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Abstract

The paper estimates the plant level employment effects of investment subsidies in one of the most strongly subsidized German Federal States. We analyze the treated plants as a whole, as well as the influence of heterogeneity in plant characteristics and the economic environment. Modifying the standard matching and difference-in-difference approach, we develop a new procedure that is particularly useful for the evaluation of funding programs with individual treatment phases within the funding period. Our data base combines treatment, employment and regional information from different sources. So, we can relate the absolute effects to the amount of the subsidy paid. The results suggest that investment subsidies have a positive influence on the employment development in absolute and standardized figures – with considerable effect heterogeneity.

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

JEL Classification: A11, D61, H20, Z0

1 Introduction

The aim of the paper is to evaluate employment effects of investment subsidies at the micro level. This instrument plays a major role in regional policy of nearly every European state: besides the Structural Funds of the European Union, almost every member state offers national regional policy programs including investment subsidies (Criscuolo *et al.*, 2016). For Germany, the joint Federal Government/Laender scheme for 'Improving regional economic structures' (GRW) is the most important instrument of redistribution policy. In the last funding period 2007-2013, a total amount of about 11.6 billion € was spent for GRW (Federal Office for Economic Affairs and Export Control, 2016). The common intention of regional policy is to enable disadvantaged regions to catch up with the national average. Investment subsidies in particular should foster the competitiveness and the economic development in a whole region by generating sustainable growth in particularly promising plants or sectors and positive spillovers to other economic actors. In this context, we focus on the initial step of the intended catching-up process. We do not only want to know, if investment subsidies work or not, but also where the strongest effects can be expected, and where the GRW may have small or no effects.

From theoretical literature one would expect that individual plant characteristics and economic environment influence the strength of the treatment effect. But despite the fact that heterogeneous treatment effects are an important issue in every state providing investment subsidies,[1] we find only few evidence for the importance of heterogeneity of the treated plants in the empirical literature so far. Our study serves as a first attempt to fill this gap. We analyze the treated plants as a whole, as well as their heterogeneity in characteristics and economic environment. Compared to existing studies, this gives a more precise and detailed view on the effects of investment subsidies. Additionally, we relate the observed employment effects to the amount of the subsidy paid in the respective subsamples. Thus, we provide standardized employment effects in terms of additional employment per 100.000 € which are comparable among the subsamples. Subject of the analysis are the short-

[1]The magnitude of equalization transfers is particularly large in the EU (Becker *et al.*, 2010).

term and mid-term employment effects of GRW investment subsidies in Saxony Anhalt, one of the most strongly subsidized German Federal States.[2]

Our data base is constructed by matching detailed administrative treatment data with rich employment and regional information. In the data we observe specific individual treatment phases within the funding period. That means, we face a situation with individual treatment starts and treatment durations. This is a typical pattern for subsidy schemes that has not been considered so far in previous literature. In order to process the uniquely rich information and to correctly take account of its special structure, an extraordinary flexible estimation approach is required. Hence, we modify the standard matching and difference in difference approach in two ways. First, we replace the common Propensity Score for matching by a combined statistical distance function that adequately considers time varying variables. Second, we introduce the opportunity to account for flexible durations of observed outcome differences. In our paper, the estimated effects are average employment developments over plant specific durations from application until one year after the funded projects started and finished, respectively. This approach ensures that individual treatment phases can be accounted for in an appropriate way and that the point in time a plant is compared to his 'statistical twin' can be exactly determined.

Our results suggest that GRW investment subsidies have a positive influence on the employment development in the treated plants both in the short and medium run. The short-term effect measured one year after the funded project started amounts to about 3.4 full-time equivalents (FTE) in absolute figures, the mid-term effect (measured one year after the project is finished) is with 6.36 FTEs even larger. Relating the absolute effect to the amount of the subsidy, the average standardized short-term effect is about 0.54 FTEs per 100.000 €, the mid-term effect is with about 1 FTE per 100.000 € subsidy nearly twice as large. The presented results also confirm the presumed influence of heterogeneity in individual plant characteristics, economic environment and the timing of the treatment on the strength of the treatment effect.

[2] In the period 2007–2013, about 15 percent of the federal GRW funds were assigned to Saxony Anhalt (Alm, 2014).

The remainder of the paper is organized as follows. The next section gives a short overview of the literature on the micro-level effects of investment subsidies in theoretical and empirical studies. 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 quality and robustness checks. The last section concludes with a summary of the most important findings and some aspects of further research.

2 A closer look to the literature

2.1 Theoretical considerations

In general, investment subsidies are supposed to directly affect the stock of physical capital that influences the level of output, but also other input factors, in particular labor. According to the microeconomic theory, an investment subsidy reduces the marginal costs of physical capital, thus leading to a substitution of labor with capital due to a change in the relative factor prices. Under the assumption of sufficiently elastic demand, an outward production isoquant can be reached (Varian, 1992). In cases with relatively low substitution elasticities, the resulting output effect leads to an increase in both capital and labor. The opposite might be the case if high substitution elasticities occur. Then the (negative) substitution effect may exceed the (positive) output effect. Consequently, the number of jobs in the firm may decrease (Klodt, 2000; Criscuolo *et al.*, 2016). But why treatment effects of investment subsides should differ with heterogeneous firm characteristics? According to economic theory and data available we consider this question for three groups of variables, namely quality of inputs, internal (dis)economies of scale, and (time varying) general economic environment – or external economies of scale.

First, there is a bulk of literature suggesting that the quality of inputs affects the productivity of plants. According to the concept of the production function, not only physical capital, e. g. in terms of physical and technical equipment is important, but also the human capital endowment of a plant is decisive for its productivity (see SYVERSON (2011) for an overview). Following Mincer, the qualification and work experience of the workforce are regarded as standard proxies for human capital endowment (MINCER, 1962).

Another group of variables is related to (dis)economies of scale, meaning that average costs decrease (increase) with a specific amount of output representing productivity gains (losses) of the firm. The general economic reason for economies of scale is some degree of indivisible inputs (in the sense that an input is useless if it is divided) (SILVESTRE, 1987). In line with the literature we distinguish between internal and external economies of scale.

Plant size, plant age and economic sector represent different aspects of internal economies of scale. On the one hand, plant size concerns static economies of scale meaning that a specific input with a given capacity, e. g. a machine, cannot be physically divided (SILVESTRE, 1987).[3] This would point to a positive relationship between firm size and productivity. On the other hand, smaller firms are expected to act more flexible in the market due to entrepreneurial spirit, risk behavior, new ideas and products (PAGANO and SCHIVARDI, 2003; DHAWAN, 2001).
Firm age can be related to dynamic economies of scale. Here, average cost diminish as a result of improvements of the production process over time. This holds true particularly for goods respectively industries where optimal technical procedures cannot be developed in advance, e. g. aircrafts, ships, vehicles or semiconductors (SYVERSON, 2011). Furthermore, the age of the firm's workforce is not only a proxy for the quality of human capital. It can also be recognized as a specific case of dynamic economies of scale. Literature emphasizes that individual worker's productivity considerably increases in the first years after job entry. It reaches its maximum in the mid-term of the life cycle and often decreases towards the end of the career (SKIRBEKK, 2004). Drivers behind this cycle are cognitive capabilities (cognitive mechanics and cognitive pragmatics) which change with aging (BALTES, 1993). However, these productivity effects differ across the tasks that have to be fulfilled (JOHNSON, 2005).[4]

[3]Beyond that, specific corporate functions such as R&D and financing departments are also discussed in the context of indivisible inputs.

[4]Recent literature also pays attention to the composition of the plant's workforce claiming that age diversity has positive effects on productivity (BACKES-GELLNER and VEEN, 2013).

Finally, despite there is no specific theoretical argument why treatment effects should differ across economic sectors, we expect heterogeneous effects. The reason is that industries often represent specific combinations of characteristics discussed above. For example, the aircraft industry is characterized by high learning-by-doing effects, and the chemical industry generally requires large machinery.

Third, regarding external economies of scale we refer to productivity spillovers between firms that are often discussed in the context of agglomeration economies (Syverson, 2011). The literature typically distinguishes between two types of externalities (Beaudry and Schiffauerova, 2009). The first strand (localization economies) can be traced back to Marshall (1920) who argues that geographical proximity promotes intra-industry knowledge exchange, reduces transport costs and provides a specific labor-market pool provoking geographically specialized industries. The second strand (urbanization economies) goes back to Jacobs (1969) who emphasized the role of dense and diverse knowledge bases as engines for the development of regions. So far, the literature did not find whether localization or urbanization economies drive regional economic development processes (Beaudry and Schiffauerova, 2009). These types of agglomeration economies can be measured with the help of an agglomeration index and regional R&D input intensities.

