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Abstract

This paper estimates establishment-level employment effects of investment grants in one of the German Federal States receiving the most support. We analyze general treatment effects, as well as the influence of heterogeneity in the characteristics and economic environment of the establishment on its employment development. Modifying the standard matching and difference-in-differences approach, we develop a new procedure that is particularly useful for evaluating funding programs with individual treatment phases within the period of observation. Our data basis combines treatment-related, establishment-specific and regional information from different sources. The results suggest that investment grants have a positive influence on the development of employment in establishment in both absolute and standardized figures (i. e. in relation to the amount of subsidy received) – with considerable effect heterogeneity.

Zusammenfassung

Im vorliegenden Beitrag werden die Beschäftigungseffekte der Investitionsförderung für eines der am stärksten geförderten deutschen Bundesländer ermittelt. Wir analysieren dabei nicht nur die allgemeinen Effekte auf die Beschäftigungsentwicklung, sondern betrachten auch ihre Heterogenität bezüglich unterschiedlicher betrieblicher und umfeldbezogener Merkmale. Durch eine Modifizierung des Matching- und Differenz-in-Differenzen-Ansatzes entwickeln wir ein neues Verfahren zur Evaluation von Förderprogrammen, das die individuellen Förderphasen innerhalb der Beobachtungsperiode genau berücksichtigen kann. Unsere Datenbasis kombiniert dabei förderbezogene, betriebsbezogene und regionale Informationen unterschiedlicher Quellen. Die Ergebnisse zeigen, dass die Investitionsförderung einen positiven Einfluss auf die Beschäftigungsentwicklung in den Betrieben hat, sowohl in absoluter, als auch in einer standardisierten Betrachtung (d. h. in Bezug zur Höhe der Förderung) – mit erheblicher Effektheterogenität.

JEL classification: Z0, A11, D61, H20

Keywords: causal impact analysis, investment grants, matching, diffence-in-differences

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1 Introduction

The aim of the paper is to evaluate establishment-level employment effects of investment grants issued under the most important place-based policy regime in Germany. Regional policy schemes have been set-up all over the world. In the European Union, for example, a considerable share of the overall budget is allocated to such policy schemes, Euro 278 billion in the 2007–2013 funding period (Ciani/de Blasio, 2015). Beyond that, almost all member states offer national and regional policy programs including investment grants (Criscuolo et al., 2016). This type of policy is mainly designed to increase employment and productivity, particularly in disadvantaged areas (Neumark/Simpson, 2015).

The intention of such interventions is discussed in an ambiguous manner. Imperfect markets may justify the introduction of such programs in principle. The literature mainly highlights externalities, indivisible production factors, imperfect labor mobility, financial constraints as a consequence of asymmetric information, as well as regional equalization issues as rationales for such policy schemes (Neumark/Simpson, 2015; Calmfors/Forslund/Hemström, 2002). However, the literature also discusses several concerns regarding the implementation and possible side-effects of place-based policy programs, e. g. a lack of information about the type and magnitude of market failure or allocative inefficiencies due to rent seeking and rent shifting (Guerzoni/Raiteri, 2015; Neumark/Simpson, 2015; Calmfors/Forslund/Hemström, 2002).

The pros and cons discussed in the literature highlight the need for credible evaluation that addresses questions of weighing imperfect markets against government failures. As the main aim of place-based policy is to reduce spatial disparities, it makes sense to study its effects at the regional level. Recent empirical literature shows that investment grants in disadvantaged regions have causal effects on key figures of regional economic development, such as firm investments, employment, and productivity (de Castris/Pellegrini, 2012; Criscuolo et al., 2016; Dettmann/Brachert/Titze, 2016). However, an analysis at an aggregated level cannot address any impact channels through which the respective program affects regional economic development.

Our contribution to this discussion is to assess the impact of place-based policy schemes at the initial level of the intended development, namely establishments. In line with the theoretical literature we would expect individual establishment characteristics and the economic environment to influence the magnitude of the treatment effect. Despite the fact that heterogeneous treatment effects are an important issue, the empirical evidence is rather scarce in the literature so far. Our study serves as a first attempt to fill this gap. Our aim is not only to analyze whether or not investment subsidies work, but also to investigate where the program reveals its strongest effect and to contribute to a better understanding of what drives the effects. Compared to existing studies, our analysis provides a more precise and detailed insight into the effects of investment grants on employment. In addition, we relate the observed effects to the amount of the subsidy paid in the respective subsamples. Thus, we provide standardized employment effects in terms of additional employment per Euro 100,000 subsidy, which makes it possible to compare the subsamples. The subject of our analysis is mid-term employment effects of investment grants in one of Germany's most

disadvantaged regions, the federal state of Saxony-Anhalt.

The empirical analysis is based on a unique and innovative dataset. We enrich detailed administrative data on the funding process with employment and regional information. The establishment-level information reveals specific individual treatment phases within the funding period. That means we face different dates of application and varying treatment durations. In order to process the uniquely rich information and to take its special structure into account correctly, a particularly flexible estimation approach is required. Hence, we modify the standard matching and difference-in-differences approach in two ways. First, we replace the common propensity score for matching with a combined statistical distance function that takes time-varying variables adequately into consideration. Second, we introduce the opportunity to consider flexible durations of observed outcome differences. The estimated effects are average employment developments over establishment-specific durations from application until one year after the funded projects are completed. This approach ensures that individual treatment phases can be taken into account in an appropriate way and that the point in time at which an establishment is compared to its 'statistical twin' can be determined precisely.

Our results suggest that the program under analysis has a positive effect on employment development. Relating the absolute effect (+6.4 full-time equivalents) to the amount of subsidy received by the establishments, the average standardized effect is about 1 full-time equivalent per Euro 100,000 subsidy. The presented results also confirm the assumed influence of heterogeneity in the characteristics and environment of the individual establishments. For example, we find stronger effects for supported establishments in urban areas.

The remainder of the paper is organized as follows. The next section provides a short overview of the legal framework for the investment grants to be analyzed and the literature on the micro-level effects in theoretical and empirical studies. In the third section, the data and the analysis sample are described. Section four explains the characteristics of our estimation approach. In section five and six, 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 for further research.

