The Extension of Clusters: Difference-in-Differences Evidence from the Bavarian State-Wide Cluster Policy

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Abstract

If one cluster increases local competitiveness, can politicians, by interlinking clusters, achieve an even better effect at the state level? To answer this question, the paper analyzes the "Cluster Initiative" introduced in 1999 by the Bavarian State Government. The purpose of the initiative was to create a Bavarian-wide innovation network in support of state-wide knowledge flows. Using a difference-in-differences approach, we find that introducing the Bavarian-wide cluster policy increased the likelihood of innovation by a firm in the targeted industry by 4 to 7 percentage points. However, this effect is mainly driven by large firms' increased likelihood to innovate.

JEL Code: R38, R11, O32.

Keywords: difference-in-differences, cluster policy, regional policy.

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1. Introduction

Paradoxically, even though the world is becoming increasingly globalized, with decreasing transportation and transaction costs diminishing distances and allowing global sourcing, there is at the same time a rich body of academic literature celebrating the "re-emergence of local economics" (Sable 1989). Most firms can now easily spread their activities around the world, and yet they choose to cluster some activities in certain regions. This phenomenon leads Porter (1998, p. 90) to the conclusion that "enduring competitive advantages in a global economy are often heavily localized, arising from concentrations of highly specialized skills and knowledge, institutions, rivalry, related businesses, and sophisticated customers." Porter calls a regional concentration of certain firms or industries that benefit from the local environment a *cluster*, a term that quickly became a major buzzword in the field of regional economics.

Porter's concept of clusters is a practical application of a wide body of literature in the field of agglomeration theories. However, it lacks a sound theoretical framework and does not provide any empirical evidence beyond case studies. Thus, the cluster concept eventually gains legitimacy by incorporating more specialized approaches which can be found in the field of agglomeration theory. Among the theory-driven approaches, the fairly recent field of "New Economic Geography" focuses on the pecuniary external scale economies arising from decreasing transportation and transaction costs (cf. Krugman 1991, Fujita *et al.* 2000); approaches related to the industrial organization literature focus on modeling the mechanism of knowledge spillovers (cf. Loury 1979; Dasgupta and Stiglitz 1980); and empirical analyses attempt to explain the process of regional agglomeration (Ellison and Glaeser 1997), and examine the role of spillovers (Griliches 1979; Acs et al. 1994) and knowledge flows (Jaffe *et al.* 1993; Audretsch and Feldman 1996). However, and particularly outside the academic arena, it is still Porter's cluster approach that is the dominant analytical concept in regional development. “From the OECD and the World Bank, to national governments (such as the UK, France, Germany the Netherlands, Portugal, and New Zealand), to regional development agencies (such as the new Regional Development Agencies in the UK), to local and city governments (including various US States), policy-makers at all levels have become eager to promote local business clusters” (Martin and Sunley 2003, p. 6).

The popularity of Porter’s cluster concept is based in its generality and vagueness; thus it can be employed in a variety of contexts. According to Porter, clusters may occur at different geographic levels and he also stresses the importance of social ties as a cluster’s social glue. However, he does not define clear boundaries for a cluster’s geographic or industrial extension. The same is true for the concept of social ties as “pipes” for knowledge flows; Porter (1998, p. 202) only mentions that “cluster boundaries should encompass all firms, industries, and institutions with strong linkages [while] those with weak and non-existent linkages can safely be left out.” Against this background, Martin and Sunley (2003) question the practicability and profundity of Porter’s cluster concept and fear that the arbitrary deployment of cluster policies could mean taking the right sort of step but in the wrong direction. One example of a bound understanding of the mechanisms underlying a cluster is the attempt to push structurally weak regions toward forming a cluster by awarding grants to a university in the hope that a great deal of valuable knowledge will be produced and leads to a thriving environment. Unfortunately, knowledge created in a vacuum has no way of escaping.

Against this background, the paper intends to provide some empirical evidence for the applicability of the cluster concept as policy tool to support cooperation among industries and thus support regional competitiveness. In 1999, the Bavarian State Government introduced a “Cluster Initiative” with the aim of creating a Bavarian-wide innovation network in support of state-wide knowledge flows. Using a difference-in-differences approach, which has been fruitfully applied in labor economics to identify the causal effect of labor market programs on a certain outcome (e.g., the probability of finding a job), we identify the causal effect of the Bavarian cluster-oriented economic policy on firms' innovation behavior. We find that the introduction of the Bavarian-wide cluster policy increased the likelihood of innovation by a firm in the targeted industry by 4 to 7 percentage points.

