Who benefits from GRW?

Heterogeneous employment effects of investment subsidies in Saxony Anhalt

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Abstract
The aim of the paper is to assess employment effects of investment subsidies in one of the most strongly subsidized German Federal States, Saxony Anhalt. We analyze short-term and mid-term employment effects for the treated firms as a whole as well as heterogeneous effects depending on characteristics of the treated firms and the economic environment as well as timing of the treatment. Our data base combines treatment, employment and regional information from three different sources. We modify the standard matching and difference in difference approach by introducing a combined statistical distance function for matching and flexible durations for outcome differences. The results suggest that GRW investment subsidies have a positive influence on the employment development both in short and medium run. The difference amounts to about 3.5 full-time equivalents (FTE) in the short and about 6.5 FTEs in medium run. We also observe considerable effect heterogeneity. So, depending o the economic sector, the short-term effect ranges from -0.36 to 8.13 FTEs. In the medium run, we observe employment effects of e.g. 12.1 FTEs and 4.5 FTEs depending on whether the firm is located in an urbanised or rural area.

Keywords evaluation, industrial policy, matching, difference-in-difference

JEL Classifications: Z0, A11, D61, H20

1 Introduction

Regional policy programs to help disadvantaged regions to catch up with the national average and to provide equivalent living conditions play a major role in the redistribution policy of many countries. The magnitude of equalization transfer programs is particularly large in the EU (Becker *et al.*, 2010). Besides the Structural Funds of the European Union, almost every member state offers national regional policy programs like the Regional Selective Assistance in Great Britain or Italy's Law 488/1992.

The main instrument for Germany in this context are investment subsidies within the joint Federal Government/Laender scheme for 'Improving regional economic structures' (GRW). In the period under analysis (2007-2013), a total amount of about 11.6 billion €is spend for GRW. This makes an annual average of 1.66 billion €for investment subsidies (Federal Office for Economic Affairs and Export Control, 2016). Saxony Anhalt belongs to the most strongly subsidized German Federal States. In the period 2007–2013, about 15 percent of the federal GRW funds is assigned to Saxony Anhalt (Alm, 2014).

We study short- and midterm employment effects of investment subsidies for the treated firms in Saxony Anhalt. Our data consists of combined information from three different sources. So we are able to combine detailed information on the treatment with rich employment and regional information. We analyze the treated firms as a whole as well as heterogeneous effects depending on characteristics of the treated firms and the economic environment as well as timing of the treatment. Compared to existing studies, this gives a more precise and detailed view on the effects of the subsidies. Except for firm size, heterogeneity in the characteristics of the treated firms is not considered in the literature so far. But it is easy to imagine that other characteristics like workforce structure or economic sector also have an influence on the funding effect.

The special features of the data base require a very flexible estimation approach. For this reason, we modify the standard nonparametric conditional difference-in difference approach. We introduce flexible durations for the observed outcome differences and replace the common Propensity Score for matching by a combined statistical distance function. The approach exactly considers the point of time a

firm is compared to his 'statistical twin', the application date, different project durations and other important characteristics of the firms. This is a important aspect of the study, because the financial crisis changes the economic environment during the observation period 2007–2013 dramatically.

Our results suggest that GRW investment subsidies have a positive influence on the employment development both in short and medium run. The difference amounts to about 3.5 full-time equivalents (FTE) in the short and about 6.5 FTEs in medium run. We also observe considerable effect heterogeneity. So, depending o the economic sector, the short-term effect ranges from -0.36 to 8.13 FTEs. In the medium run, we observe employment effects of e.g. 12.1 FTEs and 4.5 FTEs depending on whether the firm is located in an urbanised or rural area. Also the timing of treatment plays a role for the strength of the employment effect: subsidized projects in 2009 generate only one FTEs more employment whereas subsidized investments before the financial crisis generate up to 6.6 FTEs more employment.

The Paper is organized as follows. The next section gives a short overview over the literature on the effects of investment subsidies. In the third section, the institutional background of GRW subsidies in Germany is explained. Section four describes the data and the sample of the analysis. Section five provides the characteristics of our estimation approach. In section six and seven we present the empirical results and some robustness checks. The last section concludes with a summary of the most important findings.

2 Review of the empirical literature

Place-based policies comprise a variety of measures, ranging from those that focus on enterprise zones (Neumark and Kolko, 2010; Mayer *et al.*, 2015), cluster policies (Falck *et al.*, 2010; Martin *et al.*, 2011), or large-scale regional development programs such as the Tennessee Valley Authority (Kline and Moretti, 2014). We restrict our review of the literature to evaluation studies of the GRW itself and comparable discretionary investment grant-based policy schemes. Although there is a broad literature on effects at the regional level (Becker *et al.*, 2012, 2013; de

Castris and Pellegrini, 2012; Criscuolo *et al.*, 2016), we focus on micro level studies in the following.

The first who analyzed causal effects of GRW in Germany were Stierwald and Wiemers (2003) and Ragnitz and Lehmann (2005). Using the establishment panel of the Institute of Employment Research, they find positive effects on the amount of investment per employee and on sales among East German establishments for the years 2000–2002 and 1999–2001, respectively. A study of Bade and Alm (2010) applies a matching with difference-in-difference approach. For firms subsidized during the 2001–2006 funding period, they estimate a positive effect on employment growth from the year of funding to 2008. They also find a decline in regional employment in not eligible sectors, suggesting potential intra-regional displacement effects. In a further study, Bade (2013) differentiates the GRW effect by firm size and finds stronger employment effects for larger establishments.

Similar to the GRW, Italy's Law 488/1992 provides subsidies to firms willing to invest in disadvantaged regions. Bernini and Pellegrini (2011) evaluate the effects of the program by combining plant-level data and information on subsidy allocation for the 1996–2004 period. Using a matching and difference-in-difference approach, they find positive short-run effects on output, employment, and investment, but negative long-run effects on productivity. Bronzini and de Blasio (2006) evaluate Law 488/1992 by comparing supported and rejected projects between 1993 and 2001. They confirm a positive effect on investments, but present evidence for inter-temporal substitution, given the time restriction of the programming period. Applying an RDD, Cerqua and Pellegrini (2014) estimate positive effects of this policy scheme on employment, investment, and turnover; effects on productivity remain negligible. Unlike Bronzini and de Blasio (2006), they find their results to be robust against intertemporal substitution. Pellegrini and Cetra (2006) focus on the effects of Law 488/1992 on plants in the Mezzogiorno region; they identify on average a positive effect of funding on sales, employment, and fixed assets. As in the aforementioned studies, the effect on factor productivity (in this case, labour) remains very limited, and even negative.

In the United Kingdom, the Regional Selective Assistance program (RSA) provides discretionary grants to firms in disadvantaged regions. Devereux *et al.* (2007)

find small positive effects on the location choice of new entrants. Criscuolo *et al.* (2016) analyse the effectiveness of the RSA using administrative data in combination with firm-level data for the 1986–2004 period. Applying an instrumental variable (IV) approach, they find positive RSA effects on employment and investment, but no effect on factor productivity. When differentiating the effects by firm size, they show that small and medium-sized firms experience the strongest effects, while the effect for large firms is almost zero.

All in all, the results point to positive effects on employment, investments and turnover, but negative or no effects on productivity. Differentiating the effects by firm size, the results are contradicting: Bade (2013) finds stronger employment effects for larger establishments, whereas Criscuolo *et al.* (2016) show that small and medium-sized firms experience stronger effects.

Except for firm size, heterogeneity in the characteristics of the treated firms is not considered in the literature so far. But it is easy to imagine that other firm characteristics like workforce structure or economic sector also have an influence on the funding effect. The same is true for regional characteristics like regional unemployment rate and structural type of region as well as the timing of a subsidy.