2 Institutional framework and related literature

2.1 Institutional details of the program under analysis

Investment subsidies issued under the 'Joint Task for Improving Regional Economic Structures' (Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur" (GRW)) are the most important regional policy scheme in Germany (a detailed description of the program's characteristics can be found in tables A.2 and A.3 in the appendix). A total of about Euro 11.6 billion was spent on investment grants during the observation period 2007–2013 (Federal Office for Economic Affairs and Export Control, 2016). The program aims to reduce local disadvantages, tackle structural change, and foster aggregate regional economic growth in disadvantaged regions. In line with the legislation of the European Union,

the German Federal Government identifies eligible regions on the basis of an indicator to measure structural weaknesses. Firms in eligible regions may submit proposals for investment projects. The grant covers up to 50 percent of the eligible project cost for small firms. There are lower aid-ceilings for medium-sized and large firms (40 and 30 percent, respectively). The federal state in which the project is planned assesses all submissions with regard to the targets of the program, particularly the creation and safeguarding of jobs.[1]

2.2 Theoretical considerations and sources of heterogeneity

According to microeconomic theory, an investment subsidy reduces the marginal costs of physical capital, thus leading to labor being substituted by capital due to a change in the relative factor prices. Based on the concept of the production function, increased capital intensity leads to productivity growth (Varian, 1992). In cases with sufficiently elastic demand and relatively low substitution elasticities, the resulting output effect leads to an increase in both capital and labor. The opposite might occur if the substitution elasticities are high. Then the (negative) substitution effect may exceed the (positive) output effect even if aggregate demand is inelastic. Consequently, the number of jobs in the firm may decrease (Klodt, 2000; Criscuolo et al., 2016). In line with the employment target of the program analyzed, the outcome of interest is the development of employment in establishments receiving the grant.[2]

Why should the treatment effects of investment grants differ with heterogeneous firm characteristics? This question is closely related to the drivers of the firm's productivity. A productive firm is highly competitive and thus (under the assumption of sufficiently elastic aggregate demand) capable of increasing its output and growing more rapidly in terms of employment. Consequently, we pay close attention to factors driving the establishment's productivity. Following Syverson (2011) we differentiate between internal and external sources.

The first group comprises factors that directly improve productivity within the firm. Since the seminal work of Mincer (1962), the qualification levels and work experience of the workforce have been developed as standard proxies for a firm's human capital endowment. Recent empirical studies relate these factors to labor quality and explore their impact on productivity. For example, Ilmakunnas/Maliranta/Vainiomäki (2004) find for Finland that the average level of education and plant average age improve productivity. Productivity grows as a result of improvements in the production process and practical experiences/skills over time. The study by Fox/Smeets (2011) is in a similar vein. They show for the Danish economy that human capital inputs boost firm output considerably, but do not explain most of productivity differences across firms. Galindo-Rueda/Haskel (2005) conduct a similar study for England. They find that firms with a larger share of college-educated employees

[1] A description of the key figures of the GRW grants in the samples analyzed can be found in table A.1 in the appendix.

[2] Commonly the productivity effect of such interventions would be analyzed. Unfortunately, official German statistics only provide information on productivity for establishments employing more than 20 workers (e. g., the Official Firm Data for Germany [AFiD]). Firms below 20 employees that represent the lion's share of economic activity are excluded in this data.

are more productive. Moreover, they provide evidence of positive human capital externalities within a firm. According to the available data we consider employees' formal skill level and age (as a proxy for work experience) in our empirical analysis.

The second group considers a firm's economic environment and mutual interactions. There is a vast amount of empirical literature on the nature and sources of agglomeration economies.[3] Seminal works in this field are Glaeser et al. (1992) and Henderson/Kuncoro/Turner (1995). They can be regarded as attempts to measure the effect of agglomeration on productivity in an indirect way. Both the studies look at selected industries in the U.S. and find that agglomeration economies have a positive impact on employment growth. These approaches are based on the idea that productive regions grow more rapidly in terms of employment (Rosenthal, 2004). Theoretical mechanisms driving agglomeration economies are manifold. Duranton/Puga (2004) provide a comprehensive review of the (recent) theoretical literature and distinguish three types of micro-foundations in agglomeration economies.[4]

The *first* mechanism relies on the sharing of common resources which represents an incentive for actors (firms and households) to agglomerate. This applies in particular to goods and facilities that are indivisible (e. g. specific infrastructures). Moreover, agglomeration makes it possible to share a wider variety of differentiated (intermediate) inputs. An agglomeration of workers also lays the ground for expoliting individual specialization gains (benefits due to the division of labor, learning-by-doing, fixed cost saved due to workers not switching tasks). Finally, agglomeration contributes to a reduction of risk for firms (minimizing the risk of constraints due to a limited workforce in the case of a positive shock) and households (minimizing the risk of becoming unemployed).

The *second* mechanism is linked to matching. Agglomerations are expected to improve the quality of a match between labor supply and labor demand. In other words, increasing numbers of firms and workers increase the probability of obtaining a (perfect) fit of labor demand and labor supply.

The *third* mechanism is associated with learning. Spatial proximity increases the probability of actors being able to communicate, which represents an adequate condition for knowledge exchange/diffusion and accumulation. A diversified urban environment is known to amplify the gains from interactions. Using the available data, our study considers an agglomeration index to take into account the impact of the spatial environment on an establishment's productivity.

Beyond that, further variables, such as establishment size, age and economic sector, are at the heart of the (political) discussion. However, theoretical mechanisms for these characteristics are not easy to disentangle as they can overlap and are hard to predict.[5] As

[3] See, for example, a comprehensive literature review in Rosenthal (2004).

[4] Previous literature mainly referred to the taxonomy of Marshall (1920) highlighting intra-industry knowledge exchange, linkages between intermediate and final good producers and specific labor-market pools as sources of agglomeration. Duranton/Puga (2004) point out that this taxonomy is rather inappropriate for structuring theoretical mechanisms driving agglomeration economies. Instead, they suggest a system of mechanisms based on sharing, matching and learning.

[5] Establishment size, age and economic sector represent different aspects of internal economies of scale. On the one hand, establishment 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). This would point to a positive relationship between establishment size and productivity. On the other hand, smaller establishments are

they might also be of interest to the reader, we include these characteristics but present the results in a rather descriptive way in a separate section.

2.3 Empirical literature on the effects of investment grants

Although discretionary investment grants are a very important instrument in many countries, there is only limited evidence on the nature of the effects of such programs. Our literature review is restricted to micro-level studies, because our analysis focuses on the establishment level as the initial step of the regional development process.

Similar to the regional policy framework in Germany, Italy's Law 488/1992 provides subsidies for firms willing to invest in disadvantaged regions. Bernini/Pellegrini (2011) evaluate the effects of this program by combining firm-level data and information on subsidy allocation for the 1996–2004 period. Using a matching and difference-in-differences approach, they find positive short-run effects on output, employment and investment growth, but negative long-run effects on productivity growth. Differentiating the effect with regard to the size of the firms receiving the subsidy, they find stronger effects in small and medium-sized firms. Bronzini/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 of inter-temporal substitution, given the time restriction of the programming period. Applying a regression-discontinuity design, Cerqua/Pellegrini (2014) detect positive effects on the growth of employment, investment and turnover; effects on productivity are negligible. Pellegrini/Centra (2006) focus on the effects of Law 488/1992 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, labor) remains very limited.

