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Evaluating a place-based innovation policy: Evidence from the innovative Regional Growth Cores Program in East Germany

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ABSTRACT

We evaluate one of the largest place-based innovation policies in Germany – the Innovative Regional Growth Cores (IRGC) program. It subsidizes collaborative development and commercialization projects of firms and public research institutes co-located in regions in Eastern Germany, with the explicit goal of generating local spillovers to promote regional economic development. We evaluate three potential types of effects with regard to a broad set of outcomes at the firm and regional level: (1) The policy's effects on directly subsidized firms; (2) spillover effects on non-subsidized innovative firms located in the same region; (3) (aggregate) effects on regional-level economic outcomes. We find that directly treated firms increase their R&D activities in the short- and medium-run. However, we are not able to provide significant or economically meaningful evidence for the effectiveness of channels (2) and (3), applying a wide range of econometric methods. Overall, these results cast doubt about the effectiveness of the program.

1. Introduction and conceptual framework

Do industrial policies promote economic growth in disadvantaged areas? Policy makers are and remain convinced that this is mostly or always the case, while researchers tend to be far more skeptical. The European Union spends more than a third of its budget on social and economic cohesion policies promoting the development of structurally weaker regions.[1] In Germany, the aim of providing similar living conditions throughout the country is enshrined in the constitution. Although reducing regional disparities is an objective of many countries and institutions, the approaches taken toward its implementation differ considerably.

A growing literature in the fields of regional science and urban economics studies which types of place-based policies are effective, mainly focusing on ex-post evaluations of prominent schemes in the United States and Europe.[2] In this paper, we evaluate one of the largest place-based innovation policies in Germany, the Innovative Regional Growth Cores program (IRGC).[3] The IRGC is an innovation program that provides subsidies to collaborating firms and institutions in Eastern Germany located in the same region, i.e., they are typically within a 50 km radius of each other.[4] Understanding how and whether policies such as the IRGC work is important also due to the fact that a number of similar policies are planned or have been recently initiated, particularly in Germany: For instance, the Federal Ministry of Education and Research (BMBF) has just established a major framework program "Innovation and Structural Transformation" using innovation policies as a tool for regional economic development.

The policy under consideration combines a number of features: Immediately, it provides subsidies to support the innovation efforts of firms. But beyond this, as the term "growth cores" implies, the

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[1] The most important EU place-based policy, the European Structural Development Funds, is evaluated by Becker et al. (2010, 2012, 2013, 2018).

[2] See for example Busso et al. (2013); Kline and Moretti (2014a); Gobillon et al. (2012); Criscuolo et al. (2018) for ex-post evaluations and Kline (2010); Kline and Moretti (2014b) for theoretical work on the mechanisms and channels through which the programs take effect.

[3] von Ehrlich and Seidel (2018) and Dettmann et al. (2016) evaluate two other policies that provided substantial investment subsidies for firms in disadvantaged German regions.

[4] This roughly corresponds to the size of region studied for clustering in one setting in Duranton and Overman (2005).

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intention is to enhance the formation and growth of clusters.[5] The existing results in the literature on the effectiveness of these types of policies are mixed. Innovation and investment subsidies bear the risk of deadweight-loss, especially if firms receive subsidies for activities that they would have undertaken in any case (Lichtenberg, 1984). In a recent study, Criscuolo et al. (2018) carry out a causal analysis of UK investment subsidies to disadvantaged regions and find evidence that they only benefit employment for smaller firms, while subsidies to larger firms – that are likely more able to game the system – dissipate. For innovation subsidies, What Works Centre for Local Economic Growth (2015) comprehensively review the existing robust evaluation studies (42 studies overall) and find that roughly half of these show positive effects on innovation efforts, investment or economic outcomes such as firm turnover or employment. They consider the evidence on crowding out of private innovative investment as mixed.[6] Correspondingly, the first central question of our evaluation is therefore: (1) Did the IRGC induce additional innovation efforts and turnover of firms directly subsidized through the program? For the treated firms, we study innovative investment, R&D staff levels and turnover over time. By differentiating between funding sources for the firms (especially between private sources and public subsidies or grants), we are able to analyze whether the additional public funding was complementary to or replaced private investment.

As we discuss below, the selection process and criteria for program beneficiaries are unfortunately rather opaque. An important issue to bear in mind is the different potential motivations for picking participants if there is discretionary leeway. On the one hand, officials may be tempted to pick winners to participate (Cantner and Kösters, 2012). In this case, simple evaluation approaches would tend to over-estimate the effects of policies. On the other hand, though, weaker regions, industries or firms may systematically be targeted by or become dependent upon subsidies (e.g.,Criscuolo et al., 2018; Hyytinen and Toivanen, 2005; Rodrik, 2008), which would potentially lead to underestimation of effects. The evidence for the IRGC program – as we will see – indicates that subsidized firms on average are larger and carry out more innovative investments than their peers prior to treatment. Since the selection criteria are not documented – ruling out an IV approach – we analyze pre-trends displayed by the groups of firms (and regions) to ameliorate this selection issue; but generally, we would expect selection to be more likely to lead to over-estimation of effects.

Focusing only on the direct effects of the subsidies on the treated firms may lead to a mis-estimation of the overall effects of the policy for a further central reason: There may be external effects of the policy on other firms in the region (Arrow, 1962; Hausmann et al., 2005; Rodrik, 2004; Spence, 1984). Other innovative firms may compete for (public) R&D funding or try to hire from the same labor pool of scientists and technicians (Einiö and Overman, 2016). Potentially, their services or products may be replaced by the innovations of the subsidized firms. On the other hand, there could be positive spillovers, e.g. through increased knowledge flows (Agrawal et al., 2014; Fons-Rosen et al., 2016) or demand for upstream services and products. Also, firms may benefit from increased agglomeration (Glaeser and Gottlieb, 2008) or boosted productivity resulting from investments (Ahlfeldt and Feddersen, 2018; Greenstone et al., 2010). These channels should be particularly relevant for other innovative firms, leading to our second central question for the evaluation: (2) Did other innovative firms located in the same regions, that did not receive subsidies themselves ("indirectly treated" firms), benefit or suffer from the IRGC; that is, are there geographical spillovers at the firm-level? In particular, we want to see whether there are effects of the policy on indirectly treated firms with regard to their innovative investment, levels of staff and turnover compared to similar firms in untreated regions.

These first two questions will be addressed using difference-in-differences (DiD) approaches with firm-level data from the most comprehensive survey of innovative firms in Eastern Germany. The control group contains firms that were neither directly nor indirectly treated, i.e., they are located in eligible (East German) regions that were not awarded subsidies through the IRGC program. This firm-level focus is potentially too narrow to estimate the overall effects of the IRGC policy. As the name implies, the policy also seeks to strengthen regions through cluster-type effects. The channels of effect of these types of policies are complex and often not well-specified (Duranton, 2011). Still, they can be effective; for example, Falck et al. (2010) evaluate a large-scale cluster policy in Bavaria, the "High-Tech-Offensive". This policy had an explicit focus on specific technological fields and helped improve public research infrastructure such that it could be used by (mostly geographically close) private firms in related industries. Hausman (2017) shows that university innovations are particularly beneficial for the local economy. The IRGC further seeks to address failures of the East German innovation system more generally. Freeman (1987), Lundvall (1992), and Nelson and Rosenberg (1993) point out that institutional, geographic, and economic factors are crucial in shaping knowledge flows and, hence, impact the capacity of economies to innovate. Thus, policy interventions are not only based on market failure arguments, but also on flaws in the institutional and economic settings relevant to innovations.[7] For example, Bertamino et al., (2017) note that public policies can also be justified "in order to overcome imperfections in the innovation systems because some essential links are missing, or the linkages within them are not working well." The IRGC is explicitly designed to improve the framework conditions for innovative processes.

Clearly, not only innovative firms may be affected by cluster or agglomeration effects, demand shifts or improvements of the innovation system. In the third step of our analysis, we therefore consider the overall aggregate effect of the policy at the regional level, asking: (3) Did the IRGC cause measurable improvements to relevant economic outcomes at the level of the regions targeted by the policy, compared to regions that did not receive funding? Corresponding to the firm-level analysis, we consider the outcomes value added, employment and productivity. Further, we consider startup activity and the number of establishments in the region as measures for the overall innovative environment. For the analysis at the regional level, we compare the developments of aggregate economic outcomes in treated and non-treated regions. Along all steps of our analysis, we address endogeneity concerns by introducing appropriate fixed-effects and controls. At the regional level, we also employ an interactive fixed effects (IFE) specification. We conduct a series of event study estimations that demonstrate empirically under which conditions our chosen specifications are valid.

We find that firms directly receiving IRGC subsidies significantly increase their overall R&D spending, by initially about 17–20% per year. Differentiating by sources of financing, this spending increase is purely based on investment funded by public sources, which spike by more than 40% in the years during which IRGC funding is received. The results do not at first indicate that public funding crowds out or simply replaces private investments that would have been undertaken in any case – but one has to take into account that the program requires private co-financing of funded projects. The increase in overall R&D spending for treated firms tapers off after the subsidies cease (starting at the fourth year after the grant). With regard to the other outcomes considered, i.e. R&D staff, overall employees and turnover, we find no significant effects of the policy on directly treated firms in the time-window under consideration.

[5] We introduce the details of the policy in the following section.

[6] Zúñiga-Vicente et al., (2014) and Becker (2015) provide further surveys of the literature. A recent similar application to ours is Bertamino et al. (2017), who evaluate the Technology Districts program in Italy.

[7] See, e.g., Chatterji et al. (2014), Kline and Moretti (2014b) and Neumark and Simpson (2015) for reviews on cluster and place-based policies.

As to indirect effects, there is no robust evidence that the IRGC affected other innovative firms located in the same regions, positively or negatively. Finally, there is no measurable effect on the set of indicators for regional prosperity. In addition to their lack of statistical significance, which could be due to relative imprecision, the point estimates for the second and third question are also "small" with regard to their economic importance. Even subject to the caveat, that we cannot interpret the absence of proof as proof of absence, this raises some questions to the underlying rationale behind the regional development-aspects of the IRGC. Given the increasing relevance of place-based innovation policies, this issue requires further study and more detailed attention.

The paper proceeds as follows: In section 2, we introduce the IRGC in detail. Section 3 describes the comprehensive survey as well as the aggregate regional data. Section 4 outlines the identification strategy and section 5 presents the results of the evaluation. Section 6 concludes.

2. The IRGC program

The IRGC is the flagship program of a series of innovation policies carried out within the BMBF's "Entrepreneurial Regions" (ER) initiative in East Germany. The guiding principle of all ER policies is to overcome structural weaknesses in East German regions by "improv(ing) the framework conditions for innovative processes" (BMBF, 2016a). In contrast to most other place-based policies in Germany, the ER initiative does not promote this objective by subsidizing private or public capital investments in general but by explicitly supporting collaborative innovation projects within given regions.[8]

Implementing this principle, the BMBF established the IRGC in 2001. The premise underlying the IRGC is that regions possess "unique competences (that) could for example be the command of certain technologies or applications or a specific way of processing materials. (Often, these) are based on long regional traditions and are anchored in companies and research institutes or patented" (BMBF, 2016c). Building on this premise, the IRGC supports regional collaborations between "businesses, universities and research institutes, which either already possess a joint, specific platform technology or have the potential to develop one, (and pursue a) market-oriented strategy (…) aimed at developing innovative, economically successful products in the long run" (BMBF, 2016c). For example in Rostock, a former stronghold of the German ship-building industry, the IRGC supports the development of new tanks and ships for the transport and storage of cryogenic gases.[9] Based on comparable manufacturing traditions, a growth core developing new solutions for technical textiles has been established in Chemnitz – the historical center of Germany's textile industries.[10] Emphasizing the importance of development and commercialization projects, these grants are meant to provide the starting point for a cluster process that can eventually increase regional value creation.