3 Institutional details of the analyzed program

Regional policy in Germany is a matter of the Federal States (Article 30 German Constitutional Law), but the law permits Federation's support in setting up, implementing and funding regional policy schemes. The most important example for the cooperation in regional policy is the Joint Task for 'Improving Regional Economic Structures' (GRW). The program initially was set up in 1969 and aims to reduce locational disadvantages, tackle structural change, foster aggregate regional economic growth and create 'equivalent living conditions' across Germany (Articles 91a and 72 (2) Constitutional Law).

The operationalization of the program relies on a specific law (GRW-Gesetz der Bundesregierung (1969)) and requires a close coordination between different authorities involved in this process (figure 1). The coordination committee comprises of representatives from German government and the Federal States. The members

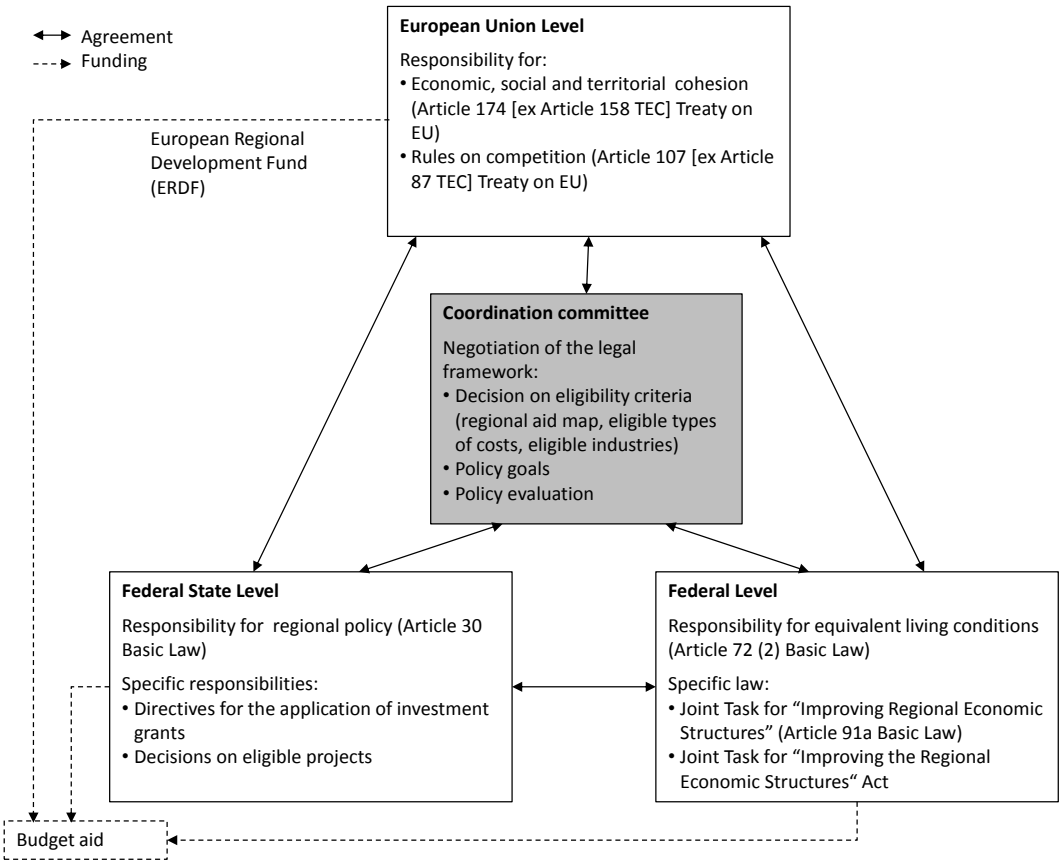


Figure 1: Negotiation process within the GRW framework

Source: own illustration.

of the committee agree e.g. on strategic policy goals, the eligibility status of regions, eligible economic sectors, types of subsidized investment projects, and finally on aid ceilings. The derived rules are content of the GRW coordination framework. This coordination framework must be approved by the European Commission (EC).[1] Due to the generally exceptional character of State aid schemes, the number of regions eligible for GRW subsidies should be significantly lower than those of not eligible regions. In the guidelines on national regional aid for the funding period 2007-2013, the EU fixed a limit to 42 percent of overall population in assisted regions in relation to the population of the EU 25 member states (European Commission,

[1]In general, state aid is prohibited in the EU because of being incompatible with the internal market regulations as it may cause distortions in competition (Article 101 [ex Article 81 TEC] Treaty on EU). An exception of this general rule is State aid that is issued to promote regional economic development of disadvantaged regions in the EU (Article 107 [ex Article 87 TEC] Treaty on EU).

2006)/C54/08.[2] In Germany, the overall population in assisted regions equals 40.17 percent in the observation period.

The eligibility of a region for GRW subsidies is based upon a structural weakness score. This score is calculated at the level of labor market regions and consists of a weighted combination of four weakness indicators. For calculation details see figure 2.

Calculation of the structural weakness score

$$S_r = \prod_m {V_{mr}}^{w_m}$$

$$\textit{with} \quad V_{mr} = \begin{cases} 100 - \frac{m_r - \mu_m}{\sigma_m} & \textit{if} \quad m = 1 \\ 100 + \frac{m_r - \mu_m}{\sigma_m} & \textit{if} \quad m = 2, 3, 4 \end{cases}$$

and
- S_r – *overall score for region r*
- V_{mr} – *standardized value of indicator m in region r*
- μ_m – *mean value of indicator m*
- σ_m – *standard deviation of indicator m*

Indicators for structural weakness

Indicator (m)		Weight (w_m)
1	Average unemployment rate (2002-2005)	0.50
2	Annual gross salary (2003)	0.40
3	Quality of business-oriented infrastructure (2005)	0.05
4	Employment projection for the period (2004-2011)	0.05

Figure 2: Details of the score calculation

Note: Indicators and weights provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). Source: own illustration.

The scores range from 97.06 to 101.36 in the funding period 2007–2013 (Eckey, 2008). Scores below 100 indicate regions with below-average structural development, or regions with locational disadvantages; values above 100 indicate relatively strong regions. In Saxony Anhalt, all 14 districts have scores below 100, ranging from 97.47 in Mansfeld-Suedharz to 98.66 in Magdeburg.

[2]The determination of eligible regions by the EC follows a complex method that is explained in detail in European Commission (2006)/C54/08, Annex IV.

Based on the structural weakness score for the labor market regions, the members of the GRW coordination committee decide on the eligibility status at the level of districts. In order to consider very localized constraints, the eligible districts are distinguished in three area categories: A, C and D areas. These categories reflect different funding intensities in terms of different subsidy ceilings. [3] The districts in Saxony Anhalt, like all East German regions (except Berlin), belong to the category A areas. That means, the highest possible subsidy ceilings are applied for eligible projects here.

In the eligible regions, firms and communities can apply for subsidies to certain investments. This permission is restricted to firms in specific economic sectors which are considered to have high potential for future development and contribute to the economic growth of the regions. The list of eligible sectors is part of the GRW coordination framework and can be further limited by the Federal government for the respective state.[4] Private firms in eligible economic sectors can apply for subsidies for business investment projects, local governments receive subsidies for business-oriented infrastructure projects (figure 3).

Consequently, the subsidy intensity for a project depends on the type of the project and the area category. For investment projects, the firm size also plays a role for the subsidy ceiling (table 1). The subsidy intensity for business investments ranges from 50 percent for small firms in A areas to only 20 percent of the eligible investment costs for large firms in D areas. Local governments receive usually 60 percent subsidy for investments in business-oriented infrastructure irrespective of the area category.