In the United Kingdom, the Regional Selective Assistance (RSA) program provides discretionary grants for firms in disadvantaged regions. Devereux/Griffith/Simpson (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 that the RSA program has positive 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.

Evidence on the causal effects of investment grants is particularly scarce in Germany. Indeed, there are some policy reports that are based on credible identification strategies, but none of these analyses have been published in the international peer-reviewed empirical literature. For example, Bade/Alm (2010) apply a matching with difference-in-differences

expected to act more flexible in the market due to their entrepreneurial spirit, risk behavior, new ideas and products (Pagano/Schivardi, 2003; Dhawan, 2001). Finally, theoretical mechanisms driving productivity across economic sectors can differ. For example, the aircraft industry is characterized by considerable learning-by-doing effects, and the chemical industry generally requires large machinery (e. g. Syverson, 2011).

approach to evaluate the GRW program. For establishments 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 employment in the control group, suggesting potential intra-regional displacement effects of employment. Differencing the sample into treatment cohorts, they observe mean annual employment effects of different sizes.[6] Summing up, the results available so far suggest that subsidies have positive effects on overall firm-level employment, investments and turnover, but minor or no effects on productivity.

Our paper makes two novel contributions to the empirical literature on the effects of investment grants: first, we provide evidence of how the GRW program for disadvantaged regions works in Germany. This will deliver additional insights for the general discussion surrounding this specific support program, since place-based policies may work differently in different jurisdictions (Neumark/Simpson, 2015). Second, we consider heterogeneity among the treated establishments resulting from individual establishment characteristics and the economic environment. Except for establishment size and the year of treatment, little attention has been paid to this aspect in the literature so far. In our study we estimate both the overall employment effect for the treated establishments and the effect in different subsamples representing heterogeneous characteristics that are assumed to have an impact on the strength of the estimated employment effect.

In previous literature, the outcome was usually measured as the development in absolute terms or in growth rates. Neither of these measures permit comparisons of the estimated effects in subsamples.[7] Our data basis includes exceptionally rich information on the treatment, enabling us to relate the estimated employment development to the amount of the subsidy and to create a comparable measure of the magnitude of the effect in the different subsamples.

3 Data and descriptive statistics

3.1 Data

Our data basis combines information from multiple sources. The treatment information is obtained from the Investment Bank of Saxony-Anhalt (which is responsible for managing the administrative funding process), employment information at establishment level is taken 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.

[6] Causal effects of GRW in Germany were first analyzed by Ragnitz/Lehmann (2005). Using a matching approach for the Establishment Panel of the Institute for Employment Research, they find positive treatment effects on the amount of investment per employee and on sales among eastern German establishments for the years 1999–2001. Bade (2013) uses the same econometric approach to differentiate the effect of GRW by establishment size. He finds no indication that establishment size influences the estimated employment effect.

[7] The development in absolute terms is assumed to be driven by the effects in large establishments in the sample (which presumably absorb a large share of the total subsidy), whereas the effects in terms of growth rates are driven more by the effects in smaller establishments.

The database on the administrative funding process contains information about 1,696 assisted projects in the funding period 2007–2013. For each assisted project the type of investment, expected additional employment, the investment volume, eligible costs, as well as the amount of the investment subsidy is included. The exact application date as well as the start and end of the subsidized projects are also available in this database. Since we know the applicant's names, we can draw conclusions about the funding frequency of the 1,208 subsidized establishments. Further establishment-specific information like address, size category (following the EU definition of small, medium-sized and large establishments) and the economic sector are also contained in the Investment Bank data.

Employment data is obtained from the Federal Employment Agency (Bundesagentur fuer Arbeit). The Employment History contains information on gender, nationality, formal and professional qualifications, the type of employment contract, working time and salary for all employees in establishments with at least one employee covered by social security.[8] For our analysis, we aggregate the information to establishment level, which allow us to observe establishment-specific characteristics, like size in terms of the number of employees and of full-time equivalents (FTEs)[9], formal and professional qualification structure, age and gender of the employees. Additionally, we have information on the years of founding and closure as well as the economic sector in which the establishment is active.

We link the aggregated Employment History and the administrative funding data with the aid of the official establishment identifier. The resulting data set contains detailed information on 1,171 of the 1,208 subsidized establishments (96.9 percent).[10] The panel structure of this dataset allows us to trace all establishments back to January 2004. It is therefore possible to control for employment development in the establishments before the funding period started. We only consider data for establishments in Saxony-Anhalt for two reasons: first, we want to ensure that the potential controls did not receive GRW subsidies[11], and second, the establishments in the control group should be located in a similar economic environment. All in all we observe 19,246 establishments in Saxony-Anhalt, with an annual average of 2.24 million FTEs for the period from January 2004 to December 2014, including the 1,171 subsidized establishments.

In the next step, we enrich the establishment-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 Gemeindeschluessel, AGS5'). This enables us to include further important information on the economic environment of the establishments, such as

[8] Under the social security scheme, every year employers are obligated to report all changes that have occurred in the number of workers who are subject to health or unemployment insurance contributions or who participate in a pension scheme. There are legal sanctions for misreporting.

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

[10] Although the sectoral information in the GRW data and that in the Employment History is based on the German Classification of Economic Activities (WZ), the allocated WZ code in the two data-sets is different for some of the treated establishments. We use the information from the Employment History in order to have comparable sectoral information for the treated and the non-treated establishments.

[11] In other words, if we took establishments outside Saxony-Anhalt as potential controls, we could not credibly rule out the possibility that these establishments may also receive GRW funding.

the region type[12], the unemployment rate and the share of employees in sectors with a high level of R&D activity. The overall result is a rich panel data-set with monthly employment and establishment-specific information, annual regional information and detailed program information concerning the investment grants.

For the following analysis, we restrict the data to subsidized establishments that receive treatment only once in the funding period. Further, we exclude establishments in sectors that are not eligible for GRW subsidies, e. g. agriculture and forestry, health and social services sector, education and public administration.[13] As a result, our sample consists of 2.7 million observations, i. e. monthly information on establishments in Saxony Anhalt, including 716 subsidized establishments.

