377)
D(reduced tax)	0.592	(0.492)
Electr. consumpt. in MWh	34.081	(15.218)
Investment in Thsd. Euro	93.591	(542.796)
Industry sectors		
Food	0.024	(0.154)
Textiles	0.028	(0.166)
Clothes	0.011	(0.105)
Leather	0.024	(0.153)
Wood	0.008	(0.087)
Paper	0.088	(0.284)
Publishing, printing	0.017	(0.128)
Chemicals	0.036	(0.187)
Rubber, plastic	0.020	(0.138)
Non-metallic	0.004	(0.065)
Metals	0.200	(0.400)
Metal products	0.174	(0.379)
Machinery	0.007	(0.379)
Electr. machinery	0.099	(0.299)
Electricity	0.020	(0.139)
Electr. equipment	0.171	(0.377)
Instruments	0.012	(0.108)
Transport car	0.008	(0.087)
Transport other	0.044	(0.206)
Manufact: n.e.c.	0.003	(0.056)
Federal states		
Schleswig-Holstein	0.037	(0.188)
Hamburg	0.017	(0.129)
Lower Saxony	0.082	(0.274)
Bremen	0.011	(0.252)
Hesse	0.067	(0.252)
Rhineland-Palatinate	0.068	(0.364)
Baden-Wuerttemberg	0.158	(0.364)
Bavaria	0.125	(0.331)
Saarland	0.014	(0.116)
Berlin	0.025	(0.156)
Brandenburg	0.028	(0.166)
Mecklenburg-West Pomerania	0.022	(0.147)
Saxony	0.069	(0.254)
Saxony-Anhalt	0.032	(0.177)
Thuringia	0.043	(0.202)
Additional covariates		
Material use in KWh	347575	(15,900,000)
Share of turnover abroad	0.098	(0.186)
Unemployment rate x 100	9.560	(4.567)
N.obs.	37,832	

Table 4: Descriptive statistics of reduced sample by year

Year	Mean of Employment	Mean of D(reduced tax)	Mean of Electr. consumpt.	N.obs	Threshold for electricity tax
1999	38.25	0.482	49.13	4776	50
2000	38.23	0.504	40.35	4529	40
2001	38.44	0.534	33.75	4281	33
2002	38.77	0.541	29.84	4415	28.6
2003	37.97	0.613	28.98	3084	25
2004	36.24	0.653	29.86	2803	25
2005	35.93	0.658	29.97	2553	25
2006	36.73	0.666	30.53	2367	25
2007	37.25	0.663	30.17	2392	25
2008	36.18	0.667	30.28	2213	25
2009	35.43	0.673	30.73	2299	25
2010	36.50	0.678	30.79	2120	25

Table 5: OLS results

Year	Reduced tax Coef.	(s.e.)	Electr. consumpt. Coef.	(s.e.)	Interaction Coef.	(s.e.)	Constant Coef.	(s.e.)	N.obs.
Pooled	-6.039	(0.854)	-0.139	(0.022)	0.193	(0.023)	31.146	(0.658)	37,832
1999	3.925	(4.199)	0.052	(0.056)	-0.057	(0.081)	23.046	(2.335)	4776
2000	-2.245	(3.554)	-0.013	(0.060)	0.075	(0.084)	27.210	(1.942)	4529
2001	-4.556	(3.480)	-0.043	(0.072)	0.131	(0.099)	30.145	(1.801)	4281
2002	-6.471	(3.291)	-0.158	(0.080)	0.260	(0.107)	31.801	(1.708)	4415
2003	-10.275	(4.764)	-0.180	(0.134)	0.250	(0.173)	35.286	(2.724)	3084
2004	-12.178	(3.295)	-0.522	(0.099)	0.603	(0.124)	33.328	(2.017)	2803
2005	-5.433	(3.388)	-0.281	(0.104)	0.277	(0.129)	30.490	(2.056)	2553
2006	-4.701	(3.595)	-0.176	(0.112)	0.182	(0.137)	29.611	(2.272)	2367
2007	-7.362	(4.234)	-0.330	(0.134)	0.334	(0.164)	34.403	(2.562)	2392
2008	-5.781	(3.467)	-0.111	(0.110)	0.163	(0.135)	30.261	(2.151)	2213
2009	-6.150	(3.524)	-0.078	(0.109)	0.140	(0.134)	30.855	(2.188)	2299
2010	-9.353	(4.125)	-0.296	(0.131)	0.350	(0.160)	25.795	(2.567)	2120