4 Data and descriptive statistics

Our data base combines information from multiple sources: The GRW treatment information is received from the Investitionsbank Saxony Anhalt, employment information is achieved from the Employment History of the Institute for Employment

[3] This differentiation reflects the degree of structural weakness of regions according to Article 107 (3) of the Treaty of EU.

[4] Eligibility of a sector is determined on the basis of the German Classification of Economic Activities (4digit WZ2008). The list of eligible sectors in Saxony Anhalt for the analysed funding period is available from the authors upon request.

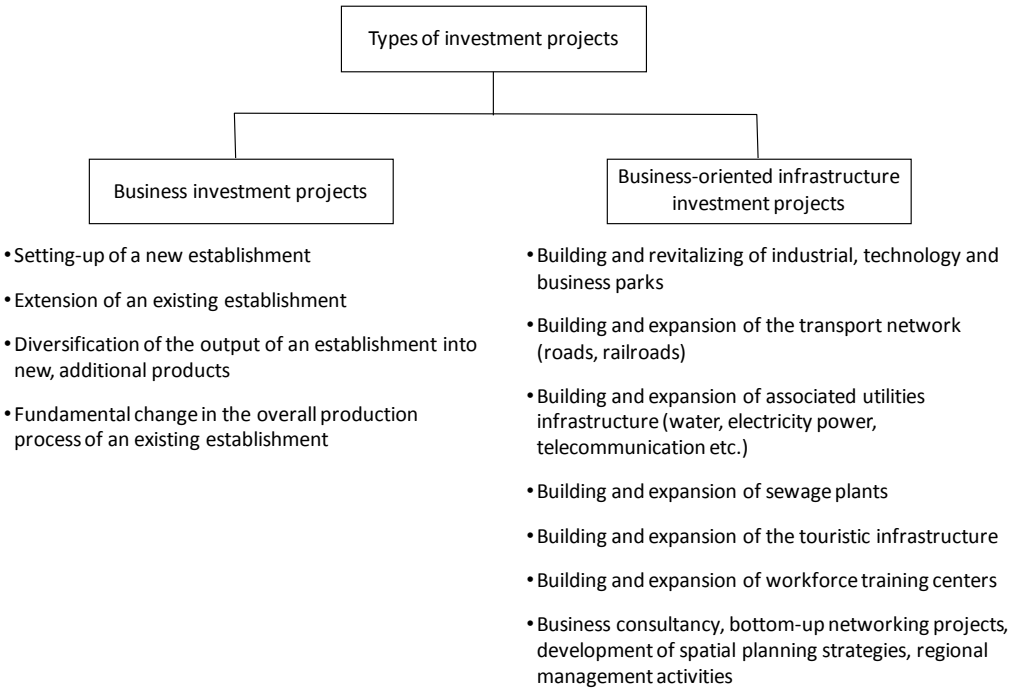


Figure 3: Investment projects eligible to GRW

Source: own illustration.

Research (IAB), and regional information is derived from the INKAR data base of the Federal Institute for Research on Building, Urban Affairs and Spatial Development.

4.1 Data base

The Investitionsbank of Saxony Anhalt, who is responsible for the implementation of GRW subsidies in the state, provides us unique data on all subsidized projects of the funding period 2007-2013 in Saxony Anhalt. The most important information on these 1690 projects include the kind of investment, expected additional employment (full time equivalents, FTE), the investment volume, eligible costs, as well as the amount of the investment subsidy and the investment premium (in place until 2012). We also know the exact application date and the start and end of the subsidized projects. Since we also know the name of the applicants, we can draw conclusions on the funding frequency of the 1294 subsidized firms. Further firm information include address, size category (following the EU definition of small, medium and large firms) and the economic sector.

Table 1: Aid ceilings
Aid intensity of eligible investment costs (in percent)

Type of investment project	Firms size	A area	C area[a]	D-area
Business investments	small	50	35	20
	medium	40	25	10
	large	30	15	0[b]
Business-oriented Infrastructure			60[c]	

Notes: [a]Differing aid ceilings in specific C-area regions possible; [b] Maximum subsidy of €200.000 according to the de minimis rule (Commission Regulation (EC) No 1998/2006 Official Journal of the European Union L379/5); [c] In certain cases up to 90 percent.

Source: GRW coordination framework (2009), pp. 43-44 and 50; own illustration.

The Employment History is based on data collected by the Federal Office of Labor (Bundesagentur fuer Arbeit) and covers all employees liable to social security contributions.[5] This comprehensive database is available since 1975 for West Germany and 1991 for East Germany. It contains information e.g. on gender, nationality, formal and professional qualification, kind of employment contract, working hours and salary of the employees. For our analysis, we aggregate employees' information on the firm level. So we can observe firm characteristics like size in terms of number of employees and FTEs, formal and professional qualification structure, age and gender of the employees. Additionally, we have information on the founding year and the economic sector of the firm. We link the aggregated Employment History and the GRW data by the official firm identifier and find Employment History information for employees of 1208 firms out of the subsidized 1294 firms.[6] For the analysis, we trace back the firms until 2004. This allows us to control for employment development in the firms before the funding period started. We only consider data for firms in Saxony-Anhalt, because we only know for them if they received GRW subsidies or not. All in all we observe 19,246 firms in Saxony-Anhalt with

[5]The Social Insurance procedure compels employers to report all changes that have occurred in the number of workers who are subject to health or unemployment insurance or who participate in a pension scheme every year. There are legal sanctions for misreporting.

[6]Although the sectoral information in the GRW data and the Employment History Panel are based on the same classification system, the German Classification of Economic Activities (WZ), the given WZ code in both data bases is quite different for a number of the treated firms. We use the information given in the EHP in order to have comparable sectoral information for treated and nontreated firms.

yearly 2.24 million FTEs for the period 2004 to 2014, including 1208 subsidized firms.

In a second step, we combine the firm and treatment data with regional information from the INKAR data base of the Federal Institute for Research on Building, Urban Affairs and Spatial Development. The data is matched by the Community Identification Number at the district level ('Amtlicher Gemeindeschlüssel, AGS5'). This way we include further important information on the economic environment of the firms like type of region[7] , unemployment rate and share of employees in sectors with high R&D activity.

The overall result is a rich panel data set with monthly employment and firm information, yearly regional information and detailed program information of GRW subsidies.

In the analysis, we focus on subsidized firms who receive treatment only once in the funding period. For the sample, we further exclude firms in sectors not eligible for GRW subsidies, e.g. agriculture and forestry, health and social services sector, education and public administration.A further reduction of the number of particularly treated firms results from the required observation period of each firm: to be considered in the analysis, the treated firms must be observable at least two years before they apply for GRW subsidies and a couple of month after application: for the short term effect we observe employment development until twelve months after the project started, for the midterm effect until twelve months after the project is finished.[8]

From the wealth of information, we choose the following firm and regional characteristics for the Matching process described below: We use firm size categories following the EU definition of small, medium and large firms, two age categories (young vs. established firm), aggregated sectoral classifications[9] , qualification structure of the employees (share of high qualified and of medium qualified), age structure (share

[7]The basis for this characterization is the definition of settlement structural spatial units of The Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR).

[8]This is problematic particularly for firms applying at the end of the funding period. Their observation duration is not long enough to be included in the analysis.

[9]We summarize the detailed sectoral information given by the WZ code in 13 aggregated economic sectors, see table 9 in the appendix.

of young employees) and employment development before application[10] . We add regional information on the unemployment rate, a broad settlement structural type of region and the employment share in R&D. We only include firms with complete information on the Matching variables and the outcomes in the analyzed sample.