3.2 Descriptive statistics

From the wealth of information provided above, we include int he analysis key characteristics that might influence employment growth. Owing to theoretical considerations and data availability, we consider the following establishment-specific and environment-related characteristics as described in table 1. Since we have panel data, the table provides some descriptives of the included variables for establishments 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 establishments, particularly with regard to establishment size and the economic sector.[14] Non-subsidized establishments are smaller on average. About three quarters of them belong to the group of very small plants (with up to 10 FTEs), but only 30 percent of the subsidized establishments belong to this group. Most of the subsidized establishments (about 42 percent), but only 19 percent of the non-subsidized ones are small establishments with 10 to 50 FTEs. Medium-sized establishments (with between 50 and 250 FTEs) account for about one quarter of the subsidized but only 5 percent of the non-subsidized establishments. Furthermore, the sectoral structure[15] of the establishments differs between the two groups: about one quarter of the subsidized establishments are in metal production, but only ten percent of the non-subsidized establishments operate in this sector. In contrast, only ten percent of the subsidized establishments 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 establishments. Further differences are found in the petroleum processing, manufacture of chemicals and pharmaceutics (12

[12] The basis for this characterization is the definition of settlement-structure spatial units used by the BBSR, which includes three components: population share in large and medium-sized cities, population density and population density excluding large and medium-sized cities.

[13] As a result of the different WZ codes in the data-sets and our decision to rely on the IAB information, we subsequently have to correct the sample to eliminate those establishments that are in non-eligible sectors.

[14] The descriptions refer to the values for 2007. As can be seen in table 1, the values for 2013 are very similar.

[15] See table A.4 in the appendix for detailed sectoral information given by the WZ code in 13 aggregated economic sectors.

Table 1: Descriptive statistics for subsidized and non-subsidized establishments

Variable	*subsidized establishments* N	Mean/ Share	Median	Std. Dev.	*non-subsidized establishments* N	Mean/ Share	Median	Std. Dev.
January 2007								
establishment characteristics								
establishment size								
$<$ 10 FTEs	144	29.21			8,586	76.25		
$>=$ 10 FTEs and $<$ 50 FTEs	210	42.60			2,096	18.61		
$>=$ 50 FTEs and $<$ 250 FTEs	121	24.54			520	4.62		
$>=$ 250 FTEs	18	3.65			58	0.52		
establishment age								
young establishment ($<$ 10 years)	211	42.80			5,972	53.04		
older establishment ($>=$ 10 years)	282	57.20			5,288	46.96		
sector of the establishment (5 largest sectors)								
metal production	135	27.38			1,174	10.43		
production and maintenance of electrical equipment, machinery and computers	63	12.78			724	6.43		
production of furniture, wooden products, glass and ceramics	60	12.17			1,132	10.05		
petroleum processing, manufacture of chemicals and pharmaceutics	59	11.97			318	2.82		
trade, repair, transport, ICT	47	9.53			4,449	39.51		
share of high-skilled employees	493	6.49	1.59	11.40	11,246	6.13	0.00	18.38
share of medium-skilled employees	493	61.88	70.41	28.77	11,246	58.22	71.43	40.17
share of young employees ($<$ 30 years)	493	23.51	21.03	17.24	11,260	18.41	3.57	26.55
regional characteristics								
unemployment rate in the region	493	16.11	15.70	2.34	11,260	15.96	15.70	2.23
R&D employment share in the region	493	0.05	0.04	0.03	11,260	0.04	0.03	0.02
type of region								
urbanized region	128	25.96			3,582	31.81		
rural region	365	74.04			7,678	68.19		
December 2013								
establishment characteristics								
establishment size								
$<$ 10 FTEs	211	30.67			7,450	74.72		
$>=$ 10 FTEs and $<$ 50 FTEs	299	43.46			1,966	19.72		
$>=$ 50 FTEs and $<$ 250 FTEs	155	22.53			489	4.90		
$>=$ 250 FTEs	23	3.34			65	0.65		
establishment age								
young establishment ($<$ 10 years)	277	40.26			4,084	40.96		
older establishment ($>=$ 10 years)	411	59.74			5,886	59.04		
sector of the establishment (5 largest sectors)								
metal production	145	21.08			1,019	10.22		
production and maintenance of electrical equipment, machinery and computers	70	10.17			696	6.98		
production of furniture, wooden products, glass and ceramics	69	10.03			1,020	10.23		
petroleum processing, manufacture of chemicals and pharmaceutics	70	10.17			302	3.03		
trade, repair, transport, ICT	55	7.99			3,613	36.24		
share of high-skilled employees	688	9.09	3.12	15.90	9,897	8.68	0.00	21.85
share of medium-skilled employees	688	62.59	75.00	30.87	9,897	56.51	70.61	40.91
share of young employees ($<$ 30 years)	688	24.50	22.22	17.44	9,970	15.90	0.00	23.66
regional characteristics								
unemployment rate	688	10.96	11.50	1.61	9,970	11.10	11.50	1.59
R&D employees	688	0.05	0.04	0.03	9,970	0.05	0.04	0.03
type of region								
urbanized region	190	27.62			3,153	31.62		
rural region	498	72.38			6,817	68.38		

Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

vs. 3 percent) and in the production and maintenance of electrical equipment, machinery and computers (13 vs. 6 percent). Similarities between the two groups become visible regarding establishment age and the workforce structure. The same applies to the economic environment.

4 Estimation approach

Our data basis consists of an unbalanced panel of monthly data 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. This means that within the funding period, the treatment phase of establishment 1 may coincide with the pre-treatment phase of establishment 2 and the post-treatment phase of establishment 3. Furthermore, our sample of treated establishments represents a very special subgroup of all the establishments in Saxony-Anhalt (see chapter 3.2). As a result, we need an extraordinarily flexible approach to handle the special features of the data.[16]

As a starting point we use the nonparametric conditional difference-in-differences approach introduced by Heckman/Ichimura/Todd (1997, 1998). It combines a difference-in-differences estimation with a matching process.[17] Within the framework of this model, usually the mean employment development in the treated group is compared with that of the control group. In contrast to the standard model, we compare the mean of the individual differences in employment development between the treated establishments i and their respective controls j to estimate the average treatment effect for the treated ATT:

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

As can be seen in equation 1, we include individual application dates, denoted by Index t_{0i}, and a flexible number of months, $t_{0i} + \beta_i$, reflecting the individual duration from application to the outcome observation. Y denotes employment. For each establishment, our observed outcome is the development of employment from application until one year after completion of the project, i. e. a mid-term effect. Due to heterogeneous project durations and different 'waiting phases', these periods are heterogeneous among the treated establishments.