Additional variables included in the regression whose results are not displayed here: Turnover, investments, federal state and industry.

Figure 2: Interacted model: Marginal effect of electricity consumption on employment by OLS, yearly effect

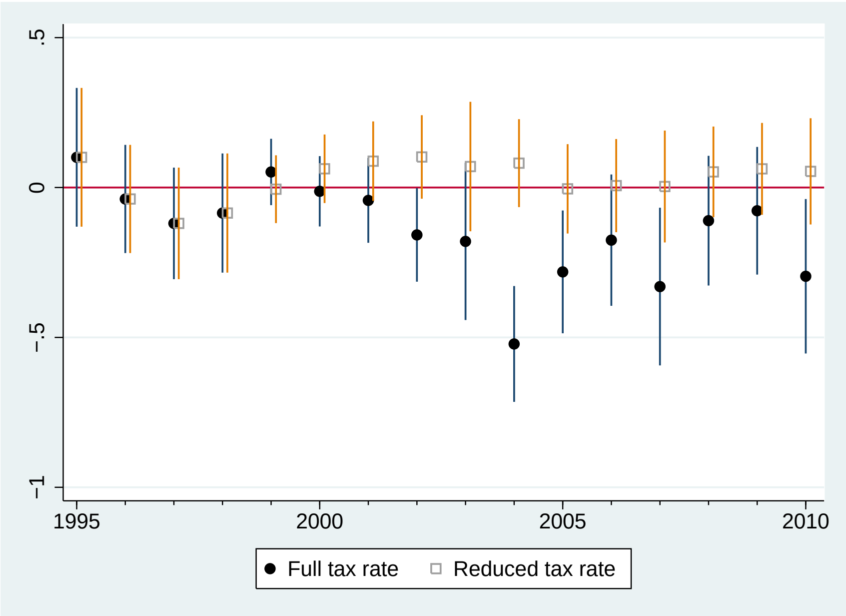

Figure 3: Interacted model: Level effect by OLS, yearly effect

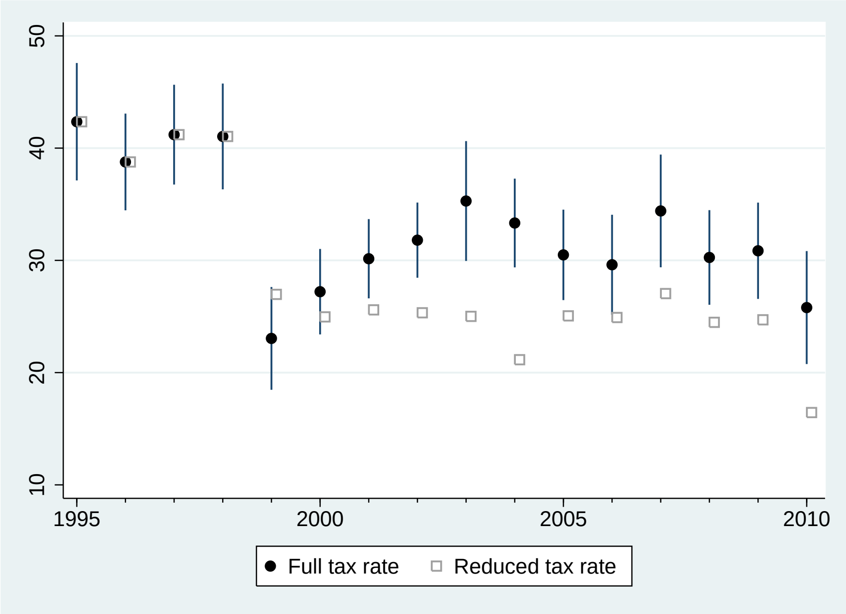

Table 6: Interacted model: OLS results with additional variables on: turnover abroad, material use and unemployment rate.