4.2 Description of the sample

As a result, our sample consists of ... observations, 565 of them are subsidized firms. The following table gives an overview on some interesting characteristics of the firms in the sample. Since we have panel data, the table shows averages of the included variables at the beginning and the end of the observation period.

The descriptive statistic in table 2 shows some remarkable differences between the treated and the potential controls, particularly regarding firm size and economic sector.[11] Potential control firms are on average smaller. About three quarters of the potential control firms belong to the group of very small firms (with up to 10 FTEs), but only 30 percent of the treated firms. Most treated firms (about 42 percent), but only 19 percent of the potential controls are small firms with 10 to 50 FTEs. The share of medium size firms (between 50 and 250 FTEs) is about one quarter among the treated and only 5 percent among the potential controls. Also the sectoral structure of the firms differs in both groups: with about one quarter, firms in metal production are most common among the treated firms, but only ten percent of potential controls operate in this sector. In contrast, only ten percent of the treated operate in trade, repair, transport and ICT, but with forty percent, this is the most important sector among the potential controls. Some smaller differences we observe in the sectors petroleum processing, chemistry and pharmaceutics (twelve vs three percent) and production and maintenance of electrical equipment, machinery and computers (13 vs. 6 percent). The distribution of age of the firm and the structure of the employees is rather similar in both groups. The same applies to the economic environment.

[10]We observe the difference in FTEs between two years and six months before application for the subsidized firms and the respective difference for potential partners.

[11]The descriptions refer to the values in 2007. As can be observed in the table, the values for 2013 are very similar.

Table 2: Descriptive statistics for the treated and their potential controls (January 2007, December 2013)

Variable	January 2007 N	Mean/ Share	Median	Std. Dev.	December 2013 N	Mean/ Share	Median	Std. Dev.
			treated					
firm characteristics								
size of the firm								
< 10 FTEs	144	29.21			211	30.67		
>= 10 FTEs and < 50 FTEs	210	42.60			299	43.46		
>= 50 FTEs and < 250 FTEs	121	24.54			155	22.53		
>= 250 FTEs	18	3.65			23	3.34		
age of the firm								
young firm (< 10 years)	211	42.80			277	40.26		
established firm (>= 10 years)	282	57.20			411	59.74		
sector of the firm (5 biggest sectors)								
metal production	135	27.38			145	21.08		
production and maintenance of electrical... equipment, machinery and computers	63	12.78			70	10.17		
production of furniture, wooden products,... glass and ceramics	60	12.17			69	10.03		
petroleum processing, chemistry and... pharmaceutics	59	11.97			70	10.17		
trade, repair, transport, ICT	47	9.53			55	7.99		
share of high qualified	493	6.49	1.59	11.40	688	9.09	3.12	15.90
share of medium qualified	493	61.88	70.41	28.77	688	62.59	75.00	30.87
share of young employees	493	23.51	21.03	17.24	688	24.50	22.22	17.44
regional characteristics								
unemployment rate in the region	493	16.11	15.70	2.34	688	10.96	11.50	1.61
R&D employment share in the region	493	0.05	0.04	0.03	688	0.05	0.04	0.03
type of region								
urbanised region	128	25.96			190	27.62		
rural region	365	74.04			498	72.38		
			potential controls					
firm characteristics								
size of the firm								
< 10 FTEs	8,586	76.25			7,450	74.72		
>= 10 FTEs and < 50 FTEs	2,096	18.61			1,966	19.72		
>= 50 FTEs and < 250 FTEs	520	4.62			489	4.90		
>= 250 FTEs	58	0.52			65	0.65		
age of the firm								
young firm (< 10 years)	5,972	53.04			4,084	40.96		
established firm (>= 10 years)	5,288	46.96			5,886	59.04		
sector of the firm (5 biggest sectors)								
metal production	1,174	10.43			1,019	10.22		
production and maintenance of electrical equipment, machinery and computers	724	6.43			696	6.98		
production of furniture, wooden products, glass and ceramics	1,132	10.05			1,020	10.23		
petroleum processing, chemistry and pharmaceutics	318	2.82			302	3.03		
trade, repair, transport, ICT	4,449	39.51			3,613	36.24		
share of high qualified	11,246	6.13	0.00	18.38	9,897	8.68	0.00	21.85
share of medium qualified	11,246	58.22	71.43	40.17	9,897	56.51	70.61	40.91
share of young employees	11,260	18.41	3.57	26.55	9,970	15.90	0.00	23.66
regional characteristics								
unemployment rate	11,260	15.96	15.70	2.23	9,970	11.10	11.50	1.59
R&D employees	11,260	0.04	0.03	0.02	9,970	0.05	0.04	0.03
type of region								
urbanised region	3,582	31.81			3,153	31.62		
rural region	7,678	68.19			6,817	68.38		

Table 3: Descriptive statistics of GRW projects in the sample

Variable	Number	Mean/ Share	Median	Standard deviation
January 2007				
project duration (months)	493	23.83	21.00	14.84
investment costs (€)	493	3,026,848	790,883	7,569,765
eligible costs (€)	493	2,444,773	677,146	536,1756
funding rate	429	37.52	40.00	13.98
Kind of investment (percent)				
setting up	7	1.42		
diversification	147	29.82		
extension	319	64.71		
other investments	20	4.06		
December 2013				
project duration (months)	688	24.33	23.00	14.36
investment costs (€)	688	3,514,769	820,361	8,453,791
eligible costs (€)	688	2,991,007	723,537	7,052,707
funding rate (percent)	604	37.47	40.00	13.81
Kind of investment (percent)				
setting up	124	18.02		
diversification	153	22.24		
extension	388	56.40		
other investments	23	3.34		

Table 3 gives an overview on the projects under analysis, again for the beginning and the end of the observation period. The subsidized projects last on average about two years. The investment volume shows a very large variation and some very large projects. So, the mean is with about 3 Mio. €much higher than the median project with less than 1 Mio. €. Eligible costs of the projects amount to about 85 percent of the median investment costs, similar in both years. The extension of an existing establishment is the most common kind of subsidized investments, from 56 percent in 2007 up to 65 percent in 2013. The importance of subsidizing settlement of new establishments grows over the funding period from one to 18 percent. The opposite is true for diversification investments; their share declines from about 30 percent in 2007 to about 22 percent in 2013.

5 Estimation approach

Our data base is an unbalanced panel with varying entry and exit dates of the firms, varying dates of application and different durations from application to the start of

the project as well as different project durations. One standard approach to deal with different application dates within a panel data set is to use a difference-in-difference model with fixed effects and to normalize the application date to zero (Autor, 2003). Additionally one could include 'leads' of the dependent variable to verify the common trend assumption. Unfortunately, this model does not consider different durations for observing before- and after-treatment outcomes.[12]

Furthermore, as we observe in the descriptive analysis, our sample of treated firms is a very special subgroup of the establishments in Saxony Anhalt (see chapter 4), so we could not expect the common trend assumption to hold for the whole sample. We apply the nonparametric conditional difference-in-difference approach of Heckman *et al.* (1997, 1998), a much more flexible standard approach for empirical research (Bergemann *et al.*, 2009; Buscha *et al.*, 2012) that better suits to the characteristics of our data.[13] It consists of the combination of a difference-in-difference estimation and matching. The matching process can be seen here as a nonparametric data preprocessing in the sense of Ho *et al.* (2007): It helps to obtain more reliable causal effect estimates by reducing bias and variance.[14]

One of the main challenges for the applied matching process is an adequate consideration of time varying variables. Due to the special time period we observe (namely, the financial crisis and the resulting economic changes), we must be sure to exclude potential 'time bias' resulting from comparing firms at different points of time. That means, we must incorporate time information from the panel data into the matching process. So we develop a sequential matching process that incorporates the observation date of all matching variables and the outcomes.[15] In a pre-selection process, we limit the set of potential partners for every treated firm

[12]This would be a problem for our analysis, because we could not identify the point of time in the individual observation period at which we observe the outcome: Before or after the start of the subsidized project? During the treatment phase? Or after finishing the project?