As is obvious from equation 1, we do not compare the treated establishments with the entire sample of non-subsidized establishments. Instead, we include a matching process as a kind of data preprocessing in the sense of Ho et al. (2007), which lead to more reliable estimates of causal effects. One of the main challenges for the applied matching process is dealing adequately with the time-varying variables. The special observation period (which covers the financial crisis and the resulting economic changes) makes it apparent that we have to be sure to exclude potential 'time bias' resulting from comparing establishments

[16] A more detailed discussion of the typical structure of data for investment grants, the special requirements for the estimation and a more comprehensive description of the developed approach can be found in our technical companion paper. See Dettmann/Giebler/Weyh (2018).

[17] For a detailed description of this approach see Abadie (2005) or Blundell/Costa Dias (2000).

at different points in time. That means we have to incorporate the time-related information from the panel data into the matching process. To this end, we develop a sequential matching process that incorporates the observation date of all matching variables and the outcomes.[18] In a pre-selection process, we limit the set of potential partners for each treated establishment to those observed at establishment's specific application date. Then the matching algorithm sequentially selects statistical twins from these pre-selected establishments. For instance, if an establishment applied for investment subsidies in January 2007, we consider its characteristics in that month and are able to match it precisely with another non-subsidized establishment that had 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 variables and the generalized matching coefficient for categorical variables. Weighting the functions by the respective number of variables, the distance function for a treated establishment i and a non-treated establishment j can be described as follows:

$$\textit{Dist}_{ij} = \frac{1}{N}\left[N_m \cdot \textit{AD}_{ij} + N_n \cdot (1 - \textit{GMC}_{ij})\right]. \tag{2}$$

The terms $\textit{Dist}_{ij}$, $\textit{AD}_{ij}$ and $\textit{GMC}_{ij}$ 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 $\textit{AD}_{ij}$ is calculated as:

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

where $||$ denotes absolute values, and $\textit{diff}_{max}(x_n)$ 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:

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

Following theoretical considerations, we choose the establishment characteristics and regional information described in section 3.2 for the matching process. In order to take the common trend assumption into consideration, we also include the employment development before application for the subsidy. We observe the absolute difference in the number of FTEs between two years and six months before application for the subsidized establishments and the respective difference for potential partners. We exclude the development

[18] Standard program code for matching and difference-in-differences does not allow the inclusion of (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 for our approach. A comparison of our approach with this Mahalanobis-nearest-neighbor matching procedure shows that our newly developed algorithm produces better (in the sense of 'more similar') control groups. One reason for this can be seen in the different scales of the matching variables being taken into consideration in our approach. See also Dettmann/Becker/Schmeißer (2011).

from six months before application until application in order to take into account a potential Ashenfelter's dip resulting from anticipation of the treatment. As the treated establishments must be observable at least two years before they apply for GRW subsidies, start-ups are ruled out by the described matching process.

5 Results

This section presents the results of our estimation. We discuss the employment effects of investment grants one year after completion of the project. The units of observation are establishments that were supported in the federal state of Saxony-Anhalt during the funding period of 2007-2013 . As we stated in the introduction, we differentiate between a general treatment effect and heterogeneous effects. We report the effects in both absolute and standardized figures (employment per Euro 100,000 subsidy), which enables us to compare the results across different subsamples.[19] The average absolute employment

Table 2: 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
quality of labor					
low share of high-skilled employees	370	4.02	1.28	2.74***	0.73
high share of high-skilled employees	410	7.92	-1.80	9.72***	1.08
low share of medium-skilled employees	392	5.61	-0.40	6.01***	0.97
high share of medium-skilled employees	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
external productivity drivers					
urbanized regions	198	9.02	-3.08	12.10***	1.51
rural regions	582	5.00	0.59	4.41***	0.75
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
establishment size					
very small ($<$ 10 FTE)	206	2.02	-0.30	2.32***	1.61
small ($\geq$ 10 and $<$ 50 FTE)	342	3.54	-0.79	4.33***	1.69
medium ($\geq$ 50 and $<$ 250 FTE)	202	11.54	2.28	9.26***	0.63
large ($\geq$ 250 FTE)	30	24.57	-13.07	37.64	1.30
establishment age					
young establishments	272	8.92	4.53	4.39***	0.62
older establishments	508	4.47	-2.94	7.41***	1.22
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 Euro subsidy; $^{(3)}$ Production and maintenance of electrical equipment, machinery and computers; $^{(4)}$ Production of furniture, wooden products, glass and ceramics; $^{(5)}$ Petroleum processing, manufacture of chemicals and pharmaceutics.
Results significant on the level: *** p$<$0.01, ** p$<$0.05.
Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

effect is 6.36 FTEs, primarily driven by the increase in employment by 6.02 FTEs in the

[19] As additional information, we present the total amount of subsidy in the subsamples as well as the costs per additionally created job in table A.5 of the appendix.

subsidized establishments (see table 2). The standardized effect is about 1 FTE per Euro 100,000 subsidy.[20]

By and large, the positive general effect of investment grants on employment development that was estimated is in line with the findings obtained in former studies, not only for Germany, but also for other European countries. For instance Bernini/Pellegrini (2011), Cerqua/Pellegrini (2014) and Pellegrini/Centra (2006) also find positive effects of Italy's Law 488/1992 on employment growth. Similarly, Criscuolo et al. (2016) observe positive effects of Regional Selective Assistance in the UK, but mainly on employment development in small and medium-sized firms. With respect to the German GRW, Bade/Alm (2010) also report positive effects on employment development for the 2001–2006 funding period.

5.1 Heterogeneous findings in the light of economic theory

In table 2 we also present the results of the subgroup analyses and discuss the findings in the light of economic theory. The general treatment effect represents the baseline scenario. In line with the available data we place specific emphasis on the quality of labor in the establishment and its economic environment.

With regard to the *quality of labor* we find that the absolute employment effect in establishments with a high share of high-skilled employees is above the average, by far exceeding the effect in establishments with a low share of high-skilled workers (9.72 FTEs vs. 2.74 FTEs).[21] The difference diminishes when we control for the size of the subsidy, but the larger effect in establishments with a high share of high-skilled workers persists (1.08 FTEs per 100,000 Euro versus 0.78 FTEs per Euro 100,000). The difference for the subgroup of medium-skilled employees is marginal, in both absolute and in standardized figures, which underlines the importance of high-skilled employees for the effectiveness of investment grants.

Not only formal qualifications, but also *work experience* is important for a firm's human capital endowment. We measure work experience by the share of employees under the age of 30 in the establishment. Here, too, we find considerable differences between the subgroups under analysis: the absolute employment effect in establishments with a low share of young employees is, at 8.59 FTEs, about twice as high as the effect in establishments with a high share of young employees, at 4.41 FTEs.[22] This relationship also remains stable when the amount of the subsidy is taken into consideration (1.3 vs. 0.6 FTEs per Euro 100,000, respectively).