Year	Reduced tax		Electr. consumpt.		Interaction		Constant		N.obs.
	Coef.	(s.e.)	Coef.	(s.e.)	Coef.	(s.e.)	Coef.	(s.e.)	
1999	6.033	(5.862)	0.114	(0.078)	-0.091	(0.112)	32.712	(5.120)	4433
2000	-4.405	(4.595)	-0.014	(0.077)	0.120	(0.108)	33.340	(4.505)	4232
2001	-6.674	(4.412)	-0.082	(0.091)	0.186	(0.126)	37.818	(4.955)	4025
2002	-8.975	(4.592)	-0.290	(0.111)	0.369	(0.149)	53.093	(5.762)	4134
2003	-12.795	(5.661)	-0.362	(0.159)	0.383	(0.206)	67.663	(8.813)	2904
2004	-21.603	(4.042)	-0.825	(0.123)	0.983	(0.153)	56.513	(6.372)	2648
2005	-14.100	(3.781)	-0.436	(0.118)	0.574	(0.145)	49.189	(5.969)	2425
2006	-9.743	(4.394)	-0.402	(0.140)	0.415	(0.170)	52.536	(7.129)	2243
2007	-10.625	(4.579)	-0.433	(0.147)	0.468	(0.179)	56.731	(6.988)	2260
2008	-7.539	(3.958)	-0.127	(0.128)	0.187	(0.155)	44.934	(9.378)	1980
2009	-6.931	(4.010)	-0.122	(0.125)	0.174	(0.153)	61.780	(6.857)	2187
2010	-13.839	(5.611)	-0.299	(0.181)	0.464	(0.219)	49.810	(10.527)	2027

Additional variables included in the regression whose results are not displayed here: turnover, investments, federal state and industry.

Figure 4: Interacted model: Marginal effect of electricity consumption on employment by QR, pooled sample