[13]For a detailed description see Abadie (2005) or Blundell and Costa Dias (2000).

[14]Constructing a synthetic control group as weighted average of nontreated firms is not a good alternative, because this approach is useful only if the number of treated units and potential controls is rather small (Abadie *et al.*, 2015).

[15]Standard program code for matching and difference-in-difference does not allow to include (different) treatment and/or observation dates. We found only one exception: After extensive data reorganization, we use the *nnmatch* option of the *teffects* command in Stata as a robustness check of our approach. A comparison of the means of the control groups of both approaches shows that the newly developed algortihm produces better (in the sense of more similar) control groups. A reason for that we see in the consideration of the different scales of the matching variables. See also Dettmann *et al.* (2011).

to those observed just at the individual application date. The matching algorithm then selects statistical twins among these pre-selected firm information. Due to this iterative process, we cannot use the commonly applied propensity score estimate as a distance measure. Instead, we use a combined statistical distance function.[16] This distance function follows an idea of KAUFMANN and PAPE (1996) and can be described as the weighted average of scale specific distance functions. It belongs to the group of linear-homogeneous aggregations (OPITZ, 1980). For our analysis, we combine the mean absolute difference for continuous and the generalized matching coefficient for categorical variables.

When combining scale-specific distance functions, the functions usually have to be normalized and transformed (DIDAY and SIMON, 1976). In our case, the differences in the continuous variables are normalized by the maximum observed differences of the respective variables, and the similarity information from the generalized matching coefficient is transformed into a distance measure. Weighting the functions by the respective number of variables, the distance function for a treated firm i and a nontreated firm j can be described as follows:

$$Dist_{ij} = \frac{1}{N} \left[N_m \cdot AD_{ij} + N_n \cdot (1 - GMC_{ij}) \right]. \tag{1}$$

The terms $Dist_{ij}$, AD_{ij} and GMC_{ij} denote the aggregated distance function and the scale-specific distances, N is the total number of variables: $N = N_m + N_n$, where N_m is the number of continuous variables and N_n that of the categorical ones.

The mean difference of the continuous variables is calculated using the normalized absolute difference:

$$AD_{n,ij} = \frac{1}{N_m} \sum_{n=1}^{N_m} \frac{|x_{ni} - x_{nj}|}{diff_{max_n}}$$

where $||$ denotes absolute values, and $diff_{max_n}$ the maximum observed difference of variable n.

[16] In a previous simulation study, statistical distance functions proved to be superior to Propensity Score matching, see DETTMANN *et al.* (2011). Besides, KING and NIELSEN (2015), KING and ZENG (2006) doubt whether the Propensity Score is suitable (or useful) for empirical studies, when the score itself has to be estimated.

The generalized matching coefficient GMC_{ij} can be defined as the share of covariates with equal values in all categorical variables:

$$GMC_{ij} = \frac{1}{N_n} \sum_{n=1}^{N_n} Q(x_{ni}, x_{nj}) \quad with \quad Q(x_{ni}, x_{nj}) = \begin{cases} 1 & \text{if } x_{ni} = x_{nj} \\ 0 & \text{else.} \end{cases}$$

As can be observed from the equation, using the GMC allows for different numbers of possible values in the covariates. The variables with coincident values are equally weighted irrespective of the number of possible values.
Based on this matching process, the mean difference between the development in employment Y in the treated firms i and their controls j are compared to estimate the average treatment effect for the treated ATT:

$$ATT = \frac{1}{I} \sum_{i=1}^{I} \left(Y_{i,t_{0i}+\beta_i} - Y_{i,t_{0i}}\right) - \left(Y_{j,t_{0i}+\beta_i} - Y_{j,t_{0i}}\right). \tag{2}$$

In equation 2, the individual application date of a treated firm i is denoted by t_{0i}, β_i is a flexible number of month that depends on the individual duration from application either to project start or to the end of the project. We observe two outcomes: first, the employment development from application to the time one year after project start, and second, the development until one year after the project is finished. Due to heterogeneous project durations and durations from application till project starts, these periods are heterogeneous among the treated firms.

6 Results

The results for the funding period 2007–2013 suggest that GRW investment subsidies in Saxony-Anhalt have a positive influence on the employment development. Table 4 gives an overview on the effects in short and medium run for the whole sample and the analyzed subsamples. In the short run, subsidized firms increase employment by 3.39 FTEs, while comparable not subsidized firms reduce employment by 0.37 FTEs, resulting in an overall short-term employment effect of 3.76 FTEs. In the medium run, this effect is with 6.41 FTEs even larger, primarily driven by the increase in employment by 6.06 FTEs in subsidized firms. The re-

Table 4: Overview of the results - firm and regional characteristics

	short-term effect				mid-term effect			
	N	treated	controls	difference	N	treated	controls	difference
full sample	906	3.39	-0.37	3.76	782	6.06	-0.35	6.41
metal production	264	-0.30	0.06	-0.36***	238	3.03	1.32	1.71***
production and maintenance of electrical equipment, machinery and computers	120	6.34	-1.79	8.13***	106	3.36	-0.99	4.35
production of furniture, wooden products, glass and ceramics	126	3.13	-0.06	3.19**	108	8.01	-4.19	12.20***
petroleum processing, chemistry and pharmaceutics	122	5.89	0.83	5.05***	102	16.46	0.69	15.77***
trade, repair, transport, ICT	88	7.50	-0.46	7.96***	62	9.97	0.60	9.37***
< 10 FTEs	230	1.31	-0.21	1.52***	206	2.02	-0.30	2.32***
>= 10 FTEs and < 50 FTEs	404	2.52	-0.34	2.86***	342	3.54	-0.79	4.33***
>= 50 FTEs and < 250 FTEs	238	7.38	-0.32	7.70***	204	11.63	2.20	9.43***
>= 250 FTEs	34	-0.05	-2.24	2.19	30	24.57	-13.07	37.64
young firms	318	5.33	0.86	4.47***	272	8.92	4.53	4.39***
old firms	588	2.34	-1.04	3.38***	510	4.53	-2.95	7.48***
low share of high qualified	436	3.26	-0.18	3.44***	372	4.01	1.24	2.77***
high share of high qualified	470	3.51	-0.56	4.07***	410	7.92	-1.80	9.72***
low share of medium qualified	454	3.85	-0.04	3.89***	394	5.68	-0.42	6.10***
high share of medium qualified	452	2.92	-0.71	3.63***	388	6.44	-0.28	6.72***
low share of young employees	422	2.41	-0.14	2.55***	364	6.81	-1.78	8.59***
high share of young employees	484	4.24	-0.57	4.81***	418	5.40	0.89	4.51***
project in 2007	224	6.18	-0.39	6.57***	28	2.96	-1.83	4.79*
project in 2008	130	3.91	-0.88	4.79***	102	-0.06	-2.77	2.71***
project in 2009	118	1.51	0.51	1.00**	104	4.46	-0.97	5.43***
project in 2010	172	3.73	0.12	3.61***	112	6.44	-0.23	6.67**
project in 2011	138	4.40	-0.13	4.53**	160	2.36	1.75	0.61***
project in 2012	52	2.43	0.31	2.12	134	8.95	3.90	5.05**
project in 2013	40	-10.89	-5.26	-5.63***	118	14.63	-3.56	18.19***
urbanised regions	234	4.85	-0.77	5.62***	198	9.02	-3.08	12.10***
rural regions	672	2.88	-0.23	3.11***	584	5.05	0.57	4.48***
region with low unemployment	504	2.58	0.21	2.37***	408	7.11	1.22	5.89***
region with high unemployment	402	4.41	-1.11	5.52***	374	4.90	-2.06	6.96***
region with low R&D employment	462	4.89	-0.24	5.13***	396	8.06	-0.35	8.41***
region with high R&D employment	444	1.82	-0.51	2.33***	386	4.00	-0.36	4.36***