Finally, we additionally consider the crucial role of agglomeration economies. We find that treated establishments in urban regions grow by 12.10 FTEs in absolute terms in comparison with their counterfactuals, whereas those in rural regions exhibit an employment

[20] As can be observed from table A.5, a total of Euro 251,000,000 subsidy was paid for the 780 projects that are included in the analysis.

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

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

development of only 4.41 FTEs. Similar to the findings for the quality of labor, the magnitude of the difference becomes smaller if we compare standardized figures. However, the difference between the two subgroups remains considerably high, with the result for urban regions, at 1.51 FTEs per Euro 100,000, being about twice as high as that for rural regions, at 0.75 FTEs per Euro 100,000.

The findings presented here are in line with the empirical and theoretical literature: firms are expected to exploit internal productivity gains arising from high-skilled employees with good work experience and external productivity gains resulting from the existence of agglomeration economies, which in turn boosts stronger employment growth in the (treated) establishment.

5.2 Further interesting results

In addition to the quality of labor, work experience and agglomeration economies, we analyzed further characteristics, such as the size, age and sector of the establishment. However, these characteristics do not provide clear micro-foundations, as they comprise several mechanisms simultaneously. Even though there is no singular micro-foundation for these establishment characteristics, it might be beneficial to describe the heterogeneity of the effects – at least in a rather descriptive way – as establishment size, sector and age are at the heart of the political debate.

With regard to the economic sector, we observe the largest effects in the sectors of petroleum processing, manufacture of chemicals and pharmaceutics and the manufacture of furniture, wooden products, glass and ceramics.[23] The absolute employment effects (15.57 FTEs and 12.2 FTEs respectively), as well as the standardized effects with about 1.9 and 1.7 FTEs per Euro 100,000 are well above the average. Also for the trade, repair, transport and ICT sector we observe above-average effects. By far the smallest effects are found in metal production, the sector with the largest number of accepted proposals (see table A.1). Here, the standardized effect is about half of the average (0.54 FTEs per Euro 100,000), and the absolute effect is even smaller. Thus, jobs created in this sector are comparatively expensive (see also table A.5).

Our results regarding the size of the subsidized establishments confirm the assumption that establishment size has an influence on the effect in absolute figures. For example, the effect in absolute figures is less than half of the average (4.33 FTEs) in very small establishments, but above the average in medium-sized ones (9.26 FTEs). Taking the amount of the subsidy into account leads to reverse results. The effect in small and very small establishments is now quite well above the average (1.69 and 1.61 FTEs per Euro 100,000 respectively), whereas the effect in medium-sized establishments is lower than the average (0.63 FTEs per Euro 100,000). The figures also point to a correlation between establishment size and the size of the subsidy. A closer look at the size of the subsidy per job also confirms this assumption: the subsidy per job in very small establishments is

[23] Table 2 contains the results for the five largest aggregated sectors. The results cover more than three quarters of the analyzed treated establishments in the sample. For an overview of the aggregation see table A.4 in the appendix.

less than half the size of that in medium-sized ones (about Euro 62,000 and Euro 159,000 respectively (see table A.5 in the appendix).

Basically, our findings for establishment size are in line with those found in the international literature. Bernini/Pellegrini (2011) and Criscuolo et al. (2016) report similar results for Italy and the UK. However, our findings do not correspond with previous studies for Germany. Bade (2013) finds no hint for an influence of the plant size on the estimated employment effect.

Further, our analysis shows that the effect in old establishments exceeds that in young ones in both absolute and standardized figures (1.2 vs. 0.6 FTEs per Euro 100,000). Interestingly, young subsidized establishments create more jobs than older ones (8.9 vs. 4.5 FTEs), but comparable non-subsidized young establishments also create jobs whereas comparable older ones reduce employment (4.5 FTEs and 2.9 FTEs, respectively), resulting in absolute employment effects of only 4.3 FTEs in younger establishments and 7.4 FTEs in older ones.

A final interesting result concerns the observation period of our study, which exhibits pronounced changes in the economic environment. At first glance, the impact of the financial crisis is not identifiable. When the subsamples are examined more closely, however, we observe that the magnitude of the effect is largely explained by the changing behavior of non-subsidized establishments over time. While subsidized establishments created jobs during and after the crisis (to a smaller or a larger extent), the employment development in comparable non-subsidized establishments was negative during and positive after the crisis. For example, subsidized establishments applying for grants in 2009 exhibit the largest employment development in absolute terms (9.18 FTEs). Also comparable non-subsidized establishments grew by 4.73 FTEs. The developments in both groups illustrate the enormous recovery of the German economy in the years after the crisis. Unfortunately, the jobs created are very expensive: One subsidy-induced FTE costs Euro 210,000 (see table A.5). As a result, the standardized effect for projects for which applications were submitted in 2009 is the lowest across all the years of application.

The results clearly confirm the importance of considering the treatment time and the necessity to define precisely the time when an establishment is compared to its statistical twin in order to exclude potential 'time biases'. Consistent with our results, in analyzing investment grants for the period 2001-2006, Bade/Alm (2010) also find employment effects of different magnitude depending on the year of the treatment.

6 Quality and robustness checks

In the following, we present the results of different quality and robustness 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.[24] Following Ho et al. (2007), we first compare the means

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

of the continuous matching variables in the two groups. Cochran (1968) provides a rule of thumb for a balancing check: when the means differ by more than one quarter of the standard deviation of the respective variable, a better balance is needed.

Table 3: Comparison of the means

Variable	Mean/Share Treated	Mean/Share Controls	Difference	Std.Dev.[1]	Cochran rule of thumb
establishment size					
$<$ 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		
establishment age					
young establishment	34.87	34.87	0.00		
older establishment	65.13	65.13	0.00		
sector of the establishment (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, manufacture of chemicals and pharmaceutics	12.82	12.82	0.00		
trade, repair, transport, ICT	7.95	7.95	0.00		
share of high-skilled employees	7.22	6.40	0.82	12.05	fulfilled
share of medium-skilled employees	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					
urbanized region	25.38	24.87	0.51		
rural region	74.62	75.13	-0.51		

Note: [1] Standard deviation in the sample.
Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

Table 3 presents the means of the two groups, the difference between them, and the quality criterion. In addition, we show 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 defined by Cochran (1968). The distributions of the values of the categorical variables for the treated and the control establishments are also very similar. Altogether, the comparison of the variable means, or value shares, confirms the required balancing property of the matching algorithm.