Unemployment rates are also discussed in this context. They can be regarded as unutilized resources. Involuntary unemployed maybe need to acquire specific skills that are required for the new job. These training and teaching activities take some time. Furthermore, the literature provides some evidence that investment subsidies reveal diminishing returns. This means that subsidies have their highest impact in the most disadvantaged regions and the effect decreases the more the region catches up (Alecke *et al.*, 2013).

2.2 Empirical literature

As discretionary investment subsidies are a very important instrument in many countries, there is a broad empirical literature on the effects of these programs. We restrict our literature review on micro level studies, because the focus of our analysis is on the plant level as the initial step of the regional development process mentioned above.

Causal effects of GRW in Germany were first analyzed by Stierwald and Wiemers (2003) and Ragnitz and Lehmann (2005). Using a matching approach for the establishment panel of the Institute of Employment Research, they find positive treatment effects on the amount of investment per employee and on sales among East German establishments for the years 2000–2002 and 1999–2001, respectively. Bade and Alm (2010) apply a matching with difference-in-difference approach. For plants subsidized during the 2001–2006 funding period, they estimate a positive effect on employment development from the year of funding to 2008. They also find a decline in regional employment in non-eligible sectors, suggesting potential intra-regional displacement effects of employment. Differencing the sample into treatment cohorts, they observe mean yearly employment effects of different size. In a subsequent study, Bade (2013) uses the same econometric approach to differentiate the GRW effect by plant size. He finds no hint for an influence of the plant size on the estimated employment effect.

Similar to the GRW, Italy's Law 488/1992 provides subsidies to plants willing to invest in disadvantaged regions. Bernini and Pellegrini (2011) evaluate the effects of this 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 growth, but negative long-run effects on productivity growth. Differencing the effect regarding the size of the subsidized plants, they find stronger effects in small and medium-sized firms. Bronzini and de Blasio (2006) evaluate the 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 Regression Discontinuity Design, Cerqua and Pellegrini (2014) estimate positive effects on the growth of employment, investment, and turnover; effects on productivity remain negligible. 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 the growth of sales, employment, and fixed assets. As in the aforementioned studies, the effect on factor productivity (in this case, labor) remains very limited.

In the United Kingdom, the Regional Selective Assistance (RSA) program also provides discretionary grants to plants in disadvantaged regions. Devereux *et al.* (2007) find small positive effects on the location choice of new entrants. Criscuolo *et al.* (2016) analyze the effectiveness of the RSA program using administrative data in combination with plant-level information for the 1986–2004 period. Applying an instrumental variable approach, they find positive RSA effects on employment and investment, but no effect on factor productivity. Differentiating the effects by plant size, they show that small and medium-sized plants experience the strongest effects, whereas the effect for large plants is almost zero.

Summing up, the results existing so far point to positive effects of subsidies on overall plant-level employment, investments and turnover, but to negative or no effects on productivity. Except for plant size and the year of treatment, heterogeneity among the treated plants has not been considered in the literature so far. As is explained above, we would expect that individual plant characteristics and the economic environment influence the employment effect. In our study we estimate both the overall employment effect for the treated plants and the effect in different subsamples representing heterogeneous characteristics that are presumed to have an impact on the strength of the estimated employment effect.

In the literature so far, the outcome is usually measured as the development in absolute terms or in growth rates. Both measures do not allow to compare the estimated effects in the subsamples.[5] Our data base include exceptional rich information on the treatment, so we are able to relate the estimated employment development to the amount of the subsidy and create an comparable measure of the effect strength in the different subsamples.

[5]The development in absolute terms is presumed to be driven by the effects in large plants in the sample (who presumably absorb a large share of the total subsidy), whereas the effects in terms of growth rates are more driven by the effects in smaller firms.

3 Some facts about the GRW program

The Joint Task for 'Improving Regional Economic Structures' (GRW) is the most important regional policy scheme in Germany and is jointly implemented by the German government and the Federal States. The program initially was set up in 1969 and aims to reduce local disadvantages, tackle structural change, foster aggregate regional economic growth and create 'equivalent living conditions' across Germany (Articles 91a and 72 (2) Constitutional Law). The main instrument within this framework are investment subsidies for plants and communities. For every funding period, the respective GRW coordination framework determines the key features regarding the eligibility of economic sectors, types of investment projects, and aid ceilings. The framework must be approved by the European Commission. Due to the generally exceptional character of state aid schemes (EUROPEAN COMMISSION, 2006), not all German regions are eligible for GRW subsidies. The eligibility of a region depends on a structural weakness score that consists of a weighted combination of four weakness indicators (see figure 1) and the threshold that is determined by the European Commission.

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 1: *Information on the structural weakness score*

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

In the funding period 2007–2013 the scores ranged from 97.06 to 101.36 (Eckey, 2008). Scores below 100 indicate regions with below-average structural development or regions with local disadvantages. Values above 100 indicate economically strong regions. In Saxony Anhalt, all 14 districts have scores below 100, ranging from 97.47 in Mansfeld-Suedharz to 98.66 in Magdeburg. In order to consider very localized differences, the eligible districts are generally distinguished in three area categories, namely A, C, and D areas. These categories reflect different funding intensities in terms of different subsidy ceilings.[6] The districts in Saxony Anhalt, like all East German regions (with the exception of Berlin), belong to the A areas, in which the highest possible subsidy ceilings are applied for eligible projects. Depending on their size, plants can apply for a subsidy of up to 50 percent of the eligible costs for business investment projects.[7] Local governments usually receive subsidies of 60 percent for business-oriented infrastructure projects.

4 Data and descriptive statistics

4.1 Data

Our data base combines information from multiple sources. The GRW treatment information is received from the Investment Promotion Bank of Saxony Anhalt, employment information on the plant level is achieved from the Employment History of the Institute for Employment Research (IAB), and regional information comes from the INKAR data base of the Federal Institute for Research on Building, Urban Affairs and Spatial Development.

Unique data on the subsidized projects of the funding period 2007-2013 in Saxony Anhalt we get from the Investment Promotion Bank of Saxony Anhalt, who is responsible for the implementation of GRW subsidies in the state. The most important information on the total of 1,696 projects include the kind of investment,

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

[7]The definition of plant size corresponds to the EU classification. Large plants receive a subsidy of 30 percent, medium sized plants 40 percent and small plants 50 percent of the eligible investment costs.

expected additional employment, 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 1,208 subsidized plants. Further plant information include address, size category (following the EU definition of small, medium and large plants) and the economic sector.

Data on the single employees in the subsidized plants is received from the Federal Employment Agency (Bundesagentur fuer Arbeit).[8] This comprehensive database is available since 1975 for Western Germany and since 1991 for Eastern Germany. It contains information on gender, nationality, formal and professional qualification, the kind of employment contract, working hours and salary of the employees. For our analysis, we aggregate information on the single employees to the plant level allowing us to observe plant characteristics like size in terms of the number of employees and full-time equivalents (FTEs)[9], 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 plant.

Linking the aggregated Employment History and the GRW data via the official plant identifier provides us with detailed information for employees of 1,171 plants out of the subsidized 1,208 plants.[10] For the analysis, we trace back the plants until 2004. This allows us to control for employment development in the plants before the funding period started. We only consider data for plants in Saxony-Anhalt for two reasons. First, we want to make sure that the potential controls did not receive GRW subsidies, and second, the economic environment of the subsidized and control plants should be as similar as possible. All in all we observe 19,246

[8] 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.

[9] Full-time equivalents are calculated as follows: 1*full-time employment+0.5*part-time employment+0.2*marginal employment.

[10] Although the sectoral information in the GRW data and the Employment History is both based on the German Classification of Economic Activities (WZ), the given WZ code in both data sets is quite different for a number of the treated plants. We use the information from the Employment History in order to have comparable sectoral information for the treated and the non-treated plants.

plants in Saxony-Anhalt with yearly 2.24 million FTEs for the period 2004 to 2014, including the 1,171 subsidized plants.

In a next step, we enrich the plant-level data with regional information from the INKAR data base of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). 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 plants like the type of region[11] , the unemployment rate and the share of employees in sectors with high R&D activity. The overall result is a rich panel data set with monthly employment and plant information, yearly regional information and detailed program information of GRW subsidies.

4.2 Descriptive statistics

In the analysis, we focus on subsidized plants that receive treatment only once in the funding period. We further exclude plants in sectors not eligible for GRW subsidies, e. g. agriculture and forestry, health and social services sector, education and public administration.[12] As a result, our sample consists of 3,5 million observations, i. e. monthly information on plants in Saxony Anhalt, including 716 subsidized plants.