The rest of the paper is organized as follows. Section 2 provides a theoretical basis for the economic mechanisms assumed to underlie a cluster and Section 3 describes the Bavarian Cluster Initiative. Sections 4 and 5 introduce the empirical method and the data, leading to the results presented in Section 6. Finally, Section 7 concludes with implications for further research and for the use of a cluster policy.

2. Clusters, Innovation, and the Role of Policy

Local agglomerations, or "clusters", are theorized to influence firm competitiveness in at least three ways. Cooperation of firms along the supply chain stimulates productivity enhancing process innovations; the geographical proximity of different firms induces knowledge flows that can be the basis of product innovations; and externalities in the production of knowledge can be absorbed by new businesses. These agglomeration effects have their foundation in Marshall's (1890) idea of external economies of scale resulting from access to a common labor market and shared public goods, saved transportation and transaction costs due to the proximity of firms along the supply chain, and spillovers that result from industry secrets being readily discerned due to proximity. Taken together, these externalities contribute to local endogenous innovation and productivity growth (Martin and Sunley 1998). The underlying mechanism is as follows. According to Baumol (2002), successful innovation is the major weapon employed by incumbents against entry and/or competition and Aghion *et al.* (2008) integrate this concept into a Schumpeterian growth model where innovation drives dynamics and growth results from incumbents' attempt to "escape entry" or "escape competition."

All these concepts are based in the understanding that competition for new ideas has become the major driver of economic growth in today's knowledge-based society. When engaged in fierce competition at the technological frontier, constant innovation is the only way a firm can match up to competitors in the long run. So, if knowledge and new ideas are drivers of growth and dynamics, what determines their location and fluctuation?

In an attempt to provide some empirical evidence for the location decision of firms, Ellison and Glaeser (1997) propose an index to measure geographic industry concentration. Starting from a situation where firms choose their location merely for idiosyncratic purposes, they trace the occurrence of "over-agglomerations" to the existence of two kinds of agglomerative forces—natural advantages and spillovers. While natural advantages may explain the location decision of resource-based industries, such as mining, wine production, or shipbuilding, spillovers are more likely to explain the location decision of knowledge-based industries where knowledge spillovers result from "working on similar things and hence benefiting from each other's research" (Griliches 1992). The close interconnection between the social and the economic networks within a community (e.g., friends who work for different firms) makes knowledge spill over—it jumps, or runs, or "spills" from firm to firm via the social network. Thus, a community's social life acts as a knowledge multiplier, increasing the pool of geographically bound knowledge (cf. Anselin *et al*. 1997).

Depending on a region's industry structure, agglomeration theory distinguishes between two types of knowledge flows that result in spillovers. On the one hand, there are Marshall-Arrow-Romer externalities from regional specialization in one particular industry, leading to so-called localization economies. These externalities are most likely to result from firm relations along the supply chain where shared routines and knowledge allow for productivity enhancing (process) innovations. On the other hand, there are Jacobs externalities resulting from knowledge flows between firms of different industries. Following Jacobs (1969), a diverse industry structure in support of such urbanization economies is most likely to be found in metropolitan areas where there is a diverse firm structure along with private and public R&D laboratories engaged in basic research, thereby creating knowledge that can "spill" out into the air, thus creating an atmosphere comprised of a variety of intellectual externalities just waiting to be absorbed. These inter-industry spillovers are considered especially important as they can lead to the discovery of something completely new, for example, a product or a process, which in turn leads to growth as the new thing is developed and enhanced and promoted (cf. Glaeser *et al.* 1992).

All externalities result from regional cooperation in the creation of input factors, which, in turn, contribute to the competitiveness of all local firms. Accordingly, government, in its desire for dynamic and prospering regions, has an incentive to support the development of such clusters. However, firms and other actors cannot be forced to cooperate from the top down by government; instead, cooperation is the result of continuous contact and the trust that grows from it. As mentioned by Schmitz (1999, p. 142), "for a deep division of labor and cooperation between firms to be effective at reasonable cost, trust is essential." Trust is crucial, then, in the diffusion of regional knowledge.

However, there are two sides to knowledge diffusion. On the "dark" side, rapid knowledge diffusion undermines the appropriability of "exclusive" rents arising from the lock in of knowledge. However, on the "brighter" side, knowledge diffusion across a network of firms, or, in other words, a cluster, can also act as a multiplier, resulting in the creation of new knowledge and, therefore, additional but "collective" rents open to all firms in the region. Of course, whether this multiplier is a benefit is critically dependent on the extent to which the firm will have access to the collective rents from a local knowledge stock, i.e., the intensity of knowledge diffusion. In this regard, trust in reciprocity assures that each network member is willing to feed the network with new knowledge (Powell 1990). Also, the stronger the social ties within a network, the higher the probability of being caught out as a free-rider. Assuming that free-riding would, in a worst-case scenario, lead to an exclusion from the network, the costs of free-riding usually exceed the benefits.