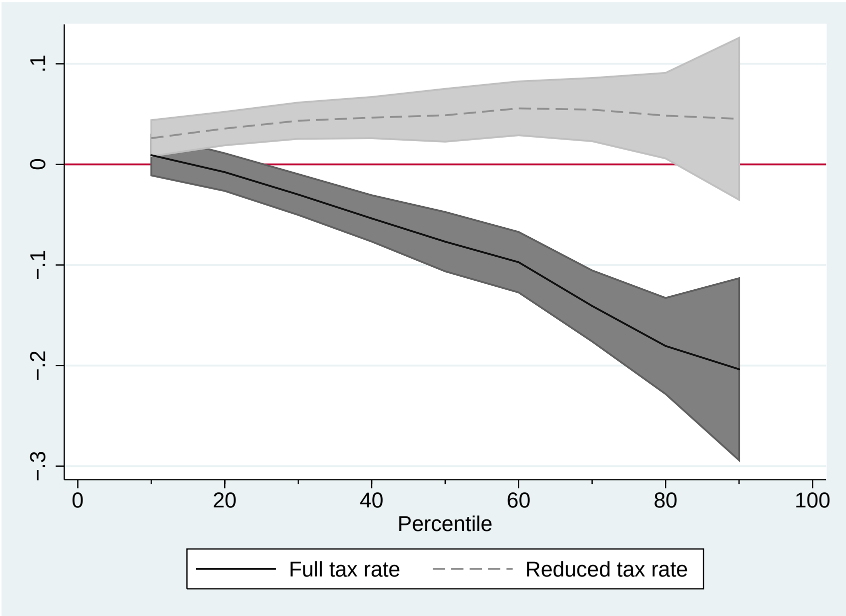

Figure 5: Interacted model: Level effect by QR, pooled sample

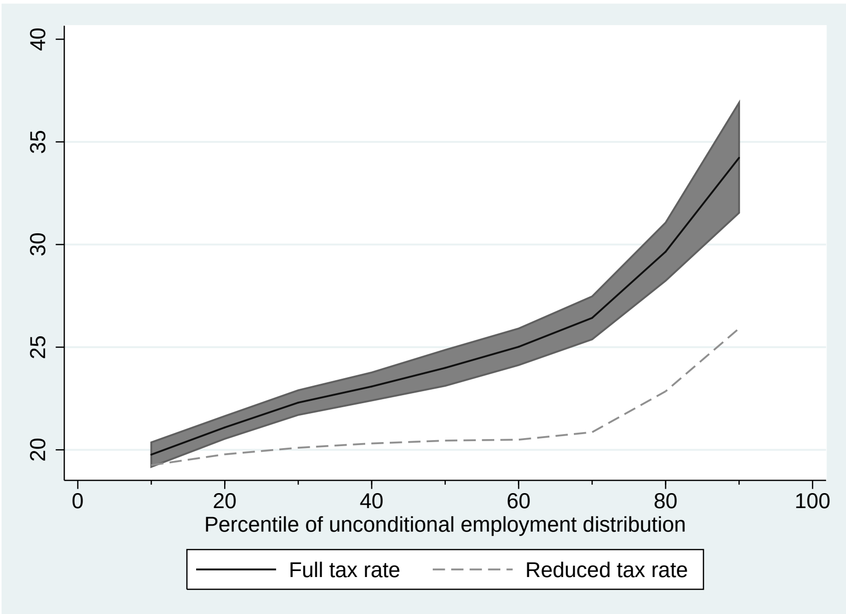

Table 7: Quantile regression on pooled sample

	Reduced tax		Electr. consumpt.		Interaction		Constant		N.obs.
	Coef.	(s.e.)	Coef.	(s.e.)	Coef.	(s.e.)	Coef.	(s.e.)	
Pooled	-6.039	(0.854)	-0.139	(0.022)	0.193	(0.023)	31.146	(0.658)	37,832
QR at τ:									
0.1	-0.514	(0.395)	0.009	(0.010)	0.017	(0.011)	19.767	(0.305)	37,832
0.2	-1.309	(0.367)	-0.008	(0.010)	0.043	(0.010)	21.090	(0.283)	37,832
0.3	-2.197	(0.397)	-0.030	(0.010)	0.073	(0.011)	22.300	(0.306)	37,832
0.4	-2.774	(0.452)	-0.054	(0.012)	0.100	(0.012)	23.086	(0.348)	37,832
0.5	-3.541	(0.578)	-0.077	(0.015)	0.126	(0.016)	23.991	(0.446)	37,832
0.6	-4.523	(0.590)	-0.097	(0.015)	0.153	(0.016)	25.018	(0.455)	37,832
0.7	-5.566	(0.693)	-0.141	(0.018)	0.195	(0.019)	26.426	(0.534)	37,832
0.8	-6.801	(0.937)	-0.181	(0.024)	0.229	(0.026)	29.651	(0.722)	37,832
0.9	-8.312	(1.775)	-0.204	(0.046)	0.249	(0.048)	34.227	(1.368)	37,832

Additional variables included in the regression whose results are not displayed here: year dummies, investments, federal state and industry.