From the wealth of information described above, we choose characteristics that are regarded as influential on the strength of the employment effects of investment subsidies. Theoretical considerations lead to the inclusion of the following plant characteristics into the analysis: plant size categories following the EU definition of small, medium and large plants (with a sub-categorization of the small plants: very small plants with <10 FTEs and small plants with 10 to 49 FTEs), two age categories (young with <10 years old vs. established plant), aggregated sectoral classifications[13] , qualification structure of the employees (share of high qualified

[11] The basis for this characterization is the definition of settlement structural spatial units of the BBSR.

[12] Resulting from the different WZ codes in the data sets and our decision to rely on the IAB information, we have to subsequently correct the sample for those plants who are in non-eligible sectors.

[13] See table 9 in the appendix for a detailed sectoral information given by the WZ code in 13 aggregated economic sectors.

and share of medium qualified) and age structure (share of young employees with <30 years old). Furthermore we use regional information that characterize the economic environment of the plants: the unemployment rate, a broad settlement structural type of the region and the regional employment share in R&D.

Table 1 gives an overview on the characteristics of the plants in the sample. Since we have panel data, the table provides some descriptives of the included variables for plants included in the sample at the beginning of the funding period in January 2007 and the end in December 2013, respectively.

The variables in table 1 show some remarkable differences between the subsidized and the non-subsidized plants, particularly with regard to plant size and the economic sector.[14] Non-subsidized plants are on average smaller. About three quarters of them, but only 30 percent of the subsidized plants belong to the group of very small plants (with up to 10 FTEs). Most of the subsidized plants (about 42 percent), but only 19 percent of the non-subsidized are small plants with 10 to 50 FTEs. The share of medium-sized plants (between 50 and 250 FTEs) is about one quarter among the subsidized and only 5 percent among the non-subsidized plants. Furthermore, the sectoral structure of the plants differs in both groups: with about one quarter, plants in metal production are most common among the subsidized plants, but only ten percent of the non-subsidized operate in this sector. In contrast, only ten percent of the subsidized belong to the aggregated sector of trade, repair, transport and ICT, but with 40 percent, this is the most important sector among the non-subsidized. Some smaller differences we observe in the sectors of petroleum processing, chemistry and pharmaceutics (12 vs. 3 percent) and production and maintenance of electrical equipment, machinery and computers (13 vs. 6 percent). Similarities between the two groups become visible as to the plant age and the workforce structure. The same applies to the economic environment.

Table 2 gives an overview on the subsidized projects under analysis, again for the begin and the end of the observation period. The projects lasted on average about two years. The investment volume showed a very large variation with some very large projects: the mean of about 3 million € was much higher than the median

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

Table 1: **Descriptive statistics for subsidized and non-subsidized plants**

	January 2007				December 2013			
Variable	N	Mean/ Share	Median	Std. Dev.	N	Mean/ Share	Median	Std. Dev.
subsidized plants								
plant characteristics								
size of the plant								
< 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 plant								
young plant (< 10 years)	211	42.80			277	40.26		
established plant (>= 10 years)	282	57.20			411	59.74		
sector of the plant (5 largest 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		
non-subsidized plants								
plant characteristics								
size of the plant								
< 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 plant								
young plant (< 10 years)	5,972	53.04			4,084	40.96		
established plant (>= 10 years)	5,288	46.96			5,886	59.04		
sector of the plant (5 largest 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 2: **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		

project of less than 1 million €. Eligible costs of the projects amounted to about 85 percent of the median investment costs in both years. The extension of an existing establishment was the most common kind of subsidized investments and its share increased from 56 percent in 2007 to 65 percent in 2013. The importance of subsidizing the settlement of new establishments grew over the funding period from one to 18 percent. The opposite can be stated for diversification investments. Their share declined from about 30 percent in 2007 to about 22 percent in 2013.

5 Special features of the estimation approach

Our data base consists of an unbalanced panel for the years 2004-2014 with varying dates of application for investment subsidies, different durations from application to the start of the project as well as different project durations. That means that within the funding period, the treatment phase of plant 1 can be the pre-treatment phase of plant 2 and the post-treatment phase of plant 3. The year 2014 consists of a mix of treatment phases and post-treatment phases. All in all, we observe treatments with individual treatment starts and durations. Furthermore, our sample of treated plants represents a very special subgroup of the plants in Saxony Anhalt (see chapter 4.2). As a result, we need an extraordinary flexible approach to handle the special features of our data.[15]

As a starting point we use the nonparametric conditional difference-in-difference approach introduced by HECKMAN *et al.* (1997, 1998). It combines a difference-in-difference estimation and matching.[16] Within the framework of this model, the mean difference between the development in employment Y in the treated plants i and their controls j are compared to estimate the average treatment effect for the treated ATT:

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

Different from the standard model, we include individual application dates and project durations. In equation 1, the individual application date of a treated plant i is denoted by t_{0i}, β_i is a flexible number of months that depends on the individual duration from application to outcome observation. For every plant, we observe two different 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 different 'waiting phases', these periods are heterogeneous among the treated plants.

In order to consider the special characteristics of our observed treated plants, we do not compare the treated plants with the whole sample of non-subsidized plants. Instead, we include a matching process as a kind of data preprocessing in the sense of HO *et al.* (2007) leading to more reliable causal effect estimates. As already mentioned above, one of the main challenges for the applied matching process is to adequately deal with the time varying variables. The special observation period (namely, the financial crisis and the resulting economic changes) makes apparent that we have to be sure to exclude potential 'time bias' resulting from comparing

[15] A more detailed discussion of the typical data structure, resulting special requirements for the estimation and a more comprehensive description of the developed approach can be found in our technical companion paper. See DETTMANN *et al.* (2018).

[16] For a detailed description of this approach see ABADIE (2005) or BLUNDELL and COSTA DIAS (2000).

plants at different points in time. That means, we have to incorporate the time information from the panel data into the matching process. Hence, we develop a sequential matching process that incorporates the observation date of all matching variables and the outcomes.[17] In a pre-selection process, we limit the set of potential partners for every treated plant to those observed just at the individual application date. Then the matching algorithm selects sequentially statistical twins among these pre-selected plants. For instance, when a plant applies for investment subsidies in January 2007, we consider its characteristics in this month and can exactly assign a plant which has similar characteristics in January 2007.

Due to this iterative process, we cannot use the commonly applied Propensity Score estimate as the distance measure. Instead, we apply a combined statistical distance function that can be regarded as the weighted average of scale-specific distance functions. For our analysis, we combine the mean absolute difference for continuous and the generalized matching coefficient for categorical variables. Weighting the functions by the respective number of variables, the distance function for a treated plant i and a non-treated plant j can be described as follows:

$$Dist_{ij} = \frac{1}{N}\left[N_m \cdot AD_{ij} + N_n \cdot (1 - GMC_{ij})\right]. \tag{2}$$

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 with $N = N_m + N_n$, where N_m is the number of continuous variables and N_n that of the categorical ones. The mean absolute difference of the continuous variables AD_{ij} is calculated as:

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

[17]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 our approach with this Mahalanobis-Nearest Neighbor matching shows that our newly developed algorithm produces better (in the sense of 'more similar') control groups. One reason for that can be seen in the consideration of the different scales of the matching variables in our approach. See also DETTMANN *et al.* (2011).

where || denotes absolute values, and $diff_{max}(x_n)$ is the maximum observed difference of variable x_n. The generalized matching coefficient of the categorical variables GMC_{ij} can be defined as the share of covariates with equal values:

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

Following theoretical considerations, we choose plant characteristics and regional information described in section 4.2 for the matching process. In order to consider the common trend assumption, we further include the employment development before application. We observe the absolute difference in FTEs between two years and six months before application for the subsidized plants and the respective difference for potential partners. We exclude the development from six months before application until application to consider a potential Ashenfelter's dip resulting from anticipation of the treatment. As the treated plants must be observable at least two years before they apply for GRW subsidies, plants setting up their business are excluded from the sample.

6 Results in absolute and standardized figures

We analyze the employment effects of investment subsidies in Saxony-Anhalt at the micro level for the funding period 2007-2013. In the following, we present estimation results for the whole sample and the analyzed subsamples in terms of absolute figures as well as the effect related to the amount of the subsidy.[18] With the presented results we can answer two questions. First, we know how many jobs are created as a result of the funding in absolute terms. And second, we can compare the size of the effects among the subsamples.[19]

[18]Additionally, we relate the absolute results to the initial plant size and the observation duration. Table 11 of the appendix provides the results in terms of differences in the relative employment development.

[19]As an additional information, we present the total amount of subsidy in the subsamples as well as the costs per additionally created job in table 10 of the appendix.