Notes: Results significant on the level: *** p<0.01, ** p<0.05, * p<0.1.

sults also show considerable effect heterogeneity depending on firm and regional characteristics as well as timing of the subsidy. Depending on the economic sector, the short-term effect ranges from -0.36 FTEs in metal production to 8.13 FTEs in production and maintenance of electrical equipment, machinery and computers. In most of the analyzed sectors, the mid-term effect is greater that the short one. So the effect in petroleum processing, chemistry and pharmaceutics rises from 5.05 FTEs to 15.77 FTEs. Not surprisingly, also firm size influences the effect: the bigger the firm, the bigger the effect. In short term we observe a range from 1.52 FTEs in very small firms to 7.7 FTEs in medium-size firms, the mid-term effect ranges from 2.32 FTEs to 9.43 FTEs. Regarding the structure of employees, a high share of high qualified employees[17] seems to have a positive influence on the effect, particularly in the medium run (9.72 FTEs vs. 2.77 FTEs). Also the share of young employees has an impact on the employment effect. As expected, the short-term effect is with 4.81 FTEs bigger in firms with a high share (compared to 2.55 FTEs)[18] , but the midterm effect here is with 4.51 FTEs much smaller than in firms with a low share of young employees (8.59 FTEs). This result is a bit 'counter-intuitive'. The effect in urbanised regions is much bigger than in more rural regions – in the mid-term it is about 3 times larger (12.1 FTEs vs. 4.48 FTEs). Also the share of R&D employment in a region plays a role – the mid-term effect in regions with a comparably high share is with 8.41 FTEs about twice as the one in regions with comparably low employment in R&D.[19] The effect also changes in the course of the funding period. For the years 2009 and 2010 we observe higher mid-term effects than before and afterwards. This may indicate a stronger effect for firms that applied for subsidies shortly after the financial crisis.[20] The heterogeneous effects over time confirm the importance of exactly considering the point of time a firm is compared to his 'statistical twin' to exclude a potential 'time bias'.

[17]The terms 'high' and 'low' denote a share above and below the median of 1.6 percent.

[18]'High' means above the median of 21.4 percent, 'low' means below the median.

[19]The differentiation here is more like between 'tiny' and 'small' shares of R&D employment; the median is 0.05 percent.

[20]This may be interpreted in different ways, and we would require more information, e.g. on other funding programs at this time, to draw conclusions.

7 Quality and Robustness checks

7.1 Quality check

In the following, we present the results of different quality checks for the estimation. Our verification of the balancing property concentrates on two criteria: first, the closeness of the means in the treated and the control group, and second, the balance of the distributions as a whole.[21] First, we compare the means of the continuous matching variables in both groups. Cochran (1968) gives a rule of thumb for a balancing check: when the means differ by more than one quarter of a standard deviation of the respective variable, we need better balance. Table 5 shows the means in both groups, the difference between both, and the quality criterion. Additionally, we present the share of observations in the respective categories of the categorical matching variables. As can be observed in the table, the means of all continuous variables are very similar and fulfill the quality requirement ofCochran (1968). Also the distribution of the values of the categorical variables over the categories are very much similar between the treated and the control firms. For both, the short-term and the mid-term effect, the comparison of the variable means, or value shares, point to a confirmation of the balancing property of the matching algorithm. Second, we present the results of distribution tests and quantile-quantile-plots to verify balancing of the variable distributions between the group of the treated firms and the controls. Table 6 contains the results of KS-tests for continuous and chi-square-tests for the categorical variables. Also the test results confirm the quality of the matching result. Neither for the short-term nor the mid-term effect we have significant differences in the distribution of the matching variables between treated and control firms.

This is also obvious in a graphical comparison of the variable distributions. The quantile-quantile-plots in figure 4 give the quantiles in the treated group against that of the control group for each continuous variable. The 45°-line represents identical distributions. The distribution of all checked variables is very similar in both groups with only slight deviations from the 45°-line.

[21] Ho *et al.* (2007) recommend different checks of the quality of the results, because matching requires multivariate balance of the variables, and available tests are only one-dimensional. For a more detailed discussion of the problem see Ho *et al.* (2007).

Table 5: Comparison of the means

Variable	Mean/Share Treated	Mean/Share Controls	Difference	Std.Dev.[1]	Cochran rule of thumb
short-term effect					
size of the firm					
< 10 FTEs[2]	25.39	26.49	-1.10		
>= 10 FTEs and < 50 FTEs[2]	44.59	45.25	-0.66		
>= 50 FTEs and < 250 FTEs[2]	26.27	25.17	1.10		
>= 250 FTEs[2]	3.75	3.09	0.66		
age of the firm					
young firm	35.10	35.32	-0.22		
established firm	64.90	64.68	0.22		
sector of the firm (5 biggest sectors)					
metal production	29.14	29.14	0.00		
production and maintenance of electrical... equipment, machinery and computers	13.25	13.25	0.00		
production of furniture, wooden products,... glass and ceramics	13.91	13.91	0.00		
petroleum processing, chemistry and... pharmaceutics	13.47	13.47	0.00		
trade, repair, transport, ICT	9.71	9.71	0.00		
share of high qualified	7.00	6.41	0.59	11.63	fulfilled
share of medium qualified	60.76	62.99	-2.23	28.73	fulfilled
share of young employees	24.18	21.63	2.55	15.37	fulfilled
employment difference	4.31	2.26	2.05	14.81	fulfilled
unemployment rate in the region	13.62	13.60	0.02	2.50	fulfilled
R&D employment share in the region	0.05	0.05	0.00	0.03	fulfilled
type of region					
urbanised region	25.83	25.39	0.44		
rural region	74.17	74.61	-0.44		
mid-term effect					
size of the firm					
< 10 FTEs[2]	26.34	27.37	-1.03		
>= 10 FTEs and < 50 FTEs[2]	43.73	43.99	-0.26		
>= 50 FTEs and < 250 FTEs[2]	26.09	25.32	0.77		
>= 250 FTEs[2]	3.84	3.32	0.52		
age of the firm					
young firm	34.78	34.78	0.00		
established firms	65.22	65.22	0.00		
sector of the firm (5 biggest sectors)					
metal production	30.43	30.43	0.00		
production and maintenance of electrical... equipment, machinery and computers	13.55	13.55	0.00		
production of furniture, wooden products,... glass and ceramics	13.81	13.81	0.00		
petroleum processing, chemistry and... pharmaceutics	13.04	13.04	0.00		
trade, repair, transport, ICT	7.93	7.93	0.00		
share of high qualified	7.21	6.43	0.78	12.04	fulfilled
share of medium qualified	61.25	64.36	-3.11	28.26	fulfilled
share of young employees	24.42	21.47	2.95	15.45	fulfilled
employment difference	4.16	2.30	1.86	14.95	fulfilled
unemployment rate in the region	13.87	13.88	-0.01	2.48	fulfilled
R&D employment share in the region	0.05	0.05	0.00	0.03	fulfilled
type of region					
urbanised region	25.32	24.81	0.51		
rural region	74.68	75.19	-0.51		

Notes: [1] Standard deviation in the sample; [2] Full-time equivalents.