As is further recommended by Ho et al. (2007), we calculate distribution tests to verify whether the variable distributions between the group of the treated establishments and the controls are balanced. Table 4 contains the results of Kolmogorov-Smirnov tests for the continuous vaiables and χ^2-tests for the categorical variables. They also confirm the quality of the matching. We find no significant differences between the treated and the control establishments with regard to the distribution of the matching variables.[25]

see Ho et al. (2007).

[25] This is also obvious when the variable distributions are compared in form of a graph. The quantile-quantile plots are available from the authors upon request.

Table 4: Results of Kolmogorov-Smirnov test and χ^2 test

Variable	D / χ^2	p-value
establishment size	0.27	0.966
establishment age	0.00	1.000
sector of the establishment	0.00	1.000
share of high-skilled employees	0.08	0.170
share of medium-skilled employees	0.08	0.199
share of young employees	0.08	0.123
employment difference	0.13	0.003
unemployment rate in the region	0.02	1.000
R&D employment share in the region	0.02	1.000
type of region	0.03	0.869

Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

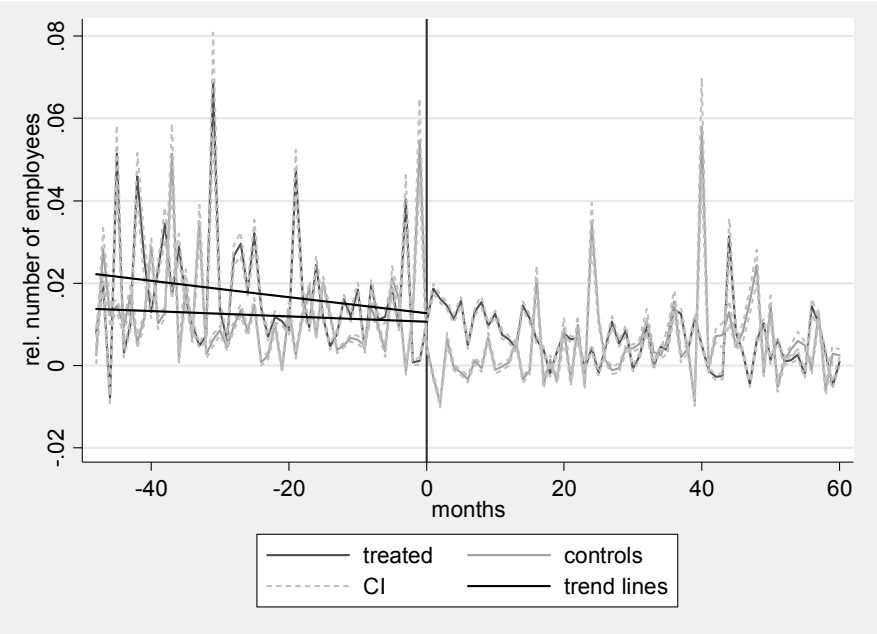
In addition, we apply the commonly used verification tools provided by Leuven/Sianesi (2003) – *pstest*: t-tests, standardized percentage bias and variance ratios of the matching variables – as proxies for the balance of the variable distributions.[26] By and large, the results in table A.6 in the appendix confirm the results of the other quality checks presented. The results of the t-tests and the percentage bias for the matching variables point to similar means in the two groups. Most of the variance ratios have values close to one, indicating that the variable variances between the treated and control establishments are similar.[27] As a last important step, we use a graph to verify the common trend assumption. This key assumption for difference-in-differences requires that establishments in both groups would exhibit the same behavior if the treated establishments had not been subsidized. We examine the common trend assumption in the usual way: by looking at the relative employment development within the two groups prior to the treatment. Figure 1 shows the monthly employment change. The vertical line indicates the time when the application for the subsidy was submitted. As can be observed, there is a large variation in the monthly employment development for both the treated and the control establishments. However, we find only a slight decrease in the trend line of treated establishments, from about 0.02 FTEs to about 0.015 FTEs, whereas the trend line for the controls is nearly horizontal, at 0.015 FTEs. Nevertheless, the employment development is very similar prior to application for the subsidy. Summing up the results of the quality checks, we can conclude that the results presented in chapter 5 are very reliable. The checks presented above are also carried out for all subsamples presented in section 5 and reveal that variable distributions are balanced too.[28]

Table 5 shows 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.

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

[27] We find only 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 regarded as a rather rough balancing measure in the literature (Leuven/Sianesi, 2003).

[28] The results of the quality checks for all subsamples are available from the authors upon request.



Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

Figure 1: Monthly employment change

Table 5: Results using different matching algorithms

	Treated	Controls	Absolute difference
Nearest neighbor matching with ties	6.02	-0.32	6.34
Radius matching with small radius (0.4)	6.02	-0.13	6.15
Radius matching with wide radius (0.6)	6.02	-0.10	6.12
Nearest neighbor matching with Mahalanobis distance	5.91	1.59	4.23

Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

The results of the three alternative assignment processes (resulting in more than one statistical twin for the treated establishments) are very similar to the results presented in chapter 5. For matching with an alternative distance measure, the Mahalanobis distance, we observe a smaller, but still positive, employment effect. There may be various reasons for the difference in the magnitude. One of them could be that although the Mahalanobis distance is a very good measure for continuous variables, it is not an adequate distance function for categorical variables.[29]

7 Conclusions

The paper analyzes establishment-level employment effects of Germany's most important regional policy program in the funding period of 2007-2013 in one of the most heavily subsidized federal states in Germany. The funding regime typically allows for flexible application times and varying starts and ends of projects. We therefore extend the standard matching

[29] This assumption is confirmed when looking at the quality checks of the different matching algorithms. The control group resulting from the Mahalanobis matching procedure is not as similar to the control group resulting from the nearest-neighbor matching procedure with our statistical distance function. The quality check of all the alternative algorithms is available upon request.

and difference-in-differences approach and introduce flexible durations for observed outcome differences as well as the possibility to take time-varying variables adequately into account. The resulting approach is particularly useful for the evaluation of policy programs with (varying) individual treatment phases within the funding period, e. g. subsidy schemes, training programs, but also EU research funding.

In addition to the new, more flexible measurement approach the explicit consideration of heterogeneity in the subsidized establishments and their economic environment is a novelty of our paper. Due to the fact that we know the amount of the subsidy paid for each project, we are able to standardize the estimated absolute effects and to directly compare the results for the subsamples.