6.1 Short-term results

Overall, subsidized plants increase their employment by 3.40 full-time equivalents (FTEs), while comparable non-subsidized plants reduce employment by 0.36 FTEs in the short term, i. e. from application until one year after the funded projects started (see table 3). The average short-term employment effect amounts to 3.76 FTEs. Relating this absolute effect to the amount of about 316 million € subsidy totally paid for the analyzed projects (see table 10), the average standardized short-term effect per 100.000 € is about 0.5 FTEs.

With regard to the economic sector we observe the largest effects in the sectors production and maintenance of electrical equipment, machinery and computers as well as trade, repair, transport and ICT.[20] Here, the absolute effects are with about 8 FTEs more than twice as high as the average, the standardized effects are almost three times the average (1.5 and 1.4 FTEs per 100.000 €, respectively).[21] Obviously, these two industries are capable to set up physical capacities very fast compared to other industries (e. g. petroleum processing, chemistry and pharmaceutics sector).[22] The absolute effect in the petroleum processing, chemistry and pharmaceutics sector is with 5 FTEs also above the average, but in this sector, the amount of subsidy per job is with 253.000 € comparatively high (the average is 186.000 €), so that the standardized effect is below the average, with 0.4 FTEs per 100.000 €Ḟor metal production we even observe a negative employment effect of -0.36 FTEs in the short run.

With regard to the size of the subsidized plants, our results confirm the presumption of an influence of plant size on the effect in absolute figures. The absolute effect in very small plants is less than a half of the average, with 1.5 FTEs, whereas the effect in medium sized plants is about twice as high as the average, with 7.7 FTEs. The opposite is true for the standardized effects: the effect in very small plants is about twice the average, with 0.98 FTEs per 100.000 € the effect size of 0.51 FTEs

[20] Table 3 contains the results for the five biggest aggregated sectors. The results cover more than three third of the analyzed plants in the sample. For an overview of the aggregation see table 9 in the appendix.

[21] This results from the comparatively small amounts of total subsidy in these sectors (33 million and 25 million €, respectively), see table 10.

[22] Particularly, warehouses and distribution centers in the logistics industry can be built with the help of pre-fabricated and standardized blocks at relative low costs.

Table 3: **Short-term effects of GRW on employment**

	N	Difference in FTE[1] Treated	Difference in FTE[1] Controls	Diff-in-Diff (FTE[1]) absolute	Diff-in-Diff (FTE[1]) standardized[2]
full sample	904	3.40	-0.36	3.76***	0.54
sector					
metal production	264	-0.30	0.06	-0.36***	-0.09
electrical equipment[3]	120	6.34	-1.79	8.13***	1.47
wooden products, glass[4]	126	3.13	-0.06	3.19**	0.43
petroleum processing[5]	120	5.99	0.98	5.01***	0.40
trade, repair, transport, ICT	88	7.50	-0.46	7.96***	1.39
plant size					
very small (< 10 FTE)	230	1.31	-0.21	1.52***	0.98
small (≥ 10 and < 50 FTE)	404	2.52	-0.34	2.86***	0.85
medium (≥ 50 and < 250 FTE)	236	7.45	-0.25	7.70***	0.51
large (≥ 250 FTE)	34	-0.05	-2.24	2.19	0.07
plant age					
young plants	318	5.33	0.86	4.47***	0.56
old plants	586	2.34	-1.02	3.36***	0.52
employee structure					
low share of high qualified	436	3.26	-0.18	3.44***	0.86
high share of high qualified	468	3.53	-0.52	4.05***	0.40
low share of medium qualified	452	3.87	-0.01	3.88***	0.58
high share of medium qualified	452	2.92	-0.71	3.63***	0.50
low share of young employees	422	2.41	-0.14	2.55***	0.40
high share of young employees	482	4.26	-0.54	4.80***	0.69
regional characteristics					
urbanised regions	234	4.85	-0.77	5.62***	0.70
rural regions	670	2.89	-0.21	3.10***	0.47
region with low unemployment	504	2.58	0.21	2.37***	0.34
region with high unemployment	400	4.43	-1.07	5.50***	0.79
region with low R&D employment	454	4.88	-0.48	5.36***	0.78
region with high R&D employment	450	1.90	-0.23	2.13***	0.30
application year					
2007	224	6.18	-0.39	6.57***	1.25
2008	130	3.91	-0.88	4.79***	0.57
2009	118	1.51	0.51	1.00**	0.12
2010	172	3.73	0.12	3.61***	0.49
2011	138	4.40	-0.13	4.53**	0.57
2012	52	2.43	0.31	2.12	0.55
2013	40	-10.89	-5.26	-5.63***	-0.85

Notes: (1) Full Time Equivalents; (2) per 100.000 € subsidy; (3) Production and maintenance of electrical equipment, machinery and computers; (4) Production of furniture, wooden products, glass and ceramics; (5) Petroleum processing, chemistry and pharmaceutics.

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

per 100.000 € in medium-sized plants corresponds to the average. This points to a correlation between plant size and the size of the subsidy. A closer look at the size of the subsidy per job also confirms this presumption: the subsidy per job in very small plants is about half the size of that in medium sized plants, with about 101.000 € and 197.000 € respectively (see table 10 in the appendix). The short-term results reveal a hint for a weak influence of the plant age on the employment effect. In absolute terms, younger plants positively deviate from the average; older ones slightly negative (4.5 FTEs and 3.3 FTEs, respectively).

Plants with a relatively high share of high qualified employees[23] have a slightly above average absolute effect (with about 4 FTEs), but related to the amount of subsidy (221 million total subsidy), the effect is below the average, with 0.4 FTEs per 100.000 €In contrast, in plants with a lower share of high qualified employees (3.4 FTEs and 0.86 FTEs per 100.000 €) the effect is slightly lower than the average. With regard to the share of medium qualified employees, the deviation from the average is rather small. The impact of a high share of young employees in a plant[24] is positive in terms of absolute figures (4.8 FTEs) as well as related to the amount of the subsidy (0.7 FTEs per 100.000 €).

The employment effect in urban regions is larger than in rural regions. Both, the absolute and the standardized effects are above average (5.6 FTEs and 0.7 FTEs per 100.000 €, respectively). This confirms the expected positive influence of agglomeration from the theory. In addition, the GRW subsidy has a larger effect in regions with a high unemployment rate[25] in terms of the absolute effect (5.5 FTEs) as well as the standardized effect (0.8 FTEs per 100.000 €). This result is also in line with theoretical considerations on the use of activating underutilized input factors. On the contrary, in regions with a relatively high share of R&D employment[26] we find below average effects, with 2.1 FTEs and 0.3 FTEs per 100.000 € subsidy. If we relate this observation to the amount of subsidy per job, we observe that the jobs created in these regions are much more expensive (333.000 € vs. 128.000 € in

[23]The terms 'high' share and 'low' share mean that the share of high qualified employees is above or below the median of 1.59 percent.

[24]'High' means a share above the median of 21.4 percent, 'low' means below the median.

[25]That means, above the median unemployment rate of 13.7 percent.

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

regions with low R&D employment). This counter-intuitive result might be related to the overall low endowment with (private) R&D personal across the five Federal States in East Germany.

Due to the fact that employment development is analyzed in a time period with pronounced changes in the economic environment, we also differentiate the effect by the years of application. Here, the influence of the financial crisis clearly becomes visible. For projects started before the crisis had arrived in real economy (2007 and 2008), the comparatively large positive employment effects of 6.6 and 4.8 FTEs mainly result from the job creation in the subsidized plants and a negative employment development in comparable non-subsidized plants during the crisis.[27] For the following two years (2009 and 2010), employment development is positive but small in both groups, resulting in relatively small employment effects of 1 and 3.6 FTEs in absolute terms and 0.12 and 0.49 related to the amount of the subsidy. Afterwards, for projects started in 2011, the employment effect rises again to a level of 4.5 FTEs.

6.2 Mid-term results

The mid-term results, the employment development until one year after the funded projects finished, are presented in table 4. In the medium run, the average absolute effect is even larger than in the short run (with 6.36), primarily driven by the increase in employment by 6.02 FTEs in the subsidized plants (see table 4). Also the standardized mid-term effect is nearly twice as high as in the short-term, with about 1 FTE per 100.000 € subsidy.[28]

Compared to the short-term results, we find some interesting changes in the findings on the influence of individual plant characteristics. Considerable changes appear with regard to the economic sector. In the medium run the effect in metal

[27] Our definition of short-term effects as the employment development from application to one year after project start implies the observed development is only slightly longer than twelve months and thus is strongly influenced by the crisis prevalent in 2008 and 2009.

[28] The amount of 251.000 € subsidy totally paid for the analyzed projects (table 10) differs from the short-term one, because due to the longer observation period our sample reduces from 904 to 780 observations.