In principle, all companies and public research institutes (including universities) that have a joint platform technology and are based in the same East German region are eligible to apply. Despite the IRGC's focus on regions, the geographic boundaries of the term "region" are not explicitly defined within the program. Based on the observed existing projects and the wider documentation of the IRGC, in the context of our evaluation we define regions according to so-called regional labor markets (RLMs).[11] To allocate funding, the BMBF has designed an elaborate application process intended to ensure the quality of selected projects.[12] This application process does not involve explicit measurable selection criteria that are publicly observable (either *ex ante* or *ex post*). Instead, the BMBF announces the winning projects without providing any information on unsuccessful contestants. Similar selection approaches are also used for a wide range of other innovation policies in Germany – especially within the ER framework. For successful applicants, the IRGC provides non-repayable subsidies that can finance up to 50% (100%) of the eligible costs incurred by private firms (public research institutes or universities). In the context of these project-based subsidies, eligibility covers both investment and personnel expenditures, including the salaries of individuals administering the project.[13]

In our analysis of the IRGC, we consider the first 13 waves of the program and include all 43 joint research projects that were started between 2001 and 2013. Within these 13 waves, the IRGC granted a total of 276 million Euros (MEUR), implying an average grant of roughly 6.4 MEUR per project. Fig. 1 illustrates the timing of these projects (grey bars) and clusters them according to their "core regions" (plotted along the vertical axis).[14] Focusing on the regional incidence of IRGC funding, this figure shows that several RLMs have hosted multiple IRGC projects. For example, Dresden was the core region of four distinct IRGC projects, namely IKON, inno.zellmet, Molecular Designed Biological Coating, and Autotram. This figure further highlights that some IRGC projects received funding for more than three years, that is, they exceeded the originally intended project duration. Although the possibility of project continuation is not explicitly mentioned in the IRGC's funding guidelines, some projects either entered a second "development phase" (e.g., the Maritime Safety Assistance project in Rostock) or were succeeded by follow-on projects (e.g., ReaWeC in Anhalt-Bitterfeld).

At the project level, we obtain the names, locations, as well as information on treatment duration and intensity (i.e., amount of subsidies received) of all participants in the IRGC from the *Förderkatalog des Bundes* (FdB).[15] With respect to the first 43 IRGC projects, our excerpt of the FdB includes the records of 366 private firms, 114 universities, 47 public research institutes, and 28 participants belonging to other categories (such as public-private partnerships). We further hand-collect the names, locations, and treatment durations of 33 additional private firms that are mentioned on the homepages of the IRGC projects but not included in the administrative database. Overall, private businesses received 54% of the IRGC grants, whereas 41% of the subsidies went to public research institutes and universities. For private firms, this implies an average grant of 377 thousand Euros (TEUR). In our analysis of the direct effects, we consider all participants of the IRGC to be treated once they receive an IRGC grant for the first time. From this point, their treatment status remains unchanged until the end of our observation period in 2013.

To investigate the existence of indirect effects, we have to define "indirect" IRGC treatments at the firm level. Given the structure and design of the IRGC, the logical decision is to consider firms co-located in the same regions as treated firms to be "indirectly treated". Applying the same logic in our analyses of the indirect and aggregate effects, we consider a region (and the firms therein) to be treated once the BMBF

[8] See, e.g., the *Zonenrandgebietsförderung*, the *Gemeinschaftsaufgabe* "*Verbesserung der regionalen Wirtschaftsstruktur*" (GRW), and the European Regional Development Funds (ERDF) for programs primarily focusing on the provision of investment subsidies.

[9] http://www.unternehmen-region.de/de/1743.php, last accessed: 17 March 2019.

[10] http://www.unternehmen-region.de/de/1034.php and http://www.malitec.org/, last accessed: 17 March 2019.

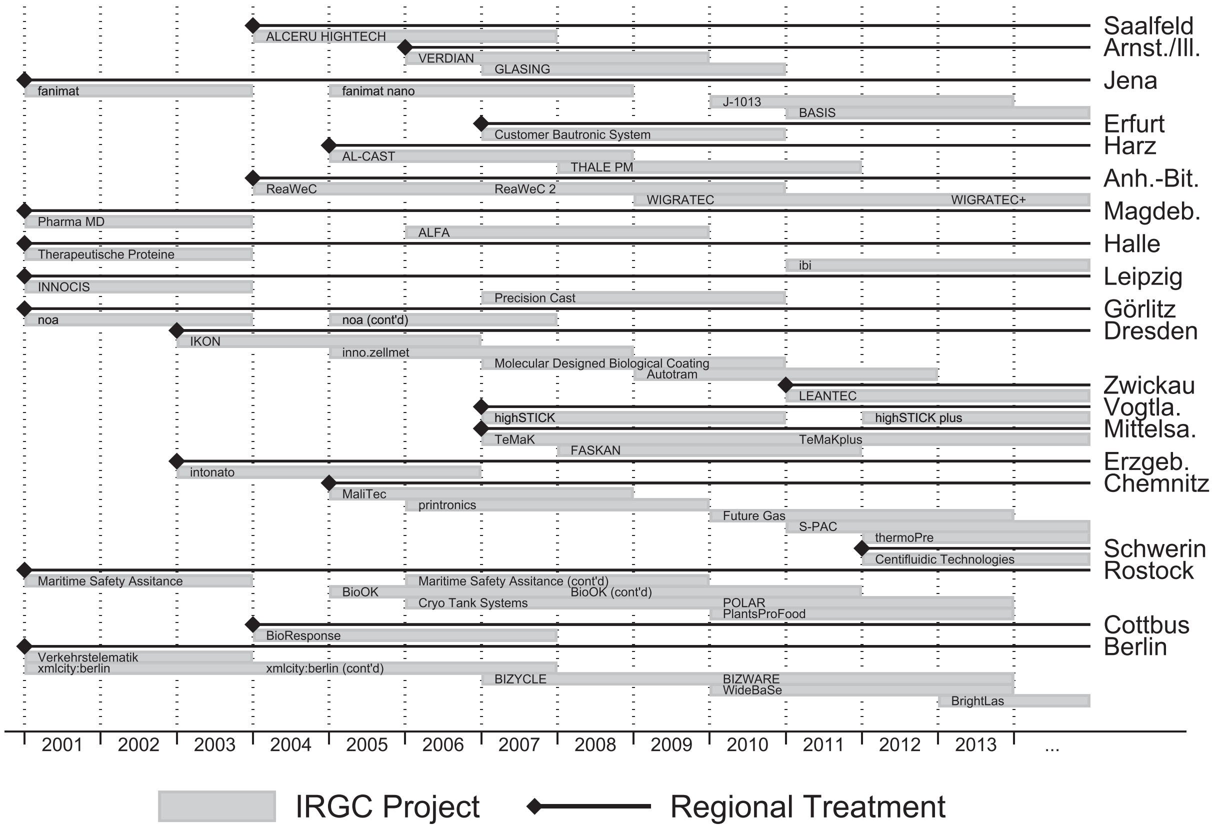
[11] See Appendix A.1.1 for a detailed discussion of this issue.

[12] See Appendix A.1.2 for more details on the application process.

[13] Investments into real estate are excluded. For the current version of eligibility criteria for project-based subsidies (in German), see https://www.bmbf.de/foerderungen/bekanntmachung-1429.html.

[14] Figure A.1 in Appendix A.2 displays the regional incidence of IRGC grants in a map of East German RLMs.

[15] The FdB is an online database maintained by the German government that collects information on a selection of Federal subsidy programs. Although the decision to include a specific program in this database is at the discretion of the Federal department running it, the coverage of programs – especially with respect to the BMBF – is highly comprehensive. The online database is available at https://foerderportal.bund.de/foekat/jsp/StartAction.do. The data used in this paper was downloaded from the FdB on July 3rd, 2017.



Note: This figure shows the timing of the 43 IRGC projects started between 2001 and 2013 (gray bars). On the vertical axis, it lists all RLMs in East Germany that were named as the "core region" of at least one IRGC project. The black lines indicate the duration of the indirect and regional IRGC treatments.

Fig. 1. Timing of IRGC Projects – Firm- and Regional-Level Treatments.

declares it to be the core region of an IRGC project for the first time (indicated by the black time lines in Fig. 1). This implies that our indirect and regional treatment definitions depend on the announcement of the first IRGC project rather than the disbursement of actual grants. As the incidence of multiple IRGC projects is often associated with either receiving follow-up funding for the same growth core or hosting several projects that are thematically related and based on similar networks, our definition provides the advantage that it does not inflate the actual number of treatments.[16] Nevertheless, we also conduct additional analyses to investigate whether the exposure to multiple or very large IRGC projects (as measured by the total sum of IRGC subsidies) has heterogeneous effects among indirectly treated firms.[17]

3. Data

In our firm-level analysis, we are the first to use confidential survey data provided by the Wissenschaftsstatistik of the Stifterverband (WiStat) in the area of innovation policies. On behalf of the BMBF, WiStat has collected information on private R&D activities in Germany since the early 1970s. With the objective to gather information in a census-like manner, WiStat conducts comprehensive surveys among innovative firms in Germany in all odd-numbered years.[18] These comprehensive surveys are complemented by smaller surveys of the largest R&D conducting firms in all even-numbered years. To obtain a more balanced panel, we use interpolation to generate yearly observations for firms with consecutive observations.[19] As participating in WiStat's surveys is not legally mandatory, the data collected do not include complete information on the entire population of innovative firms in Germany.[20] Nevertheless, they are particularly suitable for our analysis as they are highly comprehensive, unique in terms of time span and detail covered, and also represent the central source of information about innovative activities for the BMBF – the institution rolling out the IRGC program. Furthermore, in aggregated form, WiStat's data are an integral part of national reporting systems in Germany (e.g., the regional accounts) and also incorporated internationally (e.g., they are the German contribution to the "Community statistics on science and technology" required by the implementing regulation No. 995/2012 of the EU).

[16] E.g., Rostock hosted several growth cores thematically related to the shipbuilding industry and maritime technologies.

[17] We do not conduct a similar exercise at the regional level as we lack the statistical power to arrive at robust conclusions in this setting.

[18] WiStat defines a firm as the smallest part of a privately owned business enterprise that is required to provide balance sheet information. Since there is no administrative definition of the term "innovative firm", WiStat identifies the population of R&D conducting firms, among others, from previous R&D surveys and auxiliary variables such as a firm's industrial classification, its size and the receipt of public R&D subsidies.

[19] The results discussed below are robust to this decision; results without interpolation are available upon request.

[20] To minimize problems related to panel attrition or general unit- and item-non-response, WiStat complements the written surveys with telephone interviews and partly relies on imputing techniques for particularly important variables (i.e., total R&D expenditures and R&D personnel).

WiStat's surveys are designed according to OECD's Frascati Manual and collect information on R&D expenditures, R&D personnel, a small selection of general business indicators (i.e., total employment and turnover), and a set of questionnaire-specific questions. In our firm-level analyses, we focus on the effects of the IRGC on *total R&D expenditures*, defined as the overall yearly volume of expenditures classified for R&D purposes by the firm under consideration, *R&D personnel*, measured by the working hours per week (WHpW)[21] of all types of employees involved in R&D activities, and annual *turnover*. In the Appendix, we also consider R&D expenditures differentiated by sources of financing, R&D personnel differentiated by types of tasks, and the total number of employees as additional outcomes to provide a more comprehensive evaluation of the IRGC.[22] We interpolate missing values in even years if a firm participated in the comprehensive surveys before and after the year considered.[23]

Between 1995 and 2013, WiStat has collected information on 24,825 distinct firms with valid entries in at least one comprehensive or complementary survey. For 87.1% of these firms, it was possible to assign a Bureau van Dijk (BvD) identifier that allows to link the survey data with external information at the firm level. Among the firms with a valid BvD identifier, we are able to identify 287 (out of 389, i.e. 73.8%) private firms that participated in the first 13 waves of the IRGC.[24] Given WiStat's sample of innovative firms, we determine our final estimation sample by successively implementing the following restrictions: First, we drop 15,187 firms located in former West Germany as they are not eligible to apply for funding within the IRGC. Second, we omit 107 firms that move across RLM boundaries in former East Germany. Even though it is one of the IRGC's objectives to foster the clustering of (innovative) firms in targeted regions, actual firm relocations are rarely observed by WiStat (i.e., only 1.7% of all firms in East Germany move across RLM boundaries). As these moves pose a particular challenge for our indirect and regional analyses in that treatment exposure of these firms is highly selective, we choose to drop these few cases.[25] Finally, we exclude 918 firms that reside in Berlin so as to be consistent with our regional analysis and to alleviate concerns related to the specific industry and firm structure of Berlin. After restricting WiStat's data in this way, we obtain a final estimation sample of 5399 distinct innovative firms in East Germany. Of these, 231 received direct subsidies within the IRGC (directly treated). Among the firms not directly associated with the IRGC, 3069 are located in regions with at least one IRGC project (indirectly treated) while the remaining 2099 firms are located outside targeted regions (control group).