Supplementary, we use the verification tools given in *pstest* (Leuven and Sianesi, 2003) – t-tests, standardized percentage bias and variance ratios of the matching variables – as proxies for the correspondence of the variable distributions.[22] By and large, the results in table 7 confirm the presented quality checks. The results of the t-tests and the percentage bias for the matching variables point to similar means in both groups, the variance ratios have mostly values near one – indicating similarity of the variable variances between treated and control firms.[23]

As a last step, we verify graphically the common trend assumption. This key assumption for difference in difference requires that the firms in both groups would have the same behavior, if the treated firms would not have been subsidized. This assumption is usually verified before treatment starts. We proxy the behavior of a firm by the relative employment development. Figure 5 shows the month by month employment change, or a quasi monthly employment growth. The vertical line denotes the time of application for subsidies. We consider the development before application to verify the common trend assumption. As can be observed, the monthly employment growth shows big variations up and down for both, treated and control firms. But the trends are nearly identical for the firms in both groups regarding the short-term effect. Regarding the mid-term effect, a slight decrease in the trend line of treated firms from about 0.02 FTEs to about 0.015 FTEs is observ-

[22]We cannot interpret the measures in the usual way, because t-tests are valid only in case of normally distributed variables, and standardized bias an variance ratio are meaningful only for continuous variables.

[23]We find only one exception: the variance ratio of the employment difference is outside Austin's rule of thumb for similar variances (Austin, 2009). But this rule is considered as rather rough measure for balancing in the literature (Leuven and Sianesi, 2003).

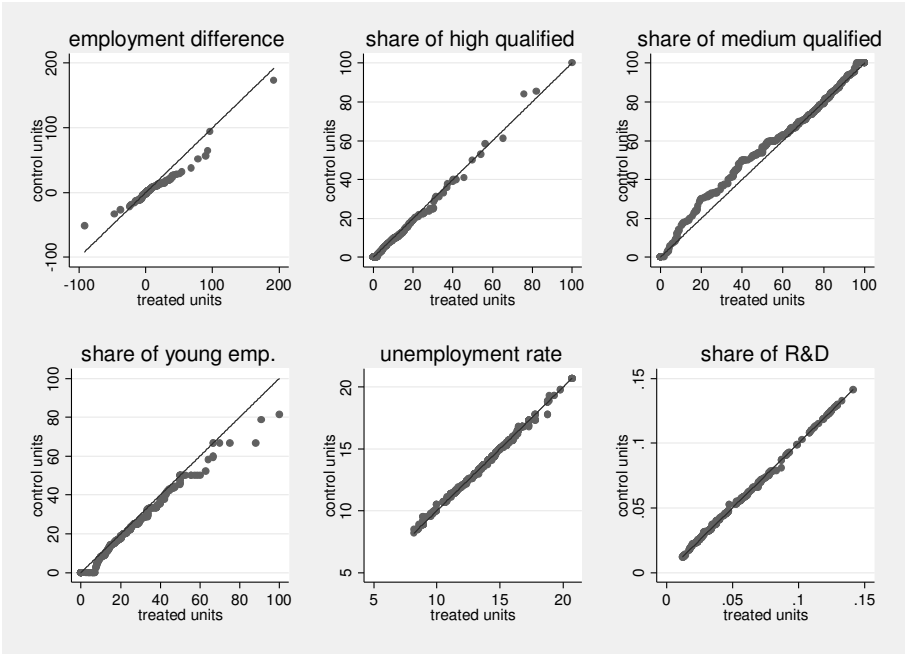
Table 6: Results of KS-Test and χ^2-Test

	short-term effect		mid-term effect	
Variable	D / χ^2	p-value	D / χ^2	p-value
size of the firm	0.53	0.913	0.27	0.966
age of the firm	0.00	0.945	0.00	1.000
sector of the firm	0.00	1.000	0.00	1.000
share of high qualified	0.07	0.181	0.08	0.171
share of medium qualified	0.08	0.156	0.08	0.171
share of young employees	0.08	0.114	0.09	0.104
employment difference	0.13	0.002	0.13	0.003
unemployment rate in the region	0.02	1.000	0.02	1.000
R&D employment share in the region	0.03	0.997	0.02	1.000
type of region	0.02	0.879	0.03	0.869

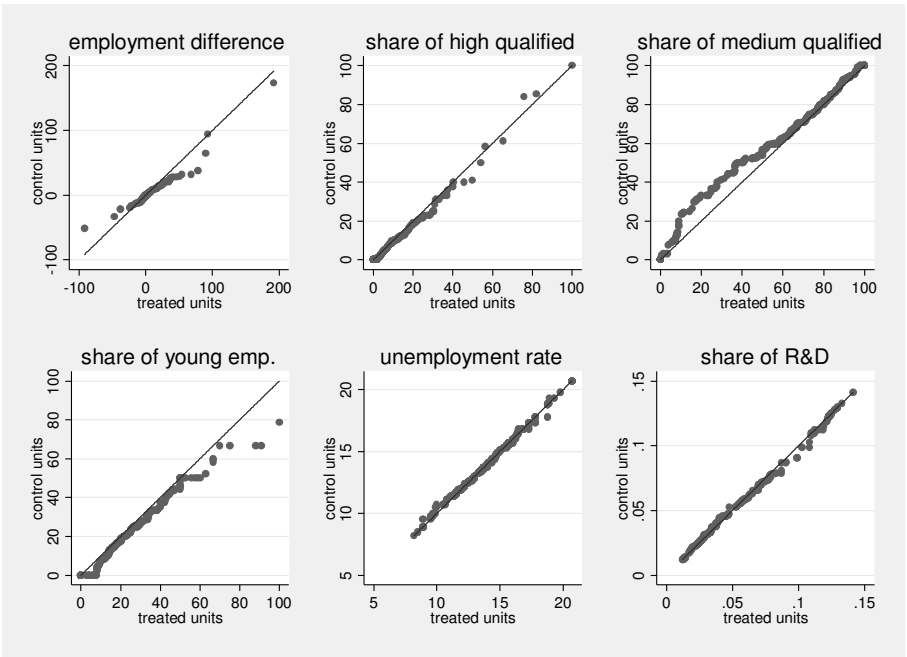
Table 7: Results of pstest

Variable	Mean		% Bias	t-test		V(T) /
	treated	control		t	p-value	V(C)
short-term effect	3.39	-0.37	26.4	3.98	0.000	2.72*
size of the firm	2.08	2.05	4.4	0.66	0.510	1.03
age of the firm	1.65	1.65	0.5	0.07	0.945	1.00
sector of the firm	104.40	104.40	0.0	0.00	1.000	1.00
share of high qualified	7.00	6.41	5.1	0.77	0.442	1.03
share of medium qualified	60.76	62.99	-7.7	-1.17	0.244	1.09
share of young employees	24.18	21.63	16.6	2.50	0.013	1.13
employment difference	4.31	2.26	13.9	2.09	0.037	1.69*
unemployment rate in the region	13.62	13.60	0.5	0.07	0.944	1.05
R&D employment share in the region	0.05	0.05	-0.5	-0.08	0.939	1.02
type of region	1.74	1.75	-1.0	-0.15	0.879	1.01
mid-term effect	6.06	-0.35	28.1	3.92	0.000	0.91
size of the firm	2.07	2.05	3.4	0.48	0.630	1.02
age of the firm	1.65	1.65	0.0	0.00	1.000	1.00
sector of the firm	104.06	104.06	0.0	0.00	1.000	1.00
share of high qualified	7.21	6.43	6.5	0.91	0.364	1.07
share of medium qualified	61.25	64.36	-11.0	-1.54	0.124	1.13
share of young employees	24.42	21.47	19.2	2.68	0.008	1.15
employment difference	4.16	2.30	12.4	1.74	0.082	1.62*
unemployment rate in the region	13.87	13.88	-0.3	-0.04	0.970	1.05
R&D employment share in the region	0.05	0.05	0.5	0.07	0.942	1.05
type of region	1.75	1.75	-1.2	-0.16	0.869	1.01

Notes: * variance ratio exceeds Austins rule of thumb.