The importance of strong social ties suggests that trust is more likely to develop between geographically proximate agents because transactions and cooperation in form of frequent face-to-face contacts and informal meetings is less costly at this level (Dei Ottati 1994; Williamson 1999). However, if knowledge flows are determined only by geographical proximity and, hence, costs of transactions and cooperation, there remains an important policy question, namely: Are there additional gains from cooperation and could these be exploited by interlinking existing local clusters? Regarding the gains, Burt's (1992) theory of structural holes suggests that a network's dynamics are largely driven by the creation of new productive ties between existing networks that allow for additional knowledge flows. This leaves us with the question of whether politicians can build on existing network structures and try to strengthen and develop them as part of a public-private partnership.

This sort of public-private partnership would be especially interested in creating connecting platforms that increase knowledge flows. Such platforms connect actors of similar industries and thus create new and productive ties. Knowledge creation and innovation particularly gain from firm cooperation as the individual risk of failure decreases. Furthermore, pooling ideas from different firms can act as a multiplier—that is, each firm "stands on the shoulders" of the others. Additionally, government can support (basic) research institutions that further stimulate the innovation process, as well as provide other services that leverage innovation by making private R&D more effective. However, it must be noted that such institutions create spillovers and have the desired result *only* if they are already embedded in an existing industry structure.

By providing infrastructure in the form of supporting institutions and services, government acts, in a Schumpeterian manner, as an entrepreneur and provides leadership by, first, recognizing an opportunity and, second, taking advantage of it. Note, however, that this does not mean that government should act as the entrepreneur by actually creating new firms or products. We are in agreement with Hayek (1978) in this matter, and believe that politicians do not have better information than the market and thus should not interfere with the market's search for new ideas. Rather, government should be entrepreneurial by creating supporting institutions and services for up and coming industries. For instance, today's knowledge-based production is heavily dependent on human capital and creativity and thus requires a different environment than a capital-based mass production economy. This environment is very fluid and can change quickly and so government needs to keep a careful eye on the future, watching for developments and trends, so as to be able to adjust institutions in a time-appropriate way. In this context, the government's success—its pioneer rent—is reflected in a prospering and dynamic environment that attracts firms and eventually results in a regional agglomeration or cluster.

3. The Bavarian State-Wide Cluster Policy

One example of governmental action to foster cooperation among industries in order to support regional competitiveness is the Bavarian State Government's "Cluster Initiative," the focus of this paper. Since its introduction in 1999, the Cluster Imitative has worked to further mobilize the inherent strengths of companies through the formation of tightly woven regional cooperation networks in the form of clusters. Bavaria is one of the largest German states and thus it should be possible to discern the effects of a state-wide cluster policy as compared to more narrowly defined local cluster policies that exist in all German states. Once we have done so, we will be able to evaluate whether it is useful to pursue a cluster policy at the state level or whether all the possibly positive effects of clusters are locally bound.[1] If we discover

[1] For an overview of the cluster policies in German states, see Kiese and Schätzl (2008).

a positive effect of the Bavarian state-wide cluster policy, it will be a clear indication that cluster effects are not completely locally bound.

In 1999, Bavaria was the first German state to initiate a highly visible, state-wide cluster policy. The Cluster Initiative allocated around 1.45 billion euro for developing prime technologies in the state. This program was the successor to the Initiative for Bavaria's Future Development, which was begun in 1994 with a budget of around 4 billion euros, but no clear direction as to how this money should be spent. The 1999 initiative remedied this lack of direction by defining five key technologies as eligible for support: life science, information and communication technology, new materials, environmental technologies, and mechatronics. The initiative rests on four pillars: the development of world-class technology centers; technology concepts for all areas within Bavaria; a state-wide qualification, infrastructure, and start-up network; and the internationalization of the initiative. One of the initiative's chief goals is to link science, business, and finance in order to foster innovation activity and development in Bavaria.

Not until 2001 did other German states follow Bavaria's lead and introduce their own state-wide policies (Hesse and Saarland took such a step in 2001, Thuringia followed in 2002). However, the Bavarian program dwarfs the other states' programs, both in visibility and scope.

4. Method

In theory, the main advantage of clusters is their contribution to innovation by way of competition. Thus, we are interested in estimating the effect of a state-wide cluster policy on the innovation of firms in the targeted industries. Therefore, we use difference-in-differences methodology (cf. Campbell 1969; Card 1990). The key estimation equation is the following:

$$inno_{fsit} = \alpha_s + \alpha_i + \alpha_t + \beta\, cluster_{sit} + \chi X_{fsit} + \varepsilon_{fsit} . \qquad (1)$$

Here, f stands for the firm, s for the state, i for the industry, and t for time. The outcome variable *inno* is a binary variable that takes the value of 1 if firm f has introduced an innovation in year t. α_s are state fixed effects, α_i are industry fixed effects, and α_t are time fixed effects.