In Table A.3, we illustrate how these restrictions affect sample composition with respect to R&D expenditures, R&D personnel, turnover, and the total number of employees, both for all firms (Columns (1) and (2)) and for the directly treated ones (Columns (3) and (4)). For all firms, implementing these restrictions leads to a sharp reduction in the sample means of all outcomes across all years. For example, average R&D expenditures and average turnover in the unrestricted sample are roughly ten times larger than in the restricted one. A similar pattern also applies to R&D personnel and the number of employees overall. Especially the differences between Columns (1) and (2) reflect the substantial differences between innovative firms in Western and Eastern Germany, with eastern firms still lagging in almost all structural indicators of size and innovation efforts. These underlying fundamental difference are the main justification for the existence of the IRGC subsidies. With respect to the change in the composition of treated firms, a decisively different picture emerges in that the restricted sample of firms is very similar to the unrestricted one across all years and outcomes. While the sample restrictions imply a small reduction in the sample averages for the years before 2013, the restricted firms tend to be slightly larger than the unrestricted ones in the final year observed. However, all averages in Columns (3) and (4) are not statistically significantly different from each other.

Table 1 reports the industrial distribution of innovative firms included in our sample by treatment type and status (Columns (2) to (4)). Within the manufacturing sector (which is the main focus of the program), this table shows that the industrial composition of innovative firms in East Germany is relatively similar across treatment types and status. The resemblance of the industrial distribution between Columns (1) and (2), that is, between all innovative East German firms outside Berlin and the directly treated ones, indicates that the IRGC's allocation mechanism did not result in a specific industry benefiting disproportionately from the program. Furthermore, comparing the industrial structures between treated and non-treated regions (Columns (3) and (4)), differences between indirectly treated and non-treated firms are also limited. This is important for our regional analysis as it supports the assumption that non-treated regions are a suitable control group for IRGC regions.

To further assess potential effects of the IRGC at the regional level, we obtain data on gross value added (GVA), which denotes a direct measure for aggregate value creation, and four additional RLM-level outcomes: the number of startups, the stock of establishments, the number of employees, and productivity measured as GVA per employee. Beyond these additional outcome variables, we also assemble two sets of regional control variables that account for structural differences across regions. The first set of control variables includes population density, the share of the working-age population, the share of elderly people (> 65 y.o.), the share of females, the share of foreigners, the share of employees with a medium level of qualification, and the share of employees with a high level of qualification at the RLM level to accommodate for geographic and socio-economic differences between regions. The second set of controls is intended to address the concern that regions not hosting any IRGC projects might have been compensated with public funds from other sources. Therefore, our second set of control variables contains information on the amount of subsidies per capita that a given region received within the GRW and ERDF programs, which represent the two most important place-based policies in Germany, as well as from the BMBF.[26] Our two measures indicat-

21 In WiStat's surveys, working time for (groups of) employees can be distributed across different types of tasks, e.g., an individual's job description might only involve a small fraction of tasks that are classified as R&D activities. As this implies that some of the values of the R&D personnel variable take on very small values (i.e., smaller than one and close to zero), we convert the full-time equivalents surveyed by WiStat to the number of WHpW to reduce problems otherwise associated with the log-transformation in our empirical analyses.

22 See Tables A.1 and A.2 in Appendix A.3 for detailed descriptions of all outcome and control variables, respectively.

23 As we show in the Appendix, this interpolation does not affect results. Further results are available from the authors upon request.

24 Beyond these 287 firms, we are also able to match the BvD identifiers of 8 additional IRGC treated firms with WiStat's data. However, the BvD identifiers of these additional firms were assigned to multiple survey respondents. This may, for example, be caused by inconsistent definitions of the term "firm" employed by WiStat and BvD or M&A activities. As this ambiguity implies that we cannot identify the observations in the WiStat data that actually received the treatment, we drop these firms.

25 Note that our exclusion of moving firms does not apply to firms that terminate their activities in a specific location and start a new (but possibly related) activity in another area as these would be considered as separate entities in WiStat's data.

26 To calculate the amount of subsidies a region received from programs carried out by the BMBF, we downloaded all information that is available within the FdB. We aggregated the project-level data to the level of RLMs and calculated two measures. Our first measure is the sum of all expenditures the BMBF made toward a specific RLM, irrespective of the type of institution receiving the grant but excluding all IRGC projects, per capita. Our second measure considers only grants made to private institutions (i.e., only firms but not to universities or public research institutes).

Table 1
Distribution of firms by industrial sector (percentages).

Sector	East Germany w/o Berlin (1)	Directly Treated (2)	Indirectly Treated (3)	Controls (4)
Manufacturing	68.2	70.6	67.7	68.6
Textiles & leather	3.4	6.1	4.2	2.0
Chemicals & pharmaceuticals	4.2	3.5	4.0	4.4
Non-metallic products	3.4	4.3	3.0	3.9
Basic & fabricated metals	11.4	11.7	10.6	12.5
Electronics & optics	13.9	17.3	14.5	12.5
Machinery & equipment	14.7	14.3	15.4	13.7
Cars & transport	5.2	4.8	5.1	5.4
Other manufacturing	12.0	8.7	10.9	14.0
Services	19.2	24.7	20.7	16.4
Others	12.6	4.8	11.5	15.1
Total	100.0	100.0	100.0	100.0

Note: This table shows the industrial distributions of innovative firms included in our sample. We distinguish between four different groups: all firms in East Germany (excluding Berlin), directly treated firms, indirectly treated firms, and the control group. For data confidentiality reasons, we subsume firms in industrial sections or divisions (printed in italic) with more than 1 but less than 5 firms observed between 1995 and 2013 in the "Others" section or the "*Other manufacturing*" division.

ing regional funding from the BMBF are particularly important as they should capture any substitution of funding that might take place within the institution rolling out the IRGC.

4. Identification strategy

We apply DiD approaches at the firm and at the regional level to address the three levels of our evaluation. At the firm-level, the control group contains firms in Eastern Germany situated in regions that did not receive IRGC funding, even though they were in principle eligible. In the spirit of, e.g., Ahlfeldt et al. (2018), the first step is to study the temporal pattern of potential pre-trends using an event-study design, without imposing parametric constraints. For our study, the main purpose of this exercise is to determine whether the DiD parallel trend assumption holds (Angrist and Pischke, 2009), or – if it does not, e.g. due to the selection process of treated firms – whether there are reasonable approximations that can be applied in the subsequently employed parametric model.

With minor differences explained below, the event study models have the following form, which we spell out formally for the effects on directly treated firms:

$$TFE: \quad ln(y_{irt}) = \sum_{k\neq -1} \gamma_k \mathbf{1}\{K_{it} = k\} + \alpha_i + \delta_t + \epsilon_{irt} \tag{1}$$

where the natural log of an outcome y of firm i in RLM r and year t is regressed on firm α_i and year δ_t fixed effects (which we refer to as two-way fixed effects or TFE), as well as a full set of indicator variables depending on "relative time" K_{it}. It measures the difference between year t and the first year of treatment for treated firms.[27] For non-treated firms, K_{it} always assumes a value of zero. Consequently, the coefficients $\{\gamma_k\}$ indicate "pre-trends" for all periods $k < 0$ and dynamic treatment effects for $k \geq 0$.

In estimating effects on indirectly treated firms, note that all firms within a given region become "treated" at the same time and the treatment dummy varies only at the regional level (we have $K_{rt} = k$). Therefore, we cluster standard errors within RLMs. For the aggregate level analysis, outcome, treatment and fixed-effects apply to regions, not to individual firms. Given the broad and unspecific scope of the IRGC, we refrain from including any additional time varying controls as they could represent "bad controls" and, therefore, should instead be considered as separate outcomes (Angrist and Pischke, 2009).

Fig. 2 presents the pre-treatment results of the event studies at the three levels of analysis for the central outcomes.[28] In the three graphs in the first line, we consider the directly treated firms. As one might expect, here we find the clearest indications for potential issues with pre-trends. Firms that are selected into the program on average do follow significantly different trends for the central outcomes total R&D-expenditures, R&D personnel and turnover, than the control firms situated in regions that do not receive IRGC funding. Linear trends (based on the pre-treatment outcomes following Ahlfeldt et al. (2018)) capture these differences for all outcomes under consideration. For the indirectly treated firms (the three graphs in the second line of the figure) observed pre-trends are smaller and insignificant. The firms in this treatment group are not selected based on their characteristics, they are of interest to us because they are co-located with directly treated firms. Significant differences here would have indicated that treated regions – or certain industries therein – were on more (or less) dynamic growth trajectories. The outcomes at the regional level (the two outcomes in line three of the figures) reflect this finding in that there are no significant pre-trends – treated and non-treated regions display fewer differences than treated vs. non-treated firms.

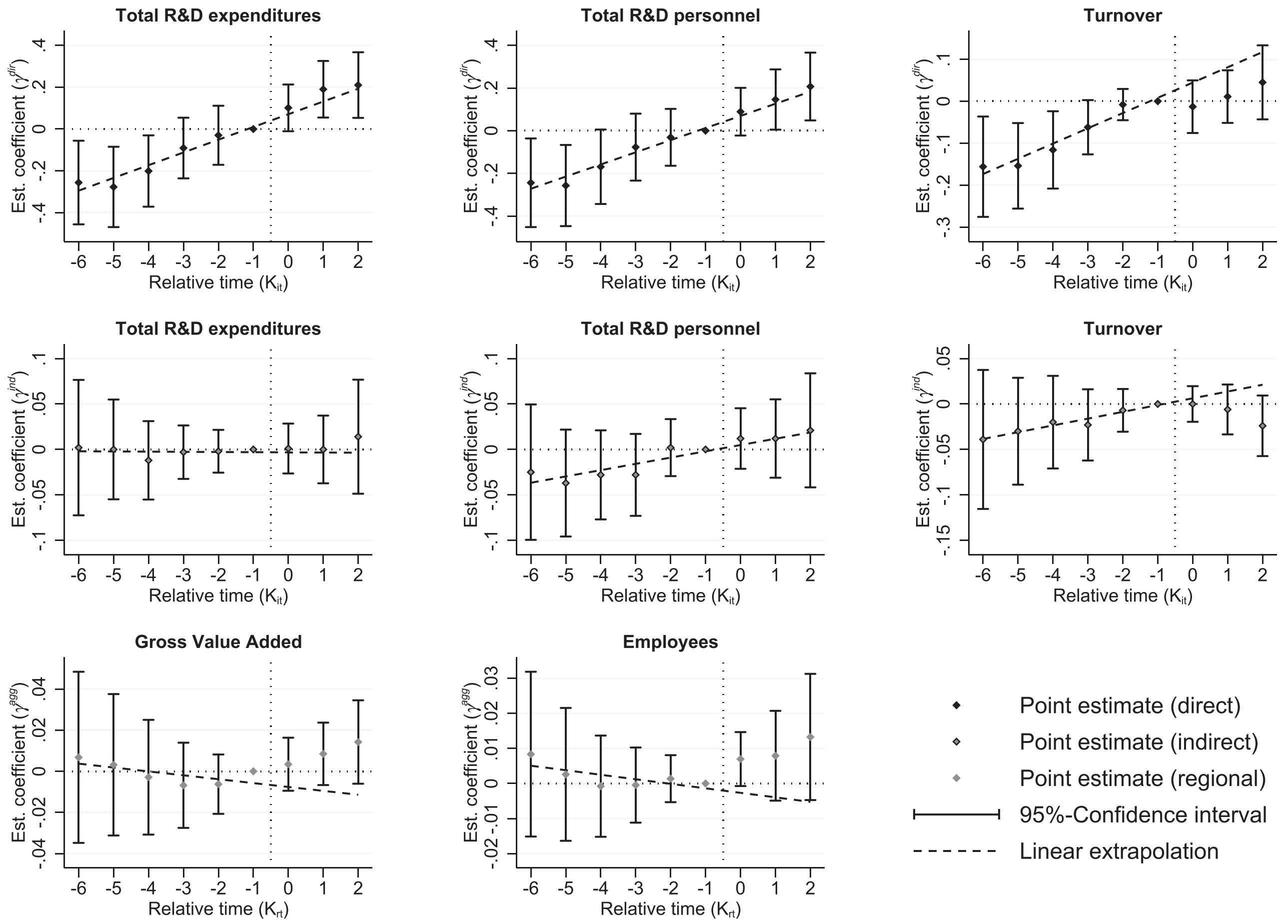
The results show that in the cases in which the pre-trends do diverge, this can be accounted for by introducing or "controlling for" linear pre-trends. To estimate a parsimonious model, we choose the following semi-dynamic DiD approach to evaluate the effects of the IRGC, which we again spell out for the analysis of direct effects at the firm level:

$$ln(y_{irt}) = \sum_{k=0}^{\bar{k}} \gamma_k \mathbf{1}\{K_{it} = k\} + \alpha_i + \delta_t + \mu t \cdot \mathbf{1}\{D_i > 0\} + \epsilon_{irt}. \tag{2}$$

Here, γ_k captures the treatment effects in post-treatment period k. For the evaluation of direct subsidies, we introduce a linear-trend for treated firms $\mu t \cdot \mathbf{1}\{D_i > 0\}$. For the indirectly treated firms and at the regional level, we instead allow for region-specific linear trends $\mu_r t$ (note also that here treatment is defined by regions). To keep the presentation of our results concise, we present dynamic average treatment effects for three intervals: years 0–1, years 2–3, years 4–5. We calculate these effects using weighted (by number of underlying

[27] In case of multiple treatments, which occur mainly in the context of indirect and regional effects, we use the first treatment year.

[28] The event study figures for all considered outcomes as well as non-interpolated data can be found in Figures A.2 to A.6 in the Appendix.



Note: This figure illustrates the results of the event study models according to in Equation (4.1) for $\{k\}_{-6}^{2}$. Outcome variables are interpolated in even years and expressed in natural logs. At the firm level, values smaller than one have been replaced by one prior to taking logarithms.

Fig. 2. Event Studies – Direct, Indirect, and Regional Analysis.

observations) averages of the estimated coefficients. The effects for the years thereafter, i.e., 6+, become noisy due to the time-window that we observe and ensuing attrition, so they are difficult to interpret; they are estimated, but not reported. Note that we already observe the fade-out of the treatment effect within the observed time-window, i.e., for years 4–5. Using the information on the funding amounts for individual projects, in an extension we are able to interact the treatment with the intensity – projects with funding above the median level are defined as high-intensity, while the remainder is defined as low-intensity.[29]

Finally, following Gobillon and Magnac (2016) we introduce interacted fixed effects (IFE) at the regional level, allowing for the existence of heterogeneous effects of macro shocks (such as the financial crisis) and ensuing potential spatial correlation. For instance, if politicians lobby for the allocation of IRGC projects because their jurisdiction is strongly affected by a current business cycle downturn, this could lead to biased estimates of the treatment effect. Similarly, technological progress may exhibit heterogeneous effects across regions if a specific invention affects individual industries more than others. In general, German innovation policy has a tendency to favor specific fields or technologies (e.g., biotechnology). If these tendencies are related to technological breakthroughs, it could give rise to biased estimates. Formally, we estimate:

$$ln(y_{rt}) = \sum_{k=0}^{\bar{k}} \gamma_k \mathbf{1}\{K_{rt} = k\} + \alpha_r + \delta_t + \mu_r t + \lambda_r' F_t + \epsilon_{rt}. \quad (3)$$

where F_t denotes a $L \times 1$ vector of common factors and λ_r an $L \times 1$ vector of factor loadings. We are trying to account for the fact that certain regions may be more (or less) susceptible to common shocks or business cycle effects than others due to unobserved characteristics such as industry composition at the local level. The factor loadings λ_r allow for individual regions r to be more or less exposed to commonly experienced shocks – the common factors, which are time-dependent and whose complexity is defined by L. We estimate the equation using the algorithm derived by Bai (2009) and derive the number of factors L, i.e., the dimensionality of potential common shocks – algorithmically based the information criterion (Bai, 2009; Bai and Ng, 2002).

[29] The median subsidy received by private firms according to the project database was about 220,000 Euro; firms below the median on average received about 120,000 Euro, while firms above the median on average received more than 620,000 Euro. Analogously, the median project was subsidized with a sum of about 5.3 million Euro. The average project below the median received subsidies worth 3.4 million Euro, compared to an average of 8.2 million Euro for the projects above the median.

Table 2
The IRGC program's effects on central outcomes.

Dep. Var.:	*Direct*			*Indirect*			*Regional*	
	R&D exp.	R&D staff	Turn-over	R&D exp.	R&D staff	Turn-over	GVA	Employ-ees
Years 0–1	0.171***	0.111	−0.056	−0.007	0.017	−0.001	0.006	0.004
	(0.069)	(0.076)	(0.044)	(0.025)	(0.028)	(0.016)	(0.008)	(0.007)
Years 2–3	0.201**	0.164	−0.056	0.007	0.029	−0.014	0.007	0.005
	(0.097)	(0.107)	(0.067)	(0.049)	(0.050)	(0.032)	(0.020)	(0.015)
Years 4–5	0.128	0.098	−0.097	−0.026	0.011	−0.004	−0.004	0.007
	(0.126)	(0.133)	(0.090)	(0.067)	(0.073)	(0.048)	(0.035)	(0.022)
Controls	N	N	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y	–	–
Lin. Tr.	Y	Y	Y	N	N	N	–	–
RLM Trs.	N	N	N	Y	Y	Y	–	–
Year-FE	Y	Y	Y	Y	Y	Y	–	–
RLM-FE	–	–	–	–	–	–	Y	Y
RLM Trs.	–	–	–	–	–	–	Y	Y
Year-FE	–	–	–	–	–	–	Y	Y
Factors	–	–	–	–	–	–	2	4
RLMs	53	53	53	53	53	53	53	53
Firms	1,918	1,918	1,918	4,300	4,300	4,300	–	–
N	15,013	15,013	15,013	33,659	33,659	33,659	1,007	1,007
Means	350.4	218.1	9,219.5	460.4	262.7	9,579.5	6,116.4	43.5
in 1999	TEUR	WHpW	TEUR	TEUR	WHpW	TEUR	MEUR	'000s

Note: This table shows the dynamic treatment effects of the IRGC during the sub-periods "Years 0–1", "Years 2–3", and "Years 4–5". We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects shown in this table are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. At the firm level, values smaller than one have been replaced by one prior to taking logs. Standard errors (shown in parentheses) are clustered at the firm level in the direct effects analysis and at the RLM level in the analyses of indirect and regional effects. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

5. Results

In this section, we discuss the outcomes of the evaluation at each of the three levels under consideration. Table 2 contains the results for the central outcomes of interest as an overview.[30] On average, there are no significant effects of the policy on the central outcomes for indirectly treated firms or at the regional level. For the directly treated firms, we observe a significant increase in total R&D spending in the range of 17–20% for the first four years after the subsidy is granted. This period corresponds to the average duration of payments received by firms through the IRGC program. This indicates that the program spurred R&D-spending in the short run, but did not initiate longer lasting innovative efforts by firms that were directly treated independent of the funds received.

To get a feeling for the size of this effect in relation to IRGC-spending, we can derive a lower bound for the magnitude of the effect on total spending by firms. In 1999, the average firm in our sample in total spent 350.4 TEUR on R&D efforts. Treated firms – by the result above – increased their yearly spending by between 60 TEUR and 70 TEUR for four years starting at treatment. This overall additional spending sums up to 240 to 280 TEUR, which can be compared to the approximately 377 TEUR that were spent in subsidies in the course of the IRGC on participating firms. While taking the 1999-averages for total spending as a starting point is a rather conservative assumption (given growth of spending over time), this back of the envelope-calculation is not an indication for the existence of any substantial multiplier effects of the received public subsidies.

A further obvious question to ask is whether crowding out of private investment is one of the issues driving this result. For this, we can consider the more detailed results of the direct treatment by funding source, as depicted in Table 3.[31] Additional spending is driven only by significant increases in outlays financed from public sources (such as the IRGC program). The fact that there is no significant change in privately funded spending cannot be taken as definitive evidence that no crowding out effect is present, because the IRGC's funding guidelines require a significant private co-financing of any project undertaken under its auspices. This private effort washes out in the data, which we consider a further indication for the existence of crowding-out of private investment.

With regard to the other outcomes – R&D staff and turnover – we find no statistically significant effects of the policy. The effect on overall employees is both statistically and economically insignificant. For R&D personnel, though, the effects are sizeable and the statistical insignificance is driven in part by the size of the standard errors, which could be a measurement issue. The "cleanest" estimate regards the total number of research personnel, where the effect implies an approximately 16% increase in years 2–3 after treatment (which is also on the verge of statistical significance), then drops substantially in years 4–5. This shape mirrors the effect on expenditures, which fades out after the funding period.

The only channel for which we observe significant effects on average therefore is increased research spending by subsidized firms. Based on our data, we are able to differentiate by treatment intensity, i.e., the amount of funding received by firms. We define treatments as high-intensity, if the amount received is above the median of those observed. An overview of the effects on the central outcomes is displayed in Table 4. We find that both for directly and indirectly treated firms, the size of the grants received does matter systematically.

With regard to total spending, there are no differential effects between the recipients of smaller or larger grants. Again, we find effects in a similar magnitude for the first 4 years as the baseline effect, while higher intensity yields no additional significant benefits. Zooming in on the different sources of funding further illuminates this picture (see Table A.5). For the larger subsidies, it is only the public spending that balloons by an additional 65–83% while IRGC funding continues, while the effect on the private share is statistically unchanged. For the two years after the IRGC funding runs out (i.e., years 4–5), the difference

[30] In Tables A.4, A.7., and A.10, we provide results for specifications including controls as a robustness check – these are qualitatively unchanged.

[31] See Table A.6, for more details on the indirect effects of the IRGC.

Table 3
More details on the direct effects of the IRGC.

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	0.171***	−0.025	0.406**	0.111	0.156	0.051	−0.056	−0.005
	(0.069)	(0.135)	(0.207)	(0.076)	(0.125)	(0.146)	(0.044)	(0.040)
Years 2–3	0.201**	−0.086	0.559*	0.164	0.212	0.141	−0.056	−0.017
	(0.097)	(0.168)	(0.308)	(0.107)	(0.167)	(0.199)	(0.067)	(0.065)
Years 4–5	0.128	0.004	−0.151	0.098	0.217	0.099	−0.097	0.009
	(0.126)	(0.197)	(0.409)	(0.133)	(0.194)	(0.256)	(0.090)	(0.093)
Controls	N	N	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
Lin. Tr.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	1918	1918	1918	1918	1918	1918	1918	1918
N	15,013	15,013	15,013	15,013	15,013	15,013	15,013	15,013
Means in 1999	350.4 TEUR	314.6 TEUR	30.3 TEUR	218.1 WHpW	126.8 WHpW	45.7 WHpW	9219.5 TEUR	75.9 Count

Note: This table shows dynamic treatment effects for the directly treated firms during the sub-periods “Years 0–1”, “Years 2–3”, and “Years 4–5”. We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the firm level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

is even more pronounced. Firms receiving higher subsidies report more than twice the research spending funded publicly. This indicates that they are significantly more likely to obtain consecutive public grants from different sources. For the period after the IRGC funding, the recipients of larger subsidies display a significant reduction in private R&D spending. While these firms are more adept at securing public funding, the observed effects on overall and privately funded spending indicate that the additional public returns of larger grants are doubtful. This is in line with finding in the literature that larger firms (in our case, larger grants) are more likely to be associated with gaming of the system (Criscuolo et al., 2018).