Table 4: **Mid-term effects of GRW on employment**

		Difference in FTE[1]		Diff-in-Diff (FTE[1])	
	N	Treated	Controls	absolute	standardized[2]
full sample	780	6.02	-0.34	6.36***	0.99
sector					
metal production	238	3.03	1.32	1.71***	0.54
electrical equipment[3]	106	3.36	-0.99	4.35***	0.84
wooden products, glass[4]	108	8.01	-4.19	12.20***	1.95
petroleum processing[5]	100	16.39	0.82	15.57***	1.71
trade, repair, transport, ICT	62	9.97	0.60	9.37***	1.76
plant size					
very small (< 10 FTE)	206	2.02	-0.30	2.32***	1.61
small (≥ 10 and < 50 FTE)	342	3.54	-0.79	4.33***	1.69
medium (≥ 50 and < 250 FTE)	202	11.54	2.28	9.26***	0.63
large (≥ 250 FTE)	30	24.57	-13.07	37.64	1.30
plant age					
young plants	272	8.92	4.53	4.39***	0.62
old plants	508	4.47	-2.94	7.41***	1.22
employee structure					
low share of high qualified	370	4.02	1.28	2.74***	0.73
high share of high qualified	410	7.92	-1.80	9.72***	1.08
low share of medium qualified	392	5.61	-0.40	6.01***	0.97
high share of medium qualified	388	6.44	-0.28	6.72***	1.01
low share of young employees	364	6.81	-1.78	8.59***	1.30
high share of young employees	416	5.33	0.92	4.41***	0.60
regional characteristics					
urbanised regions	198	9.02	-3.08	12.10***	1.51
rural regions	582	5.00	0.59	4.41***	0.75
region with low unemployment	408	7.11	1.22	5.89***	0.90
region with high unemployment	372	4.82	-2.04	6.86***	1.09
region with low R&D employment	396	8.06	-0.35	8.41***	1.31
region with high R&D employment	384	3.92	-0.33	4.25***	0.66
application year					
2007	222	2.65	-1.37	4.02***	0.96
2008	130	7.80	-0.36	8.16***	0.97
2009	116	9.18	4.73	4.45**	0.48
2010	158	7.25	0.50	6.75***	1.13
2011	102	6.37	-3.52	9.89**	1.51
2012	26	2.85	0.42	2.43***	2.22

Notes: (1) Full Time Equivalents; (2) per 100.000 € subsidy; (3) Production and maintenance of electrical equipment, machinery and computers; (4) Production of furniture, wooden products, glass and ceramics; (5) Petroleum processing, chemistry and pharmaceutics.

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

production is positive, but remains with 1.7 FTEs very small. Also the effect related to 100.000 € subsidy is with 0.5 only about half of the average standardized effect. Thus, created jobs in this sector are comparably expensive (see also table 10). The comparatively large short-term effects in the production and maintenance of electrical equipment, machinery and computers sector change to below-average employment effects in the medium run. The effects in the sectors of production of furniture, wooden products, glass and ceramics as well as petroleum processing, chemistry and pharmaceutics, remarkably increase compared to the short run. The absolute employment effects (12 FTEs and 15 FTEs respectively), as well as the standardized effects with about 1.9 and 1.7 are far above the average. A possible explanation for the strength of the effect might be connected to the presumably large plant size and indivisible inputs in the mentioned sectors, that enable plants to exploit economies of scale. The findings for the trade, repair, transport and ICT sector do not change considerably; also for the medium run, the effect remains above average.

The comparison of the sector specific results reveal that different production functions/regimes in the different economic sectors imply job creation at different points of the investment process. For instance, employment effects in the trade, repair, transport and ICT sector show up relatively early, whereas the effects e. g. in the petroleum processing, chemistry and pharmaceutics are observable later. This confirm the importance of considering heterogeneity as well as defining the outcome observation period in relation to the treatment as exactly as possible.

The observed impact of plant size (and the corresponding influence of the amount of the subsidy) on the short-term employment effect is confirmed in the mid-term results. Again, the effect in terms of absolute figures e. g. in very small plants is less than a half of the average (2.3 FTEs), in medium sized plants above the average (9.3 FTEs). Considering the amount of the subsidy leads to reverse results. The effect in small and very small plants is now quite above the average (1.7 and 1.6 FTEs per 100.000 € respectively), whereas the effect in medium-sized plants is smaller than the average (0.63 FTEs per 100.000 €).

For plant age we now observe a larger employment effect in older plants. Interestingly, the effect in younger plants is similar to the observed short-term effect, but subsidized older plants create slightly more jobs in the medium run whereas in comparable non-subsidized plants employment is (even more) reduced, resulting in an employment effect of 7.4 FTEs. These findings are also in line with the theoretical literature as incumbents might achieve a higher point at their learning-curve.

In the medium run, we also find support for the presumed influence of the employee structure on the strength of the effect. Different from the short-term results, the effect in plants with a high share of high qualified employees is above the average and stronger than in plants with less high qualified employees (9.7 FTEs absolute and 1.1 FTEs per 100.000 € vs. 2.7 FTEs and 0.7 FTEs per 100.000 €). The effect in plants with a high share of young employees is about twice as high as the effect in plants with lower shares of young employees (8.6 FTEs vs. 4.4 FTEs and 1.3 vs. 0.6 FTEs per 100.000 €, respectively). The share of medium qualified employees again has no noteworthy impact on the strength of the employment effect.

With regard to regional characteristics, the observed pattern in the short-term results remains stable. Also in the medium run, we observe larger effects in urbanized regions (12.1 FTEs compared to 4.4 FTEs in rural regions) and in regions with relatively high unemployment rates (6.9 FTEs vs. 5.9 FTEs). Also the smaller number of additionally created jobs in regions with a high share of R&D employment (2.1 FTEs vs. 5.3 FTEs) – which are more expensive (152.000 € vs. 76.000 €, see table 10) – we observe in the medium run. One could expect that the jobs created in these regions are presumably of higher quality.

The time dimension of the subsidy basically shows the same pattern as for the short-term results. Again, the size of the effects are largely explained by the changing behavior of non-subsidized plants over time. While subsidized plants created jobs during and after the crisis (to smaller or larger extent), the employment development in comparable non-subsidized plants was negative during and positive after the crisis. However, the impact of the crisis is not as apparent as in the short run, because the observed employment development from application until one year after finishing the projects covers on average a period of three years.[29] This implies that

[29]From the descriptive statistics we know, that the mean project duration is about 24 months, see table 2).

for project applications in the years 2007 to 2009, the influence of the economic crisis is mixed with the influence of the economic recovery from 2010 onwards.

By and large, the estimated positive effects of investment subsidies on employment development are in line with the findings in former studies, not only for Germany, but also for other European countries. For instance BERNINI and PELLEGRINI (2011), CERQUA and PELLEGRINI (2014) and PELLEGRINI and CETRA (2006) also find positive effects of Italy's Law 488/1992 on employment growth. Similarly, CRISCUOLO *et al.* (2016) observe positive effects of the Regional Selective Assistance in UK, but mainly on employment development in small and medium sized plants. Particularly for the German GRW, BADE and ALM (2010) also find positive effects on employment development for the 2001–2006 funding period. Consistent with our results, they find employment effects of different extent depending on the year of the treatment. In a subsequent study, BADE (2013) finds no hint for an influence of the plant size on the estimated employment effect. In this point, our heterogeneous results with regard to plant size deviate from the literature for Germany, but largely correspond to the European studies of BERNINI and PELLEGRINI (2011) and CRISCUOLO *et al.* (2016).

7 Quality and Robustness checks

7.1 Quality checks

In the following, we present the results of different quality checks for our estimations. The verification of the balancing property concentrates on two criteria: first, the closeness of the means in the treated and in the control group, and second, the balance of the distributions as a whole.[30] Following HO *et al.* (2007), 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, one needs a better balance.