Investment grants are effective: we find an average absolute employment effect of 6.36 FTEs. Relating this effect to the amount of the subsidy paid, the standardized employment effect is 1 FTE per Euro 100,000. We also observe positive, but remarkably heterogeneous effects among the analyzed subsamples. Investment grants are more effective in establishments with a high share of skilled and experienced employees as well as in establishments located in urban areas. These findings are in line with theoretical considerations regarding what drives the productivity in firms.

In addition, we present heterogeneous effects regarding the establishments's size, age and sector. For these characteristics we cannot provide micro-foundations, because theoretical mechanisms can overlap and are hard to disentangle. Nevertheless, they play an important role in the political debate. With respect to the sector we find investment grants to be more effective in the manufacture of furniture, glass and ceramics and in petroleum processing, manufacture of chemicals and pharmaceutics. The smallest, but most expensive effect is found for metal production. Our estimations also reveal a clear correlation between establishment size and the amount of the subsidy. The employment effect in absolute terms is thus strongest in medium-sized establishments, but we find the largest effect in terms of the standardized effect in small and very small establishments. We also observe remarkable differences in the magnitude of the employment effect with regard to the time of application.

As usual, some questions remain for further research: Does the quality of the jobs created differ among the establishments analyzed? Are the employment effects persistent over time? Do intra-regional displacement effects occur? Do we find effects on other establishment-level outcomes like investments, turnover or productivity?

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8 Appendix

Table A.1: 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
Type 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
Type of investment (percent)				
setting up	124	18.02		
diversification	153	22.24		
extension	388	56.40		
other investments	23	3.34		

Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

Table A.2: Legal framework for GRW in Germany for the analyzed program period

Type of the program	Non-repayable grants for investment projects (co-funding)
Set-up of the program	1970
Program period	2007-2013
Targets	Reduction of regional disparities Increase of regional income and employment in assisted regions Catching-up of assisted regions to the general economic development
Regional scope of the program	Eligible labor market regions in the Federal Republic of Germany → Eligibility depends on the degree of the structural weakness of a region; Structural weakness indicator consists of: ○ unemployment rate (50%), ○ income per employee (40%), ○ quality of infrastructure (5%), ○ employment projection (5%) Limitation of the number of assisted regions according to the population share (40.2% of German population)
Legislation	Treaty of the European Union (Articles 87 and 88) German Basic Law (Articles 72(2) No. 2, 91a, 106(3) No. 2) Joint Task Law (GRW-Gesetz) Coordination framework ○ No.36, BT-Drucksache (reference number) 16/5215 ○ Koordinierungsrahmen, BT-Drucksache (reference number) 16/13950 Legislation of the Federal States
Application process	Assessment of a detailed description of the investment project; proposals that do not meet the criteria of excellence are rejected
Granting authority	Government of the federal state where the investment project is planned

Source: Own compilation and illustration.

Table A.3: Description of GRW funding rules for the analyzed program period

Recipients	Establishments in eligible areas			Municipalities in eligible areas
Amount of funds	€ 11.6 bn. (71.0%)			€ 3.4 bn. (29.0%)
Subject of funding	Investments in fixed assets ○ starting a new establishment ○ capacity expansion of existing establishments ○ changing the production program or overhauling the entire process of production ○ purchasing an inoperative establishment *Sectoral scope of the program* ○ industries with supra-regional sales ○ exclusion of industries according to EU state aid legislation and further economic intentions			Investments in local commerce-related infrastructure ○ building of business parks ○ revitalizing of business parks ○ building and expansion of transport infrastructure ○ building and expansion of associated utilities infrastructure (water, electricity, telecommunication etc.) ○ building and expansion of sewage plants ○ building and expansion of touristic infrastructure ○ building and expansion of workforce training centers ○ building and expansion of technology parks
Aid ceilings (as % of eligible costs)	A-areas*	small	50	90
		medium-sized	40	
		large	30	
	C-areas**	small	35	
		medium-sized	25	
		large	15	
	D-areas	small	15	
		medium-sized	7.5	
		large	7.5, max. 200,000 €	

Notes: * An official review of the 'statistical-effect regions' by the European Commission in 2011 contributed to a reduction of the maximum state-aid intensity to 20, 30 and 40 percent. ** Deviations from the standard rule are possible.

Source: Own compilation and illustration.

Table A.4: Aggregated economic sectors for the analysis

Name of the sector	WZ codes included	
	WZ 2003	WZ 2008
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, manufacture of chemicals 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 A.5: Amount of the subsidy in the subsamples, total and per job created

	N	total subsidy	subsidy per job
full sample	780	251,000,000	101,122
low share of high-skilled employees	370	67,300,000	136,733
high share of high-skilled employees	410	183,000,000	92,298
low share of young employees	364	140,000,000	76,993
high share of young employees	416	111,000,000	167,465
urbanized region	198	79,400,000	66,310
rural region	582	171,000,000	133,646
metal production	238	37,700,000	184,559
electrical equipment$^{(1)}$	106	27,500,000	119,242
wooden products, glass$^{(2)}$	108	33,800,000	51,358
petroleum processing$^{(3)}$	100	66,400,000	85,375
trade, repair, transport, ICT	62	16,500,000	56,960
very small establishment ($<$ 10 FTE)	206	14,800,000	61,990
small establishment ($\geq$ 10 and $<$ 50 FTE)	342	43,800,000	59,145
medium-sized establishment ($\geq$ 50 and $<$ 250 FTE)	202	149,000,000	158,905
large establishment ($\geq$ 250 FTE)	30	43,500,000	77,012
young establishment	272	97,100,000	162,486
older establishment	508	154,000,000	81.649
application in 2007	222	54,800,000	103,635
application in 2008	130	55,400,000	102,989
application in 2009	116	54,300,000	209,893
application in 2010	158	49,500,000	88,316
application in 2011	102	33,500,000	66,206
application in 2012	26	3,111,687	44,967

Notes: $^{(1)}$ Production and maintenance of electrical equipment, machinery and computers; $^{(2)}$ Production of furniture, wooden products, glass and ceramics; $^{(3)}$ Petroleum processing, manufacture of chemicals and pharmaceutics. Results significant at the level: *** p<0.01, ** p<0.05.

Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

Table A.6: Results of pstest

	Mean		% Bias	t-test		V(T) /
Variable	treated	control		t	p-value	V(C)
establishment size	2.07	2.04	3.5	0.48	0.630	1.02
establishment age	1.65	1.65	0.0	0.00	1.000	1.00
sector of the establishment	104.06	104.06	0.0	0.00	1.000	1.00
share of high-skilled employees	7.22	6.40	6.8	0.96	0.339	1.07
share of medium-skilled employees	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

Note: * variance ratio exceeds Austins rule of thumb.
Source: Employment History, Investment Bank of Saxony-Anhalt, own calculations.

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