Differentiating by intensity (i.e., the size of the project at the regional level) also provides additional detail on the indirectly treated firms. Here, we find significant and sizable negative effects of the baseline low intensity on R&D staff: reductions in the range of 6–9% in the first four years. The more detailed channels depicted in Table A.8 indicate that the weekly working hours of scientists, i.e., researchers with university degrees, decrease by approximately 15 h (or about 0.4 FTE) by firm. There are two potential explanations for this: First, in tight labor markets for qualified personnel, it appears plausible that firms receiving IRGC funding compete with the remaining firms, poaching individuals or driving up wages. Beyond this, though insignificant, the reduction in publicly funded R&D-spending could indicate that IRGC-funding at the regional level does crowd out other public sources of funds (in practice, although there are no formal mechanisms in place which would have to cause this) for innovative firms to be used on R&D and specialized personnel.

The picture changes for firms in regions that hosted larger projects. Relative to the baseline, indirectly treated firms in regions with high treatment intensity (which on average received almost five million Euros in additional IRGC-funding) increased their scientist and total R&D by an additional 18–33% (for a net gain of about 0.4–0.6 FTE scientists or 0.6 to 1.0 overall research staff). This effect again lasts beyond the direct funding of the IRGC. Importantly, it is not driven by the indirectly treated firms’ additional research investments. Their R&D expenditures from all funding sources remain flat irrespective of treatment intensity (again, with the potential exception of publicly funded R&D). For the potential channels, this implies that the local labor market channel is unlikely to be the (only) driver of the observed effects. If more money pours into the treated firms in a region, they should be more likely and able to drive up wages and poach personnel away from untreated firms. It is conceivable, though, that the increased demand for more sophisticated services and intermediate products overcompensates for the labor market effect. Finally, the larger treatment amount – or the prestige from winning a large project subsidy – could also conceivably make the region more attractive for R&D employees, drawing in additional labor supply.

Finally, we briefly focus on the lack of results at the aggregate level for any of the outcomes (see also Table A.9 for the full set). The average funding size of IRGC projects is about 6.4 MEUR, or 0.1% of the average GDP of the regions under consideration, which is non-negligible. But given the (lack of) spending multiplier of the subsidy and the weak (nonexistent) effects on R&D staff (total employees), the results at the aggregate level are completely consistent. Beyond this, we also do not observe any increase in the startup-activity in the observed time frame.

6. Discussion

In the last few years, a growing body of theoretical and empirical research has focused on the question of whether place-based policies are effective in promoting regional growth. Even though growth theory emphasizes the key role that innovation plays for (regional) development (Lucas, 1988; Romer, 1990), the regional effects of innovation policies still require study. This holds even more as politicians appear to be increasing their focus on fostering regional growth by the means of (place-based) innovation policies.

We develop a methodological framework that allows us to analyze the causal effects of a large place-based innovation policy not

Table 4
Effects on central outcomes depending on treatment intensity.

Dep. Var.:	*Direct*			*Indirect*		
	R&Dexp.	R&Dstaff	Turn-over	R&Dexp.	R&Dstaff	Turn-over
Years 0–1	0.160	0.113	–0.100	–0.044	–0.065***	0.007
	(0.100)	(0.103)	(0.067)	(0.033)	(0.027)	(0.016)
Years 2–3	0.225*	0.139	–0.061	–0.034	–0.091**	–0.003
	(0.128)	(0.138)	(0.101)	(0.058)	(0.055)	(0.033)
Years 4–5	0.154	0.070	–0.085	–0.078	–0.139	0.004
	(0.156)	(0.158)	(0.116)	(0.071)	(0.071)	(0.057)
Years 0–1	0.021	–0.007	0.091	0.078	0.176***	–0.018
$\times$ $\mathbf{1}\{High\}$	(0.128)	(0.129)	(0.099)	(0.043)	(0.031)	(0.034)
Years 2–3	–0.050	0.052	0.012	0.087	0.253***	–0.023
$\times$ $\mathbf{1}\{High\}$	(0.131)	(0.137)	(0.116)	(0.091)	(0.069)	(0.061)
Years 4–5	–0.046	0.063	–0.031	0.110	0.306***	–0.020
$\times$ $\mathbf{1}\{High\}$	(0.163)	(0.161)	(0.141)	(0.109)	(0.082)	(0.089)
Controls	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y
Lin. Tr.	Y	Y	Y	N	N	N
RLM Trs.	N	N	N	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53
Firms	1918	1918	1918	4300	4300	4300
N	15,013	15,013	15,013	33,659	33,659	33,659
Means in 1999	350.4 TEUR	218.1 WHpW	9219.5 TEUR	460.4 TEUR	262.7 WHpW	9579.5 TEUR

Note: This table shows dynamic treatment effects for the directly treated firms during the sub-periods "Years 0–1", "Years 2–3", and "Years 4–5". We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the firm level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

only at the firm, but also at the regional level. In this pursuit, we are among the first to use confidential firm-level survey data that enters into official German statistics and assemble a comprehensive data set of regional indicators to answer the following three questions: (1) Did the IRGC induce additional innovation efforts by firms directly subsidized through the program? (2) Did other innovative firms that were located in the same regions but did not receive subsidies benefit from the IRGC? (3) Did the IRGC cause measurable improvements at the regional level?

We attempt to answer these questions using a quantitative evaluation approach. This is important to emphasize due to the fact that the official evaluation of the program, commissioned by the Ministry, is based on a mostly qualitative questionnaire study with voluntary participation – the official evaluation concludes that the policy was "very successful" and recommends continuing it without any qualifications.[32]

Considering the direct effects on subsidized innovative firms first, we find that they do increase their overall R&D activity. This effect, however, persists only within the short and medium run while the funding from the IRGC program lasts, but not beyond the period during which subsidies are paid out. Further, according to our results, the additionally induced overall R&D spending by firms (irrespective of funding source) on average is significantly smaller than the subsidies spent on the program. The fact that the policy requires matching co-investment from private firms further exacerbates this finding. This apparent crowding-out is even more pronounced for larger projects, as the differentiation by treatment intensity reveals.

This casts substantial doubts on the cost-effectiveness of the program, but there are potential mitigating factors: First of all, the policy also aims at stimulating employment in the treated firms and regions. While we do find that certain measures of R&D-related employment in directly treated firms respond positively, the effect – again – does not last beyond the period of IRGC project funding. In addition to this, there is no observed increase in the firms' employees overall. This is particularly problematic given the fact that firms have substantial discretion in using the program subsidies for project-related personnel outlays – therefore, a (short-term) increase in research staff was not accompanied by commensurate other investment.

The second possible mitigating factor, which is embedded in the program design, is the potential for positive spillovers to other firms in the region. With regard to the effects on other firms in regions that benefit from the program, there is no robust evidence that the outcomes of interest are on average affected. In those regions receiving larger subsidies, we do find positive effects on R&D staff levels of non-treated firms; but again, these appear not to be driven by additional expenditures for innovation.

Finally, we find no indication that the IRGC discernibly affected aggregate regional prosperity as measured by five different outcomes. Taken together, our results are in line with the broader literature on the effectiveness of cluster policies and suggest that, despite continued public efforts, local spillovers are not easily generated by political means. Especially given the fact that the observed

[32] The evaluation can be viewed at https://www.unternehmen-region.de/_media/UR_Evaluation%20_WK_2016_web_bf_final.pdf, last accessed on September 24, 2019.

employment effects of the policy dissipate after the subsidies run out, more efforts need to be taken in the design of the IRGC and similar policies to mitigate the issue of crowding out of private R&D-investment.

Declaration of competing interest

We declare that we have no relevant or material financial interests that relate to the research described in the paper "Evaluating a Place-Based Innovation Policy: Evidence from the Innovative Regional Growth Cores Program in East Germany" submitted for publication consideration in *Regional Science and Urban Economics*.

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A. Appendix

A.1. Additional Program Details

A.1.1. Defining the Term 'Region'

Despite the IRGC's regional focus, the geographic boundaries of the term "region" are not defined within the program itself. The only reference made in this regard is that federal states (*Bundesländer*) are not considered to be regions and that a functional connection within the collaborations has to be made explicit in the application process (BMBF, 2016c). However, a pragmatic approach towards narrowing down the scope of this term can be based on two remarks: First, every IRGC-funded collaboration has to declare a so called *core region* in which most of the significant activities of the growth core have to take place. In many cases, the core regions match the names or centers of German counties. Second, the IRGC has been complemented by the Growth Cores Potential (GCP) program in 2007 (BMBF, 2016b). The GCP aims to prepare the grounds for an IRGC funded project by bridging public research and R&D conducting companies residing in the same geographic areas. Importantly, the program motivates scientists from universities and public research institutes to collaborate with companies located within 50 km distance to explore the opportunities for shaping joint platform technologies. Even though this 50 km distance threshold has most likely not been strictly enforced, it is relatively close to the average dimension of a typical regional labor market (RLM) as defined by the BBSR. Since RLMs nest the administrative entities of counties under consideration of regional commuter flows, we consider them to be a sensible choice for a definition of regions in the context of the IRGC. Furthermore, on average around 61% of the entities subsidized within a given project receiving more than 64% of project funds also reside in the RLM assigned to this project. 18% of the overall funds (more than 48% of the unaccounted for funds) accrue to public research institutions outside of the project area, i.e., in the most cases scientific partners located in the vicinity of universities. 13% of overall funds are allocated to private project partners in western Germany (out of sample) or to eastern German firms in regions that were also treated. Note that all firms receiving funding are defined as directly treated. Therefore less than 5% of total funds go to east German firms located in regions that we define as "not treated" in our regional specifications.

A.1.2. The Application Process

The application process begins with a consultation of the applicants and the project executing organization Projektträger Jülich (PtJ). After this consultation, the applicants have to submit an idea sketch that is subsequently examined by PtJ. If this examination is successful, the applicants are invited to an interview with the BMBF and have to prepare a so-called innovation concept, which is essentially a business plan for their collaborative innovation project, as well as a formal grant proposal. After submitting both documents to PtJ, the applicants are invited to an assessment center conducted by the BMBF in collaboration with a jury of external experts which makes the final funding decision.