[30] HO *et al.* (2007) recommend different checks of the quality of the results, because matching requires multivariate balance of the variables, and the available tests are only one-dimensional. For a more detailed discussion 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 plant					
< 10 FTEs[2]	25.44	26.55	-1.11		
>= 10 FTEs and < 50 FTEs	44.69	45.35	-0.66		
>= 50 FTEs and < 250 FTEs	26.11	25.00	1.11		
>= 250 FTEs[2]	3.76	3.10	0.66		
age of the plant					
young plant	35.18	35.40	-0.22		
established plant	64.82	64.60	0.22		
sector of the plant (5 largest sectors)					
metal production	29.20	29.20	0.00		
production and maintenance of electrical equipment, machinery and computers	13.27	13.27	0.00		
production of furniture, wooden products, glass and ceramics	13.94	13.94	0.00		
petroleum processing, chemistry and pharmaceutics	13.27	13.27	0.00		
trade, repair, transport, ICT	9.73	9.73	0.00		
share of high qualified	7.01	6.38	0.63	11.64	fulfilled
share of medium qualified	60.78	62.97	-2.19	28.75	fulfilled
share of young employees	24.16	21.64	2.52	15.39	fulfilled
employment difference	4.25	2.25	2.00	14.79	fulfilled
unemployment rate in the region	13.61	13.60	0.01	2.50	fulfilled
R&D employment share in the region	0.05	0.05	0.00	0.03	fulfilled
type of region					
urbanised region	25.88	25.44	0.44		
rural region	74.12	74.56	-0.44		
mid-term effect					
size of the plant					
< 10 FTEs[2]	26.41	27.44	-1.03		
>= 10 FTEs and < 50 FTEs	43.85	44.10	-0.25		
>= 50 FTEs and < 250 FTEs	25.90	25.13	0.77		
>= 250 FTEs[2]	3.85	3.33	0.52		
age of the plant					
young plant	34.87	34.87	0.00		
established plants	65.13	65.13	0.00		
sector of the plant (5 largest sectors)					
metal production	30.51	30.51	0.00		
production and maintenance of electrical equipment, machinery and computers	13.59	13.59	0.00		
production of furniture, wooden products, glass and ceramics	13.85	13.85	0.00		
petroleum processing, chemistry and pharmaceutics	12.82	12.82	0.00		
trade, repair, transport, ICT	7.95	7.95	0.00		
share of high qualified	7.22	6.40	0.82	12.05	fulfilled
share of medium qualified	61.27	64.34	-3.07	28.29	fulfilled
share of young employees	24.40	21.48	2.92	15.46	fulfilled
employment difference	4.08	2.29	1.79	14.92	fulfilled
unemployment rate in the region	13.86	13.87	-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	25.38	24.87	0.51		
rural region	74.62	75.13	-0.51		

Note: [1] Standard deviation in the sample.

Table 5 presents the means in the two groups, the difference between them, and the quality criterion. In addition, we provide the share of observations in the respective categories of our categorical matching variables. The means of all continuous variables are very similar and fulfill the quality requirement of Cochran (1968). The distribution of the values of the categorical variables is also very similar between the treated and the control plants. For both the short-term and the mid-term effect, the comparison of the variable means, or value shares, confirms the required balancing property of the matching algorithm.

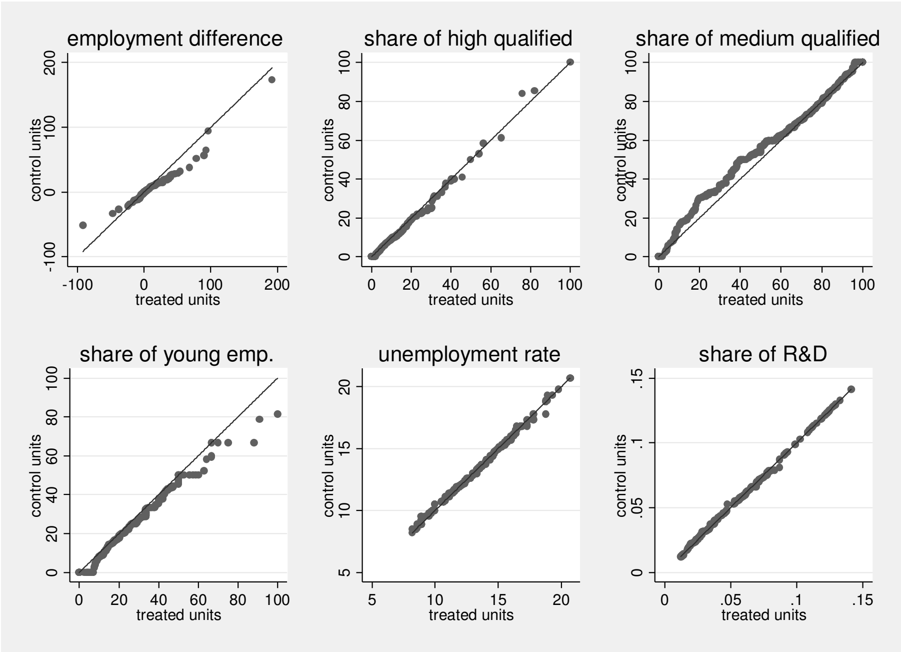
As is recommended by Ho *et al.* (2007), we additionally calculate distribution tests and quantile-quantile-plots to verify if the variable distributions between the group of the treated plants and the controls are balanced. Table 6 contains the results of Kolmogorov-Smirnov-tests for continuous and χ^2-tests for the categorical variables. They also confirm the quality of the matching. Neither for the short-term nor for the mid-term effect we find significant differences in the distribution of the matching variables between the treated and the control plants.

Table 6: **Results of Kolmogorov-Smirnov-Test and χ^2-Test**

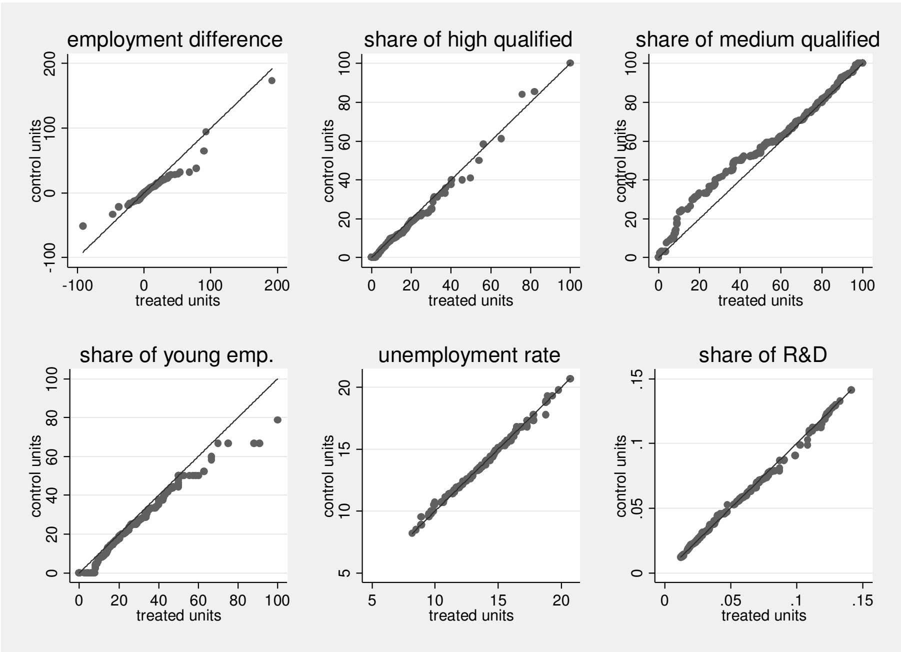
	short-term effect		mid-term effect	
Variable	D / χ^2	p-value	D / χ^2	p-value
size of the plant	0.53	0.913	0.27	0.966
age of the plant	0.00	0.945	0.00	1.000
sector of the plant	0.00	1.000	0.00	1.000
share of high qualified	0.07	0.180	0.08	0.170
share of medium qualified	0.07	0.180	0.08	0.199
share of young employees	0.08	0.133	0.08	0.123
employment difference	0.13	0.001	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

This is also obvious in a graphical comparison of the variable distributions. The quantile-quantile-plots in figure 2 compare the quantiles in the treated group with those of the control group for each continuous variable. The 45°-line represents identical distributions. The distribution of all checked variables is very similar in the two groups with only slight deviations from the 45°-line.