Figure 6: Interacted model: Marginal effect of electricity consumption on employment by QR, yearly effects

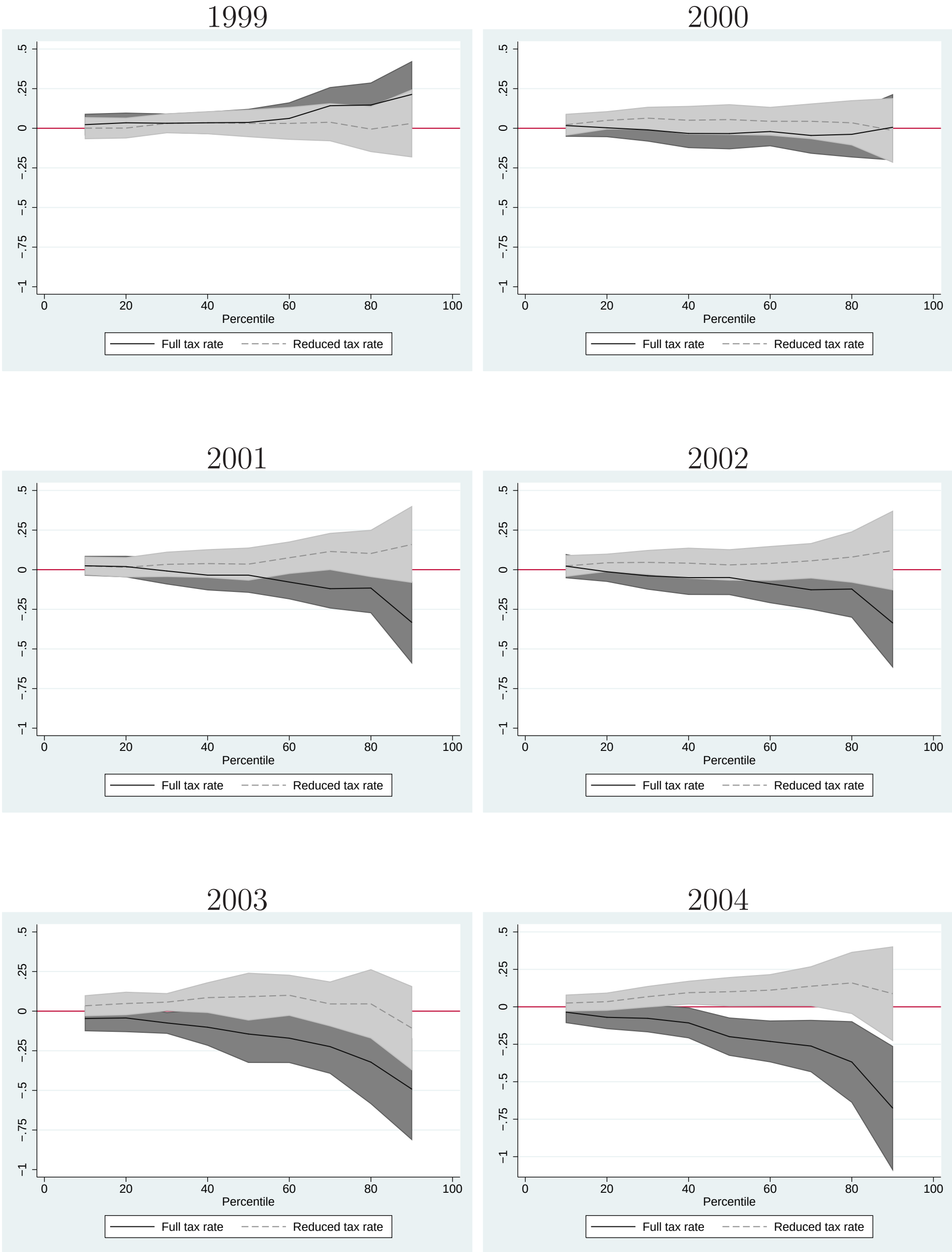

Figure 7: Interacted model: Marginal effect of electricity consumption on employment by QR, yearly effects, continued