A.2. Additional Graphs

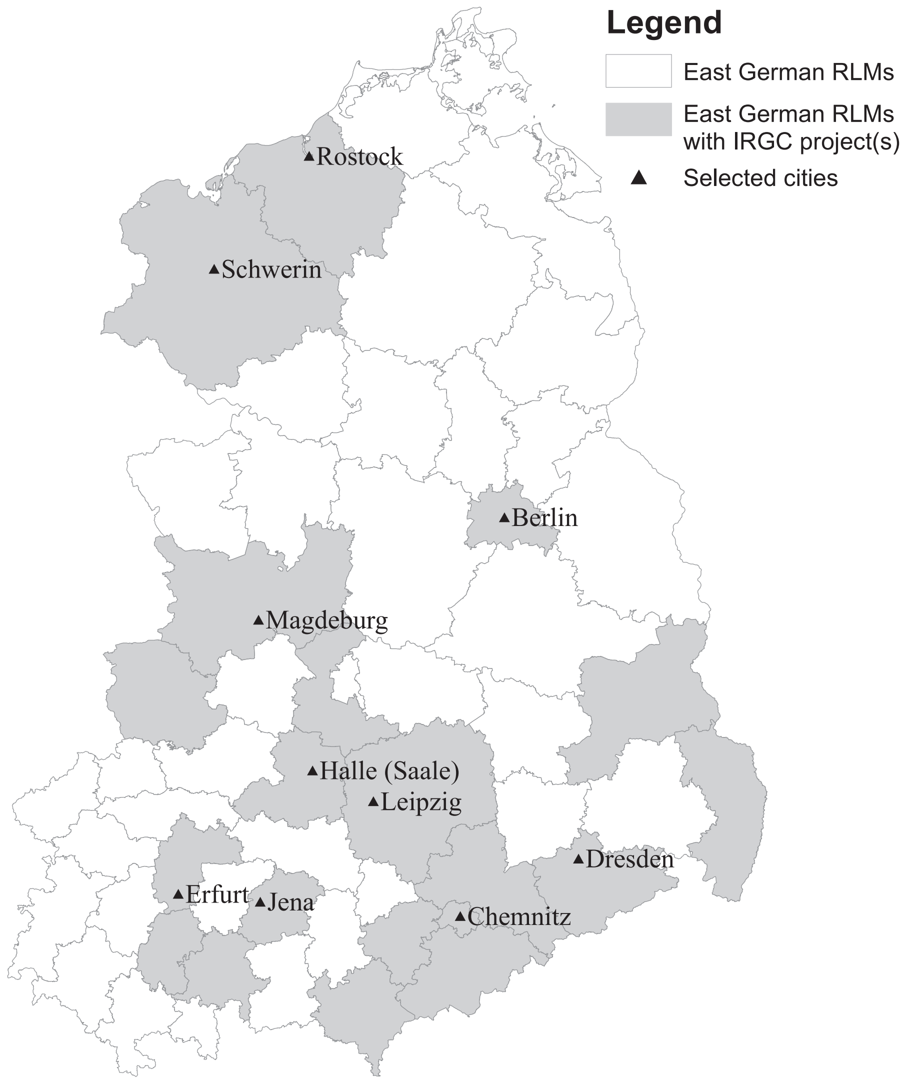

Fig. A.1 IRGC Treated Regions. *Note*: This map illustrates the geographic distribution of IRGC funding in the RLMs of East Germany. Grey shaded regions indicate RLMs that were "core regions" of at least one IRGC project between 2001 and 2013.

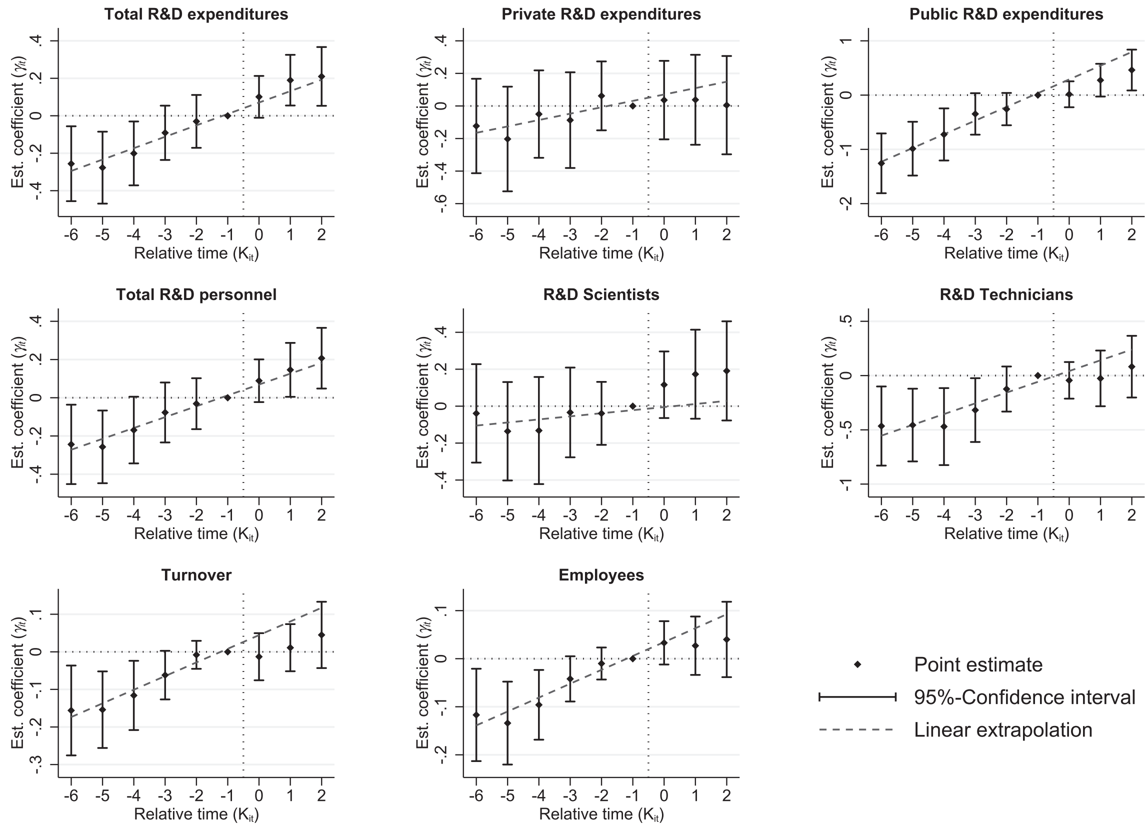

Fig. A.2 Event Studies – Directly Treated Firms. *Note*: This figure illustrates the results of the event study models shown in Equation (1) for $\{k\}_{-6}^{2}$, respectively. Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. TFE estimates are denoted by white diamonds with black outline, TFE + LT estimates are depicted by black diamonds. Solid and dotted whiskers denote confidence intervals at the 95% level.

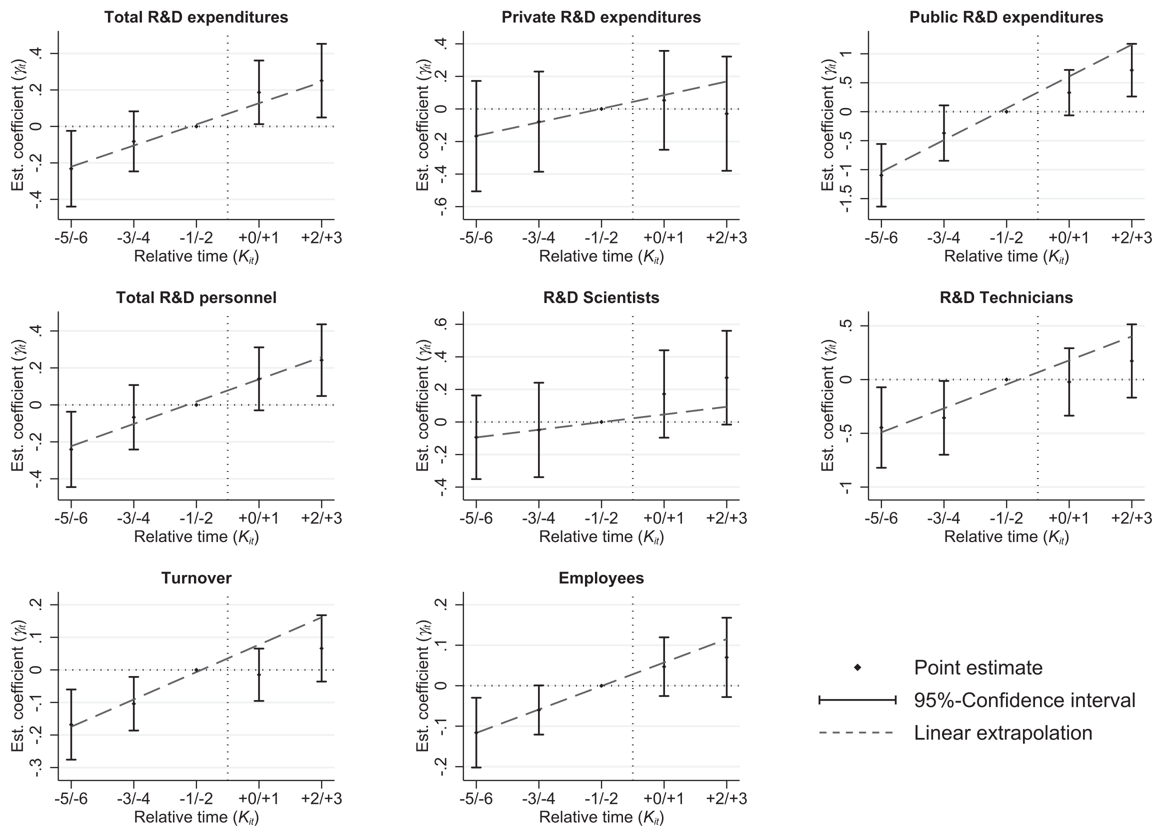

Fig. A.3 Event Studies – Directly Treated Firms (Non-Interpolated Data). *Note*: This figure illustrates the results of the event study models shown in Equation (1) for $\{k\}_{-6}^{2}$, respectively. Outcome variables are expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. TFE estimates are denoted by white diamonds with black outline, TFE + LT estimates are depicted by black diamonds. Solid and dotted whiskers denote confidence intervals at the 95% level.

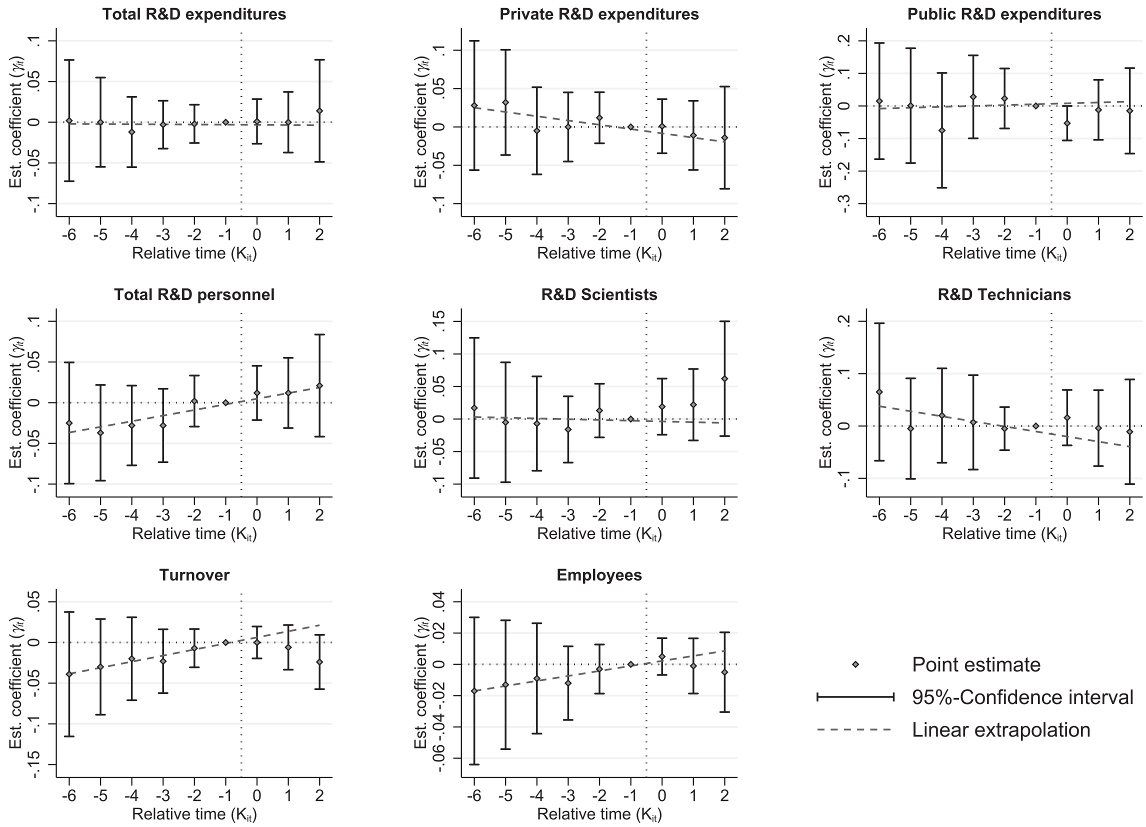

Fig. A.4 Event Studies – Indirectly Treated Firms. *Note*: This figure illustrates the results of the event study models shown in Equation (1) for $\{k\}_{-6}^{2}$, respectively. Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. TFE estimates are denoted by white diamonds with black outline; TFE + LT estimates are depicted by grey diamonds with black outline. Solid and dotted whiskers denote confidence intervals at the 95% level.