In addition, we apply the commonly used verification tools given in *pstest* (Leuven and Sianesi, 2003) (t-tests, standardized percentage bias and variance ratios of the



short-term effect



mid-term effect

Figure 2: *QQ-Plots of continuous variables*

matching variables) as proxies for the balance of the variable distributions.[31] By

[31]Since our variables are not normally distributed and the standardized bias and variance ratio have only meaningful interpretations for the continuous variables, we regard these measures more as useful supplementary information for the presented quality checks.

and large, the results in table 7 confirm the other presented quality checks. The results of the t-tests and the percentage bias for the matching variables point to similar means in the two groups. The variance ratios have mostly values near one, indicating similarity of the variable variances between treated and control plants.[32]

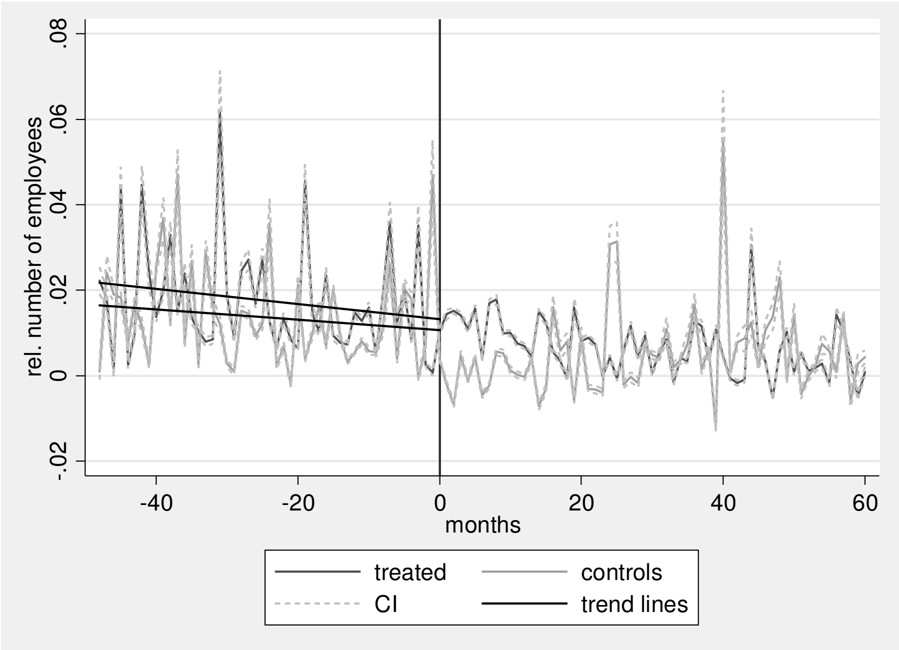
Table 7: **Results of pstest**

Variable	Mean		% Bias	t-test		V(T) /
	treated	control		t	p-value	V(C)
short-term effect						
size of the plant	2.08	2.05	4.4	0.66	0.509	1.03
age of the plant	1.65	1.65	0.5	0.07	0.945	1.00
sector of the plant	104.40	104.40	0.0	0.00	1.000	1.00
share of high qualified	7.01	6.38	5.4	0.81	0.416	1.03
share of medium qualified	60.78	62.97	-7.6	-1.14	0.253	1.09
share of young employees	24.16	21.64	16.4	2.47	0.014	1.13
employment difference	4.25	2.25	13.5	2.03	0.043	1.68*
unemployment rate in the region	13.61	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						
size of the plant	2.07	2.04	3.5	0.48	0.630	1.02
age of the plant	1.65	1.65	0.0	0.00	1.000	1.00
sector of the plant	104.06	104.06	0.0	0.00	1.000	1.00
share of high qualified	7.22	6.40	6.8	0.96	0.339	1.07
share of medium qualified	61.27	64.34	-10.9	-1.52	0.130	1.13
share of young employees	24.41	21.48	19.0	2.65	0.008	1.15
employment difference	4.08	2.29	12.0	1.68	0.094	1.61*
unemployment rate in the region	13.86	13.87	-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

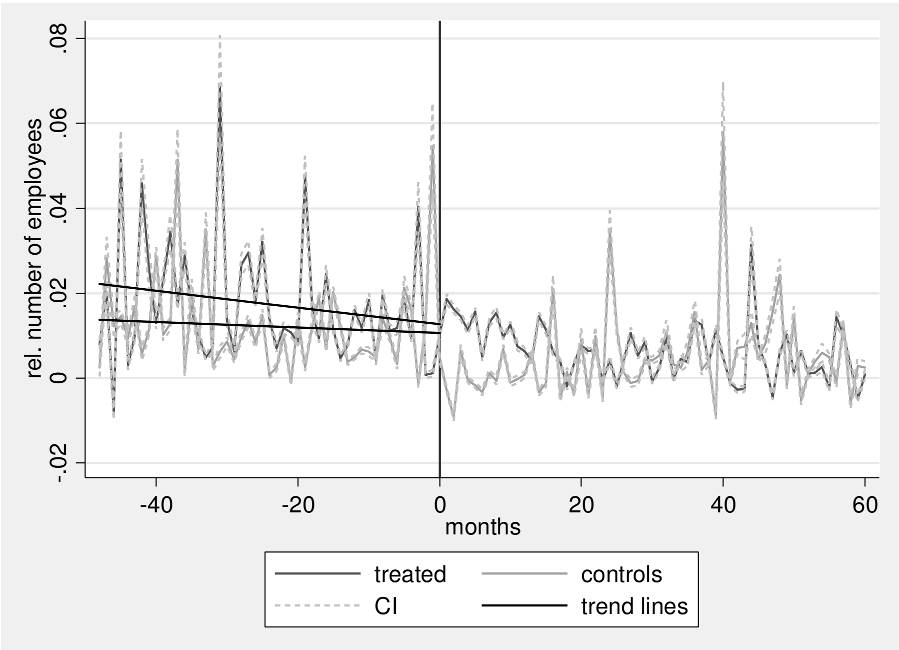
Notes: * variance ratio exceeds Austins rule of thumb.

As a last step, we graphically verify the common trend assumption. This key assumption for difference in difference requires that the plants in both groups would have the same behavior if the treated plants had not been subsidized. We examine the common trend assumption in the usual way. Looking at the relative employment development within the two groups before the treatment starts. Figure 3 shows the monthly employment change. The vertical line denotes the time of application for subsidies. As can be observed, there is a large variation in the monthly employment

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



short-term effect



mid-term effect

Figure 3: *Monthly employment change*

growth for both the treated and the control plants. However, the trends are nearly identical for the plants in the two groups with regard to the short-term effect. For the mid-term effect we find a slight decrease in the trend line of treated plants from about 0.02 FTEs to about 0.015 FTEs whereas the trend line for the control plants is nearly horizontal at 0.015 FTEs. Nevertheless, the employment development is very similar before application. Summing up the results of the quality checks, we conclude that the presented results in chapter 6 are reliable.

7.2 Robustness checks

Table 8 provides the estimation results for the absolute employment effects resulting from four alternative matching algorithms. They serve as a robustness check for the assignment process and the distance measure.

Table 8: **Results using different matching algorithms**

	treated	controls	absolute difference
Nearest neighbor matching with ties			
short-term effect	3.40	-0.34	3.74
mid-term effect	6.02	-0.32	6.34
Radius matching with small radius			
short-term effect	3.40	-0.00	3.40
mid-term effect	6.02	-0.13	6.15
Radius matching with wide radius			
short-term effect	3.40	-0.02	3.42
mid-term effect	6.02	-0.10	6.12
Nearest neighbor matching with Mahalanobis distance			
short-term effect	2.47	0.95	1.52
mid-term effect	5.91	1.59	4.23

As can be observed, the results of the three alternative assignment processes (resulting in more than one statistical twin for the treated plants) are very similar to the results presented in chapter 6. For matching with an alternative distance measure, the Mahalanobis distance, we observe a smaller employment effect, but the effect is also positive. The difference in the magnitude may have various reasons. One of them could 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.[33]

[33] 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 our statistical distance function. The quality check of all the alternative algorithms is available upon request.

8 Conclusions

The paper analyzes the effects of the most important German regional policy program in the funding period of 2007-2013 in one of the most strongly subsidized Federal States, Saxony Anhalt. This time period is influenced by the financial crisis and the associated recession of the world economy as well as a sustainable economic upturn. In this situation it is particularly obvious that we have to control for potential time biases resulting from a comparison of plants at different points in time. To this end, we extend the standard matching and difference in difference approach and introduce flexible durations for observed outcome differences as well as the possibility to adequately consider time varying variables. The resulting approach is particularly useful for the evaluation of policy programs with (different) individual treatment phases within the funding period, e. g. subsidy schemes, training programs, but also EU research funding.

We analyze short-term and mid-term employment effects of GRW investment subsidies at the micro level. What is new compared to the existing literature is the comparability of the results due to considering the amount of the subsidy paid in each (sub-)sample. In the short run, subsidized plants increase their employment by 3.40 FTEs, while comparable non-subsidized plants reduce employment by 0.36 FTEs, resulting in an average short-term employment effect of 3.76 FTEs. Relating this absolute effect to the amount of the subsidy, the average standardized effect per 100.000 € is about 0.5 FTEs. In the medium run, the average absolute effect is even larger that in the short run (with 6.36 FTEs), primarily driven by the increase in employment by 6.02 FTEs in the subsidized plants. Also the standardized mid-term effect is nearly twice as high as in the short-term, with about 1 FTE per 100.000 € subsidy.