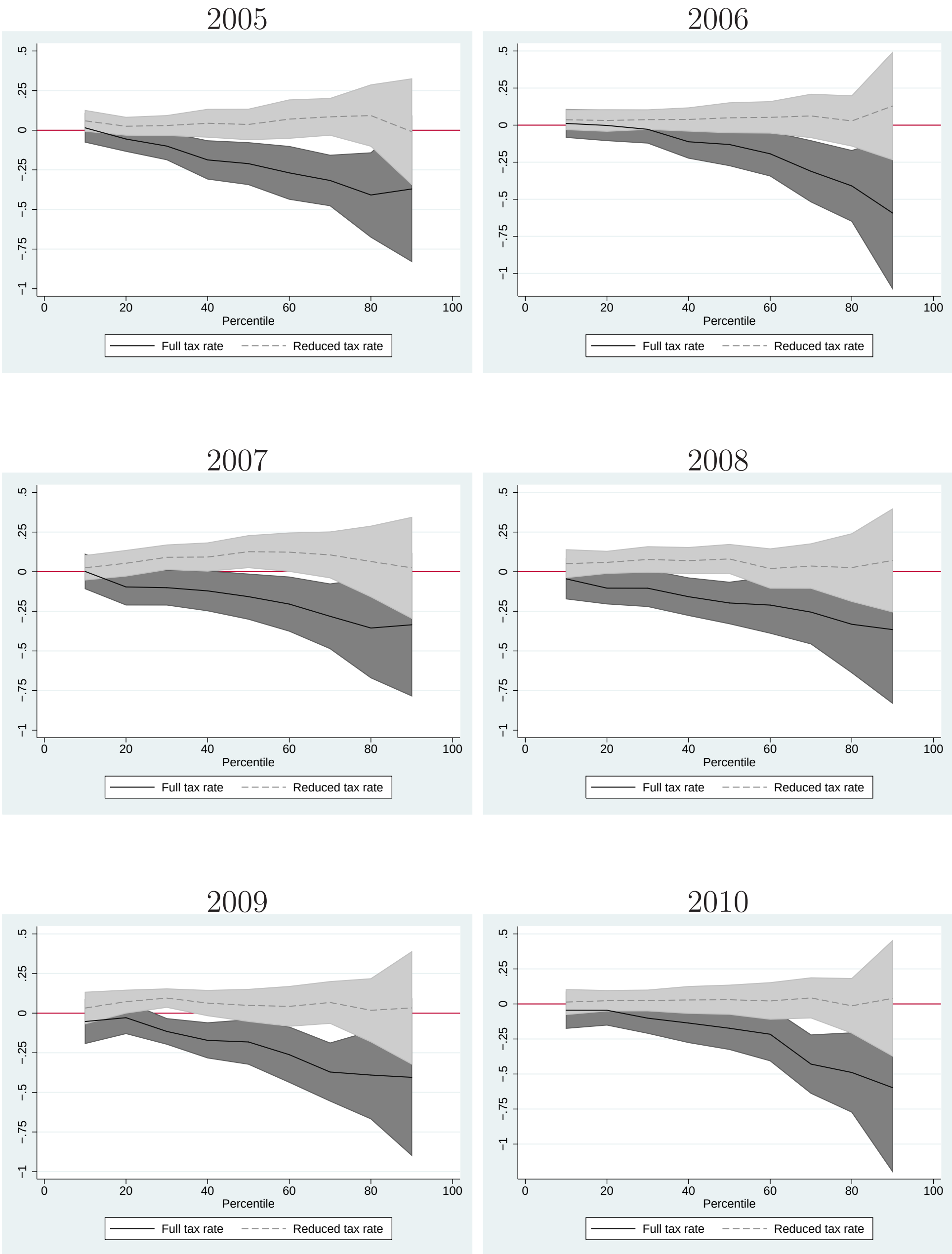

Figure 8: Share of firms with reduced tax rate, by year