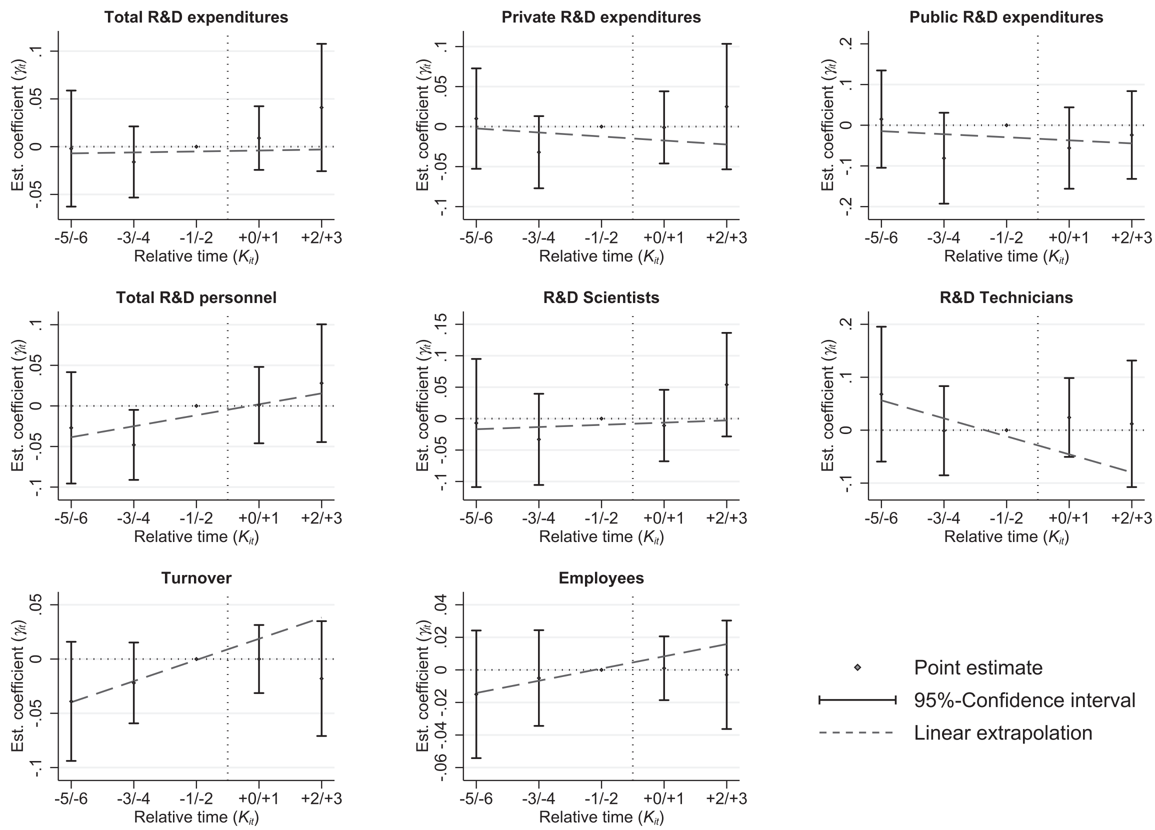

Fig. A.5 Event Studies – Indirectly Treated Firms (Non-Interpolated Data). *Note*: This figure illustrates the results of the event study models shown in Equation (1) for $\{k\}_{-6}^{2}$, respectively. Outcome variables are expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. TFE estimates are denoted by white diamonds with black outline; TFE + LT estimates are depicted by grey diamonds with black outline. Solid and dotted whiskers denote confidence intervals at the 95% level.

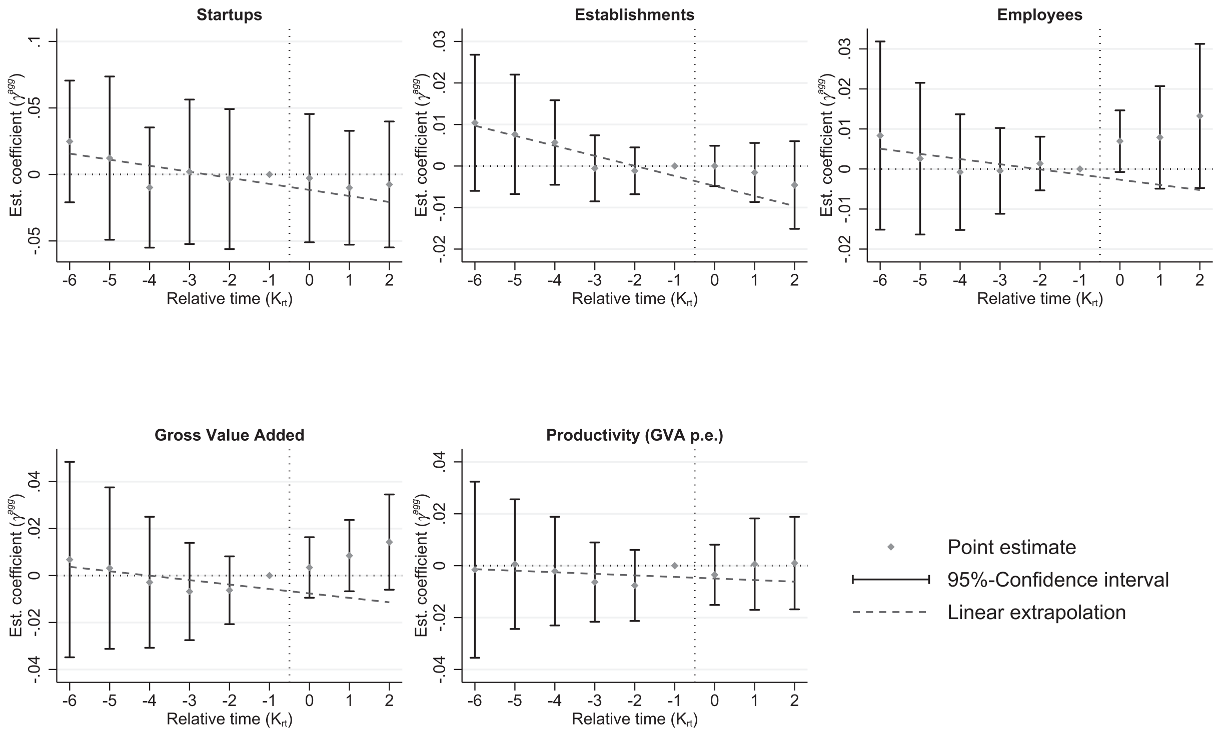

Fig. A.6 Event Studies – Aggregated Data. *Note*: This figure illustrates the results of event study models for $\{k\}_{-6}^{2}$, respectively. TFE + LTs estimates are denoted by white diamonds with grey outline whereas the grey diamonds depict the TFE + LTs + IFE model that is associated with the most preferable pre-trends according to our selection algorithm. If no TFE + LTs + IFE model reduces pre-trends relative to a TFE + LTs benchmark, we only show the results for the latter. Solid and dotted whiskers denote confidence intervals at the 95% level.

A.3. Additional Tables

Table A.1
Definition of Outcome Variables

Outcome	Description	Source
Firm-level data		
Total R&D exp.	Volume of expenditures classified for R&D purposes, TEUR	WiStat
Private R&D exp.	Volume of R&D expenditures financed by own firm or own firm group (domestic and abroad), TEUR	WiStat
Public R&D exp.	Volume of R&D expenditures financed from public programs funded by domestic authorities or the European Union, TEUR	WiStat
R&D personnel	Time spent on R&D activities by any type of employee, WHpW	WiStat
R&D scientists	Time spent on R&D activities by scientists, i.e., tasks that mainly involve scientific research, WHpW	WiStat
R&D technicians	Time spent on R&D activities by technicians, i.e., mainly applied or technical tasks that are often supervised by scientists, WHpW	WiStat
Turnover	Annual turnover, TEUR	WiStat
Employees	Number of employed individuals, head count	WiStat
RLM-level data		
Startups	Number of startups as defined by Hethey and Schmieder (2010)	BHP7514
Estabslihments	Number of establishments	BHP7514
Employees	Number of employees, '000s	FEA
GVA	Gross value added, MEUR	VGRdL
Productivity	Productivity, GVA (in TEUR) per employee	VGRdL & FEA

Note: Total R&D expenditures is not equal to the sum of private and public R&D expenditures, as it also includes other funding sources such as financing obtained from other businesses. However, these other sources of financing account for less than 5% of average expenditures. Similarly, R&D personnel does not equal the sum of R&D scientists and R&D technicians, as it also includes other types of R&D tasks (accounting for less than 17% of all R&D activities on average).

Table A.2
Definition of Control Variables

Control variable	Description	Source
Population density	Number of residents per km^2	FSO & GEO
Share working-age population	Share of population between 18 and 64 years old	FSO
Share elderly	Share of population older than 64 years	FSO
Share females	Share of female population	FSO
Share foreigners	Share of foreigners	FSO
Share medium-level qualifications	Share of employees with medium-level qualifications	BHP7514
Share high-level qualifications	Share of employees with medium-level qualifications	BHP7514
GRW bus. subs. p.c.	GRW subsidies for private businesses, TEUR p.c.	BAFA
GRW inf. subs. p.c.	GRW subsidies for public infrastructure, TEUR p.c.	BAFA
EFRE bus. subs. p.c.	EFRE subsidies for private businesses, TEUR p.c.	BAFA
EFRE inf. subs. p.c.	EFRE subsidies for public infrastructure, TEUR p.c.	BAFA
BMBF subs. (w/o IRGC) p.c.	BMBF subsidies (w/o IRGC), TEUR p.c.	FdB
BMBF bus. subs. (w/o IRGC) p.c.	BMBF subsidies for private businesses (w/o IRGC), TEUR p.c.	FdB

Note: Wissenschaftsstatistik of the Stifterverband (WiStat), Establishment History Panel 1975–2014 (BHP7514), Federal Employment Agency (FEA), Volkswirtschaftliche Gesamtrechnung der Länder (VGRdL).

Table A.3
Sample Restrictions (Firm-Level)

		Overall		Treated	
	Mean of	Unrestricted (1)	Restricted (2)	Unrestricted (3)	Restricted (4)
1995	R&D exp.	4,363.6	427.1	720.2	658.5
	R&D pers.	40.1	7.3	10.5	9.5
	Employees	687.2	99.4	148.5	120.0
	Turnover	115,698.7	9,172.2	12,771.8	10,247.5
	Obs	6,016	1,782	76	65
2001	R&D exp.	5,869.2	472.4	817.3	776.2
	R&D pers.	40.6	5.7	9.3	8.9
	Employees	566.0	77.6	115.3	110.4
	Turnover	138,586.7	11,641.9	13,681.1	12,996.7
	Obs	7,171	2,108	103	89
2007	R&D exp.	5,553.1	701.2	922.9	915.1
	R&D pers.	33.4	6.8	9.7	9.5
	Employees	417.3	76.2	127.1	100.5
	Turnover	139,284.2	15,983.3	18,796.4	16,075.8
	Obs	9,204	2153	173	144
2013	R&D exp.	5399.9	581.8	647.0	675.6
	R&D pers.	28.3	6.1	7.7	8.0
	Employees	397.5	71.0	108.5	111.0
	Turnover	153,659.1	17,205.9	23,337.1	24,115.8
	Obs	12,223	2,555	244	199

Note: This table shows how the sample restrictions discussed in Section 3 affect sample composition with respect to all firms (Columns (1) and (2)) and treated firms only (Columns (3) and (4)). The unrestricted sample (Columns (1) and (3)) contains all firms surveyed by WiStat in their comprehensive or complementary surveys. The restricted sample (Columns (2) and (4)) is used in the firm-level estimations and contains only firms in East Germany that do not move across RLM boundaries.