New as well in the paper is the explicit consideration of the heterogeneity of the subsidized plants and their economic environment. All in all, we find positive and remarkably heterogeneous effects among the subsamples. With regard to economic sector, the smallest – and most expensive – effects we find in the metal production sector. Stable above average effects we observe in the trade, repair, transport and ICT sector. We also find a stable pattern regarding the influence of plant size (and the amount of subsidy) on the employment effects: whereas the absolute effect becomes larger with plant size, the opposite is true for the effect related to the amount of the subsidy. The influence of regional characteristics is similar in the short and medium run, too. In urbanized regions and regions with a relatively high unemployment rate the effect is larger. In regions with comparatively more R&D employment, the created jobs are fever and more expensive than in regions with less employees in R&D. With regard to the influence of timing of the treatment, the heterogeneous employment effects for the different years of application clearly show the impact of the economic changes during the observation period.

The presented results prove that heterogeneity in individual plant characteristics, economic environment and timing of the treatment influence the strength of the employment effect – as is presumed from theoretical considerations. It also becomes clear that the choice, or better the definition, of the outcome influences the findings regarding comparisons among different subsamples. Furthermore, divergent results for short and medium run show that it makes a difference at which point of time related to the treatment we observe the outcome – and confirm the necessity of defining this point as exactly as possible. Moreover, the heterogeneous effects over time clearly confirm the importance of exactly determining the point in time a plant is compared to its statistical twin in order to exclude potential 'time biases'.

In addition, the results show that having a closer look at the quality of the created jobs (e. g. in terms of qualification requirements or earnings) can help to learn if observed differences in the standardized effects are correlated with quality aspects of the employment. Another interesting aspect could be to investigate if the effects of GRW subsidies are persistent over time. Of particular interest is the employment development after finishing the commitment period of 5 years. Unfortunately, our observation period is still too short to consider such long-term effects. Considering the effects on further economic outcomes like investments, turnover and productivity of the treated plants could also complete the picture of microeconometric effects of GRW investment subsidies in Germany. In a companion study, we will use the official Company Data for Germany (AFiD) of the Federal Statistical Office and the Statistical Offices of the Laender to estimate the GRW effect on alternative outcomes.

A promising path for future research as well is to analyse the reduction of employment in non-subsidized plants. This may suggest intra-regional displacement effects, which are also presumed in the study of Bade and Alm (2010). Analyzing employees' labor market biographies is one of our future research projects in order to confirm or rebut the presumption of intra-regional displacement effects.

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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: Bechmann *et al.* (2014) and Fischer *et al.* (2009); own summary.

Table 10: **Amount of the subsidy in the subsamples, total and per job created**

	short-term effect			mid-term effect		
	N	total subsidy	subsidy per job	N	total subsidy	subsidy per job
full sample	904	316,000,000	186,191	780	251,000,000	101,122
metal production	264	55,400,000	-1,154,526	238	37,700,000	184,559
electrical equipment[(1)]	120	33,100,000	67,960	106	27,500,000	119,242
wooden products, glass[(2)]	126	46,900,000	233,814	108	33,800,000	51,358
petroleum processing[(3)]	120	76,100,000	252,897	100	66,400,000	85,375
trade, repair, transport, ICT	88	25,200,000	71,949	62	16,500,000	56,960
very small plant ($<$ 10 FTE)	230	17,800,000	101,727	206	14,800,000	61,990
small plant ($\geq$ 10 and $<$ 50 FTE)	404	67,200,000	116,990	342	43,800,000	59,145
medium sized plant($\geq$ 50 and $<$ 250 FTE)	236	180,000,000	197,733	202	149,000,000	158,905
large plant ($\geq$ 250 FTE)	34	51,000,000	1,367,393	30	43,500,000	77,012
young plant	318	127,000,000	178,445	272	97,100,000	162,486
old plant	586	189,000,000	191,785	508	154,000,000	81.649
low share of high qualified employees	436	94,700,000	116,381	370	67,300,000	136,733
high share of high qualified employees	468	221,000,000	250,571	410	183,000,000	92,298
low share of medium qualified employees	452	152,000,000	173,905	392	120,000,000	103,868
high share of medium qualified employees	452	163,000,000	199,312	388	130,000,000	98,710
low share of young employees	422	166,000,000	252,099	364	140,000,000	76,993
high share of young employees	482	150,000,000	144,475	416	111,000,000	167,465
urbanised region	234	93,700,000	142,484	198	79,400,000	66,310
rural region	670	220,000,000	213,861	582	171,000,000	133,646
region with low unemployment	504	176,000,000	295,038	408	134,000,000	110,986
region with high unemployment	400	140,000,000	127,235	372	117,000,000	91,818
region with low R&D employment	454	156,000,000	128,279	396	126,000,000	76,057
region with high R&D employment	450	159,000,000	333,903	384	124,000,000	152,054
application in 2007	224	57,900,000	79,757	222	54,800,000	103,635
application in 2008	130	55,400,000	175,653	130	55,400,000	102,989
application in 2009	118	57,700,000	825,349	116	54,300,000	209,893
application in 2010	172	64,700,000	205,047	158	49,500,000	88,316
application in 2011	138	54,600,000	173,957	102	33,500,000	66,206
application in 2012	52	12,200,000	180,560	26	3,111,687	44,967
application in 2013	40	13,300,000	-118,343	.	.	.

Notes: [(1)] Production and maintenance of electrical equipment, machinery and computers; [(2)] Production of furniture, wooden products, glass and ceramics; [(3)] Petroleum processing, chemistry and pharmaceutics. Results significant on the level: *** p<0.01, ** p<0.05.

Table 11: **Estimation results related to plant size and project duration**

	short-term effect				mid-term effect			
	N	treated	controls	difference	N	treated	controls	difference
full sample	904	1.11	-0.12	1.23***	780	0.72	-0.11	0.83***
metal production	264	0.99	-0.09	1.08***	238	0.55	-0.08	0.63***
electrical equipment[(1)]	120	0.81	-0.22	1.03***	106	0.29	-0.13	0.42
wooden products, glass[(2)]	126	1.34	-0.16	1.50***	108	1.03	-0.27	1.30***
petroleum processing[(3)]	120	0.99	0.19	0.80***	100	0.73	0.00	0.73***
trade, repair, transport, ICT	88	1.88	-0.17	2.05***	62	1.48	-0.06	1.54***
< 10 FTEs	230	2.40	-0.19	2.59***	206	1.65	-0.21	1.86***
>= 10 FTEs and < 50 FTEs	404	0.80	-0.11	0.91***	342	0.45	-0.10	0.55***
>= 50 FTEs and < 250 FTEs	236	0.55	-0.11	0.66***	202	0.29	-0.04	0.33**
>= 250 FTEs	34	0.09	0.17	-0.08	30	0.21	0.04	0.17
young plants	318	1.81	0.03	1.78***	272	1.27	0.02	1.25***
old plants	586	0.74	-0.20	0.94***	508	0.42	-0.18	0.60***
low share of high qualified	436	1.66	-0.05	1.71***	370	1.04	-0.06	1.10***
high share of high qualified	468	0.60	-0.18	0.78***	410	0.42	-0.16	0.58***
low share of medium qualified	452	1.32	-0.01	1.33***	392	0.77	-0.11	0.88***
high share of medium qualified	452	0.91	-0.23	1.14***	388	0.66	-0.11	0.77***
low share of young employees	422	1.08	-0.03	1.11***	364	0.66	-0.09	0.75***
high share of young employees	482	1.14	-0.20	1.34***	416	0.76	-0.13	0.89***
urbanised regions	234	1.10	-0.12	1.22***	198	0.68	-0.34	1.02***
rural regions	670	1.12	-0.12	1.24***	582	0.73	-0.03	0.76***
region with low unemployment	504	1.11	-0.21	1.32***	408	0.87	-0.16	1.03***
region with high unemployment	400	1.12	-0.01	1.13***	372	0.55	-0.06	0.61**
region with low R&D employment	454	1.30	-0.10	1.40***	396	0.74	-0.14	0.88***
region with high R&D employment	450	0.93	-0.14	1.07***	384	0.69	-0.07	0.76***
application in 2007	224	1.31	0.13	1.18***	222	0.50	-0.04	0.54***
application in 2008	130	1.48	-0.40	1.88***	130	0.94	-0.08	1.02***
application in 2009	118	0.97	-0.25	1.22***	116	0.53	-0.16	0.69***
application in 2010	172	0.66	-0.14	0.80***	158	0.65	0.01	0.64***
application in 2011	138	1.01	-0.08	1.09***	102	0.72	-0.15	0.87**
application in 2012	52	0.89	-0.19	1.08*	26	0.80	-0.23	1.03***
application in 2013	40	1.46	-0.66	2.12**	.	.	.	.

Notes: [(1)] Production and maintenance of electrical equipment, machinery and computers; [(2)] Production of furniture,wooden products, glass and ceramics; [(3)] Petroleum processing, chemistry and pharmaceutics.

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

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