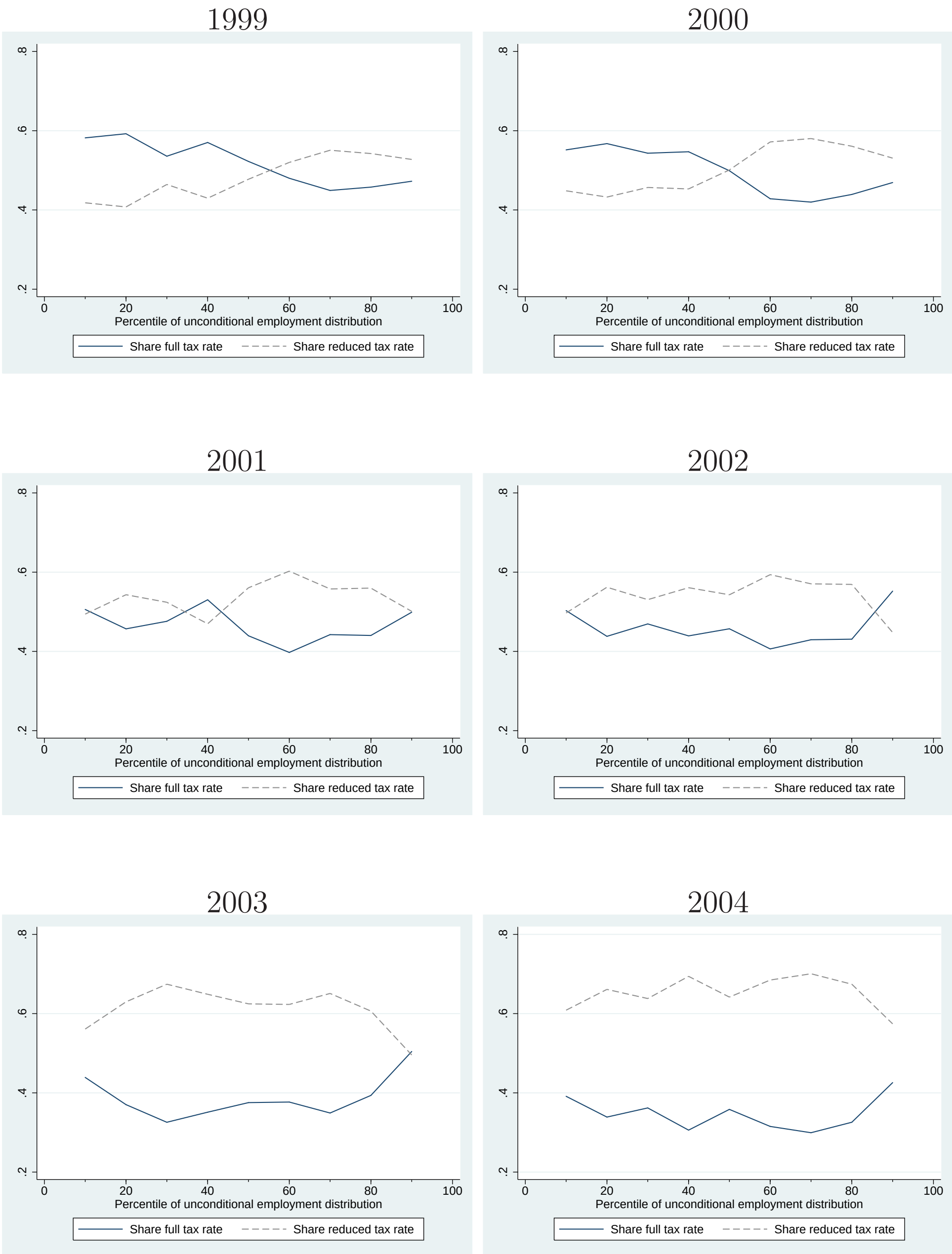

Figure 9: Reduced sample: Share of firms with reduced tax rate, by year