Table A.4
Direct Effects of the IRGC w/ Controls

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	0.169***	–0.024	0.397**	0.115	0.157	0.038	–0.055	–0.005
	(0.069)	(0.136)	(0.206)	(0.077)	(0.124)	(0.145)	(0.045)	(0.040)
Years 2–3	0.196**	–0.091	0.545*	0.168	0.215	0.113	–0.055	–0.014
	(0.098)	(0.169)	(0.306)	(0.108)	(0.166)	(0.199)	(0.069)	(0.066)
Years 4–5	0.119	0.007	–0.217	0.108	0.218	0.078	–0.101	0.009
	(0.126)	(0.200)	(0.407)	(0.134)	(0.193)	(0.259)	(0.094)	(0.096)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
Lin. Trs.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	1,918	1,918	1,918	1,918	1,918	1,918	1,918	1,918
N	15,013	15,013	15,013	15,013	15,013	15,013	15,013	15,013
Means	350.4	314.6	30.3	218.1	126.8	45.7	9,219.5	75.9
in 1999	TEUR	TEUR	TEUR	WHpW	WHpW	WHpW	TEUR	Count

Note: This table shows dynamic treatment effects for the directly treated firms during the sub-periods “Years 0–1”, “Years 2–3”, and “Years 4–5”. We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the firm level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.5
Direct Effects of the IRGC w/ Interactions

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	0.160	0.147	–0.021	0.113	0.077	–0.002	–0.100	–0.034
	(0.100)	(0.134)	(0.252)	(0.103)	(0.148)	(0.198)	(0.067)	(0.068)
Years 2–3	0.225*	0.122	0.204	0.139	0.081	0.113	–0.061	–0.060
	(0.128)	(0.179)	(0.339)	(0.138)	(0.213)	(0.252)	(0.101)	(0.102)
Years 4–5	0.154	0.273	–0.672	0.070	0.102	0.121	–0.085	–0.069
	(0.156)	(0.204)	(0.455)	(0.158)	(0.223)	(0.296)	(0.116)	(0.121)
Years 0–1	0.021	–0.334	0.834***	–0.007	0.156	0.107	0.091	0.054
$\times$ $\mathbf{1}\{High\}$	(0.128)	(0.240)	(0.349)	(0.129)	(0.223)	(0.269)	(0.099)	(0.104)
Years 2–3	–0.050	–0.403	0.655*	0.052	0.269	0.073	0.012	0.084
$\times$ $\mathbf{1}\{High\}$	(0.131)	(0.271)	(0.362)	(0.137)	(0.238)	(0.293)	(0.116)	(0.118)
Years 4–5	–0.046	–0.560*	1.105***	0.063	0.251	–0.073	–0.031	0.166
$\times$ $\mathbf{1}\{High\}$	(0.163)	(0.289)	(0.442)	(0.161)	(0.226)	(0.374)	(0.141)	(0.136)
Controls	N	N	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
Lin. Trs.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	1,918	1,918	1,918	1,918	1,918	1,918	1,918	1,918
N	15,013	15,013	15,013	15,013	15,013	15,013	15,013	15,013
Means	350.4	314.6	30.3	218.1	126.8	45.7	9,219.5	75.9
in 1999	TEUR	TEUR	TEUR	WHpW	WHpW	WHpW	TEUR	Count

Note: This table shows dynamic treatment effects for the directly treated firms during the sub-periods “Years 0–1”, “Years 2–3”, and “Years 4–5”. We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the firm level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.6
Indirect Effects of the IRGC

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	–0.007	–0.013	–0.069	0.017	0.003	0.070*	–0.001	0.006
	(0.025)	(0.030)	(0.049)	(0.028)	(0.036)	(0.036)	(0.016)	(0.011)
Years 2–3	0.007	–0.006	–0.079	0.029	0.043	0.116	–0.014	0.008
	(0.049)	(0.054)	(0.079)	(0.050)	(0.058)	(0.071)	(0.032)	(0.024)
Years 4–5	–0.026	–0.023	–0.194	0.011	0.019	0.153	–0.004	0.014
	(0.067)	(0.075)	(0.120)	(0.073)	(0.080)	(0.093)	(0.048)	(0.034)
Controls	N	N	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLM Trs.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
N	33,659	33,659	33,659	33,659	33,659	33,659	33,659	33,659
Means in 1999	460.4 TEUR	368.1 TEUR	67.9 TEUR	262.7 WHpW	152.7 WHpW	58.4 WHpW	9,579.5 TEUR	78.6 Count

Note: This table shows dynamic treatment effects for the indirectly treated firms during the sub-periods “Years 0–1”, “Years 2–3”, and “Years 4–5”. We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the RLM level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.7
Indirect Effects of the IRGC w/ Controls

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	–0.018	–0.022	–0.080	–0.007	–0.011	0.039	–0.005	0.001
	(0.024)	(0.031)	(0.053)	(0.028)	(0.034)	(0.043)	(0.015)	(0.009)
Years 2–3	–0.011	–0.020	–0.087	–0.013	0.016	0.062	–0.017	0.000
	(0.049)	(0.056)	(0.086)	(0.047)	(0.051)	(0.074)	(0.029)	(0.021)
Years 4–5	–0.049	–0.042	–0.225	–0.049	–0.027	0.083	–0.014	–0.001
	(0.067)	(0.080)	(0.136)	(0.068)	(0.071)	(0.101)	(0.048)	(0.031)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLM Trs.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
N	33,659	33,659	33,659	33,659	33,659	33,659	33,659	33,659
Means in 1999	460.4 TEUR	368.1 TEUR	67.9 TEUR	262.7 WHpW	152.7 WHpW	58.4 WHpW	9,579.5 TEUR	78.6 Count

Note: This table shows dynamic treatment effects for the indirectly treated firms during the sub-periods “Years 0–1”, “Years 2–3”, and “Years 4–5”. We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the RLM level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.8
Indirect Effects of the IRGC w/ Interactions

Dep. Var.:	*ln R&D Expenditures*			*ln R&D Personnel*			*ln Econ. Outcomes*	
	Total	Private	Public	Total	Scien-tists	Techni-cians	Turn-over	Employ-ees
Years 0–1	–0.044	–0.052	–0.095	–0.065***	–0.102***	0.046	0.007	0.005
	(0.033)	(0.042)	(0.064)	(0.027)	(0.036)	(0.053)	(0.016)	(0.011)
Years 2–3	–0.034	–0.052	–0.010	–0.091**	–0.085**	0.003	–0.003	0.005
	(0.058)	(0.058)	(0.094)	(0.055)	(0.070)	(0.092)	(0.033)	(0.015)
Years 4–5	–0.078	–0.100	–0.094	–0.139	–0.140	0.059	0.004	0.019
	(0.071)	(0.077)	(0.127)	(0.071)	(0.096)	(0.120)	(0.057)	(0.022)
Years 0–1	0.078	0.082	0.053	0.176***	0.223***	0.054	–0.018	0.001
$\times$ $\mathbf{1}\{High\}$	(0.043)	(0.053)	(0.096)	(0.031)	(0.043)	(0.060)	(0.034)	(0.023)
Years 2–3	0.087	0.100	–0.136	0.253***	0.268***	0.227**	–0.023	0.005
$\times$ $\mathbf{1}\{High\}$	(0.091)	(0.097)	(0.121)	(0.069)	(0.085)	(0.117)	(0.061)	(0.047)
Years 4–5	0.110	0.157	–0.190	0.306***	0.327***	0.195	–0.020	–0.008
$\times$ $\mathbf{1}\{High\}$	(0.109)	(0.116)	(0.146)	(0.082)	(0.094)	(0.138)	(0.089)	(0.059)
Controls	N	N	N	N	N	N	N	N
Firm-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLM Trs.	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
RLMs	53	53	53	53	53	53	53	53
Firms	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
N	33,659	33,659	33,659	33,659	33,659	33,659	33,659	33,659
Means in 1999	460.4 TEUR	368.1 TEUR	67.9 TEUR	262.7 WHpW	152.7 WHpW	58.4 WHpW	9,579.5 TEUR	78.6 Count

Note: This table shows dynamic treatment effects for the indirectly treated firms during the sub-periods "Years 0–1", "Years 2–3", and "Years 4–5". We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are interpolated in even years and expressed in natural logs. Values smaller than one have been replaced by one prior to taking logs. Monetary variables are denoted in TEUR (R&D expenditures and turnover), R&D personnel in WHpW, and employees in head counts. Standard errors are clustered at the RLM level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.9
Aggregate Effects of the IRGC (w/o Berlin)

Dep. Var.:	Startups	Establish-ments	Employees	GVA	Productivity (GVA p.e.)
Years 0–1	0.005	0.002	0.004	0.006	0.001
	(0.027)	(0.004)	(0.007)	(0.008)	(0.009)
Years 2–3	0.045	0.008	0.005	0.007	–0.006
	(0.030)	(0.008)	(0.015)	(0.020)	(0.017)
Years 4–5	0.070	0.016	0.007	–0.004	–0.007
	(0.055)	(0.013)	(0.022)	(0.035)	(0.029)
Controls	N	N	N	N	N
RLM-FE	Y	Y	Y	Y	Y
RLM Trs.	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y
Factors	1	3	4	2	3
RLMs	53	53	53	53	53
N	1,007	1,007	1,007	1,007	1,007
Means in 1999	742.3 Count	6,027.8 Count	138.1 Count ('000s)	6,116.4 MEUR	43.5 TEUR p.e.

Note: This table shows dynamic treatment effects at the regional level (RLMs) during the sub-periods "Years 0–1", "Years 2–3", and "Years 4–5". We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are expressed in natural logs. Startups, establishments and employees are measured as counts, GVA in million Euros and productivity as GVA per employee. Standard errors are clustered at the RLM level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table A.10
Aggregate Effects of the IRGC w/ Controls (w/o Berlin)

Dep. Var.:	Startups	Establish-ments	Employees	GVA	Productivity(GVA p.e.)
Years 0–1	0.004	0.004	0.005	0.003	–0.002
	(0.027)	(0.004)	(0.007)	(0.008)	(0.009)
Years 2–3	0.051	0.004	0.007	0.007	–0.012
	(0.033)	(0.008)	(0.016)	(0.019)	(0.019)
Years 4–5	0.069	0.017	0.012	–0.005	–0.016
	(0.057)	(0.014)	(0.025)	(0.032)	(0.029)
Controls	Y	Y	Y	Y	Y
RLM-FE	Y	Y	Y	Y	Y
RLM Trs.	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y
Factors	1	3	4	2	3
RLMs	53	53	53	53	53
N	1,007	1,007	1,007	1,007	1,007
Means in 1999	742.3 Count	6,027.8 Count	138.1 Count ('000s)	6,116.4 MEUR	43.5 TEUR p.e.

Note: This table shows dynamic treatment effects at the regional level (RLMs) during the sub-periods "Years 0–1", "Years 2–3", and "Years 4–5". We omit the effects for all years beyond the 6th year after treatment as the effects become noisy and hard to interpret due to attrition. The effects are weighted averages of the respective γ coefficients estimated based on Equation (2). Outcome variables are expressed in natural logs. Startups, establishments and employees are measured as counts, GVA in million Euros and productivity as GVA per employee. Standard errors are clustered at the RLM level and presented in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.regsciurbeco.2019.103480.

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