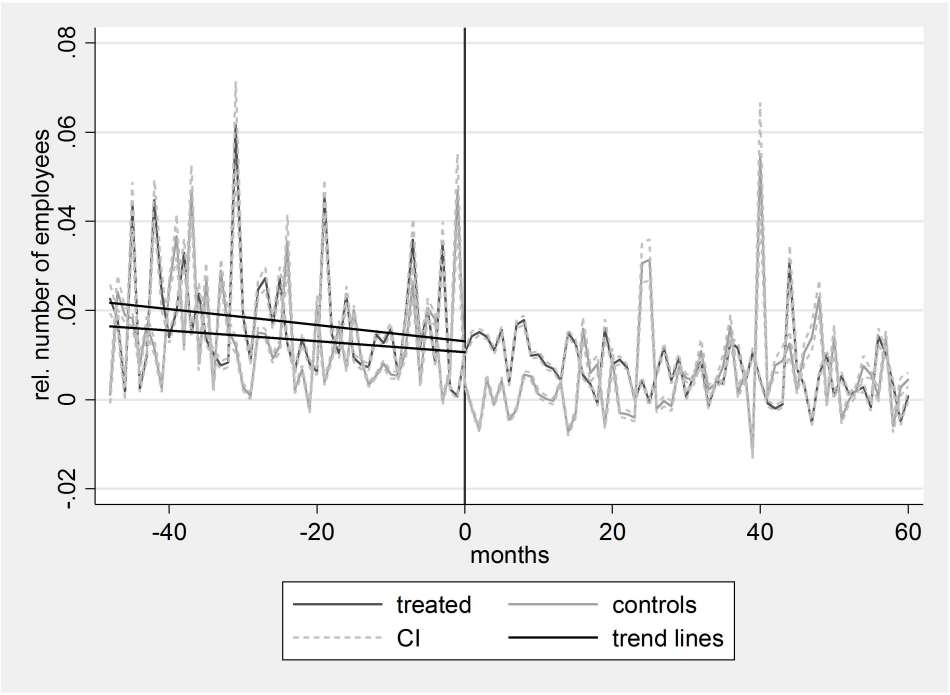
short-term effect



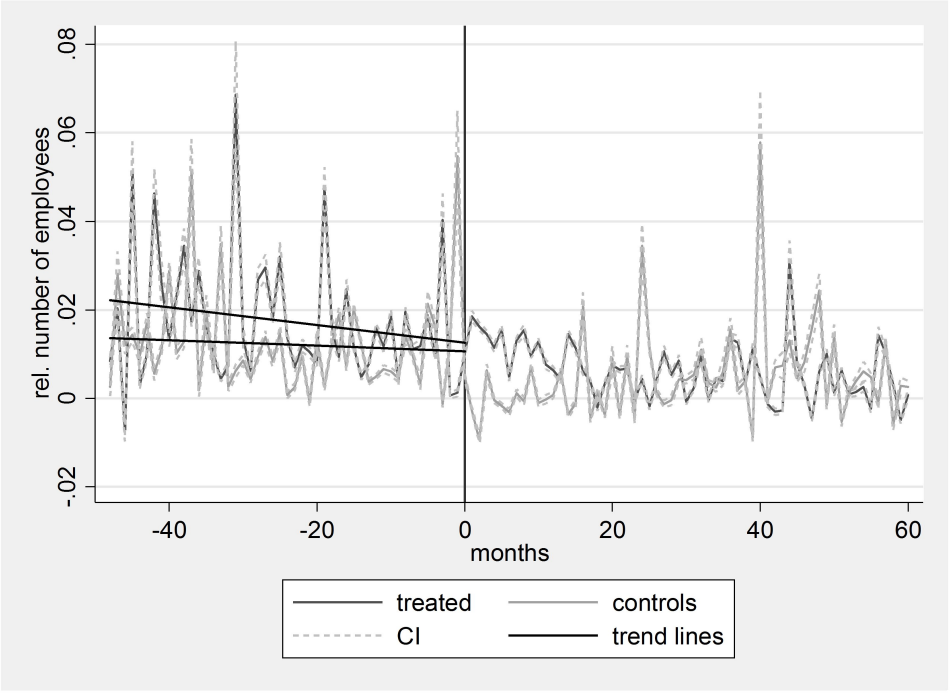
mid-term effect

Figure 4: QQ-Plots of continuous variables

able while the trend line for the control firms is nearly horizontal at 0.015 FTEs. Also this we assess as very similar employment development before application. All



short-term effect



mid-term effect

Figure 5: Monthly employment change

in all, we conclude from the quality check, that the presented results in chapter 6 are reliable.

7.2 Robustness check

Table 8 gives the results of four alternative Matching algorithms. They show that the presented results are also stable with regard to different assignment processes, resulting in different control groups (with more than one 'statistical twin' for the treated firms). Only for the alternative distance measure, Nearest neighbor matching with Mahalanobis distance, we observe a smaller employment effect. This may have different reasons, one of them may be seen in the fact that the Mahalanobis distance is a very good measure for continuous variables, but not an adequate distance function for categorical variables.[24] All in all, also the robustness check confirms the reliability of the presented results.

Table 8: Results using different matching algorithms

	treated	controls	difference
Nearest neighbor matching with Ties			
short-term effect	3.39	-0.35	3.74
mid-term effect	6.06	-0.33	6.39
Radius matching with small radius			
short-term effect	3.39	-0.00	3.39
mid-term effect	6.06	-0.12	6.18
Radius matching with wide radius			
short-term effect	3.39	-0.19	3.58
mid-term effect	6.06	-0.10	6.16
Nearest neighbor matching with Mahalanobis distance			
short-term effect	2.47	0.95	1.52
mid-term effect	5.91	1.59	4.23

8 Conclusion

N.N.

[24]This presumption is confirmed when looking at the quality checks of the different matching algorithms. The control group resulting from the Mahalanobis matching is not as similar as the control group resulting from the Nearest Neighbor matching with the statistical distance function. The quality check of the alternative algorithms is available upon request.

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9 Appendix

Table 9: Aggregated economic sectors for the analysis

Name of the sector	Included WZ codes	
	WZ2003	WZ2008
production of food, luxury food, animal feed	15, 16	10–12
production of fabrics, clothes, leather goods	17–19	13–15
pulp and paper industry, printing and publishing	21, 22	17, 18
petroleum processing, chemistry and pharmaceutics	23–25	19–22
metal production	27, 28	24, 25
production and maintenance of electrical equipment, machinery and computers	29–33	27, 28, 33
vehicle manufacturing	34, 35	29, 30
production of furniture, wooden products, glass and ceramics	26, 36, 37, 38	16, 23, 31, 32
agriculture, forestry, mining, energy and water industry, waste management	1, 2, 5, 10–14, 40, 41	1–3, 5–9, 35–39
trade, repair, transport, ICT	51, 52, 60–64	45–47, 49–53, 58–63
insurance, financial and business services	66, 67, 70, 71, 72, 73, 74	64–66, 68–79
personal services	55, 80, 85, 90, 92, 93, 95	55, 56, 85–88, 90–93, 95, 96
public administration	75, 91	84, 94

Sources: IAB research report No. 4/2009 and 14/2014; own summary.