The *cluster* variable is a binary variable that takes the value of 1 when there is a cluster policy in industry i in state s in year t. The coefficient β is the coefficient of interest indicating the effect of the cluster policy on a firm's innovation behavior.

X is a matrix of control variables. It includes time-varying control variables at both the state and industry level. These control variables, which capture state-specific and industry-specific business cycles that may affect innovation, consist of employment growth rates at different levels of aggregation and are derived from the Social Insurance Statistics. In addition, we consider firm-level control variables, namely, the firm size and whether the firm has introduced an innovation in the preceding year. The latter variable captures all unobserved time-invariant firm-level impetus for innovation.

As the dependent variable is binary, Equation (1) is estimated by both a linear probability model and by a probit model. In both procedures, cluster-robust standard errors are calculated at the state level. Calculating cluster-robust standard errors accounts for adding covariates at different levels of aggregation (cf. Moulton 1986) and for interrelations of firms within a state (cf. Williams 2000). These interrelations may result along the supply chain (input-output relations) or may be the result of cooperation in the innovation process.

5. Data

Industry-specific innovation activities of manufacturing firms are derived from the Ifo Innovation Survey (see Lachenmaier 2007, for a description of the dataset). More than 1,000 surveyed firms report yearly on whether or not they have introduced an innovation, i.e., a product or process innovation. Furthermore, firms report whether the innovation required

R&D expenditures or resulted from a patent. In our opinion, this detail captures the notion that those innovations that required R&D are of greater importance than those that did not and that those innovations that were patented are of even higher importance due to the fact that patenting is costly. However, as patenting behavior is highly industry specific (cf. pharmaceutics), we give first preference to the innovations that required R&D expenditure when evaluating the importance of an innovation.

The surveyed firms are a subsample of firms that are surveyed monthly for business cycle research. Because these firms participate regularly in the Innovation Survey, the panel character of the data is guaranteed.

The voluntary character of the Ifo innovation survey does not necessarily lead to a sample that is representative for Germany as a whole. Therefore, we compare the distribution of firms in our sample with the population of firms provided by the Federal Statistical Office. Doing so shows that we oversample large firms and undersample small firms throughout the sample period (cf. Figure A1 in the Appendix). This is because business cycle research surveys tend to include a larger number of large firms that represent a large share of the economy in terms of employees and/or sales. Furthermore, the 2-digit-NACE industries 15 and 28 are notably underrepresented in the Ifo survey while industry 21 is overrepresented (cf. Figure A2 in the Appendix).

The federal states of Bavaria, Saxony, and Thuringia are over-represented compared to other German regions. This over-representation possibly results from the geographical proximity of the surveying research institute—the Ifo Institute of Economic Research—to all three regions (cf. Figure A3 in the Appendix). However, for our purpose the treatment group are Bavarian firms, while the control group consists of firms in all other states. Therefore, the exact distribution of the control group is less important—as long as we control for location. Consequently, we can still make our inferences by controlling for firm size, industry, and state affiliation of the firm. Following Winship & Radbill (1994), this is both appropriate and more efficient than weighing the data.

As already mentioned, we regroup the surveyed firms from two-digit manufacturing industries into 10 broader industry groups to obtain the largest possible overlap with the technologies defined in the state-wide Bavarian cluster program (cf. Table A1 in the Appendix). The data from the Ifo Innovation Survey are available from 1982 to 2006. To track a single firm before and after the introduction of a specific state-wide cluster policy, we consider only those firms in our data with a spell that spans from three years before the introduction of the cluster policy to three years after its introduction, i.e., 1996–2001. This restriction forced us to remove a large number of firms from our sample. However, we want to use the panel character of our data in order to control for time-invariant unobserved firm characteristics and we do not want to extend the time span beyond 2001 as state-wide cluster policies were introduced in other German states at that time. This procedure results in a firm-level balanced panel dataset with six yearly observations per firm. Additionally, possible endogeneity of the form that firms might be induced to change their location from some other state to Bavaria in order to benefit from the initiative is taken care of. Only those firms are included in the finale sample that did not move between states during the six years. Our final sample consists of 270 firms; each of the firms is followed for six years. Seventy-four of the firms are located in Bavaria; 196 are located in other German states. Out of the 74 firms located in Bavaria, 46 belong to industries targeted by the cluster policy. Of the 270 firms in our sample, 41 have more than 500 employees.

Figure 1 provides a preliminary look at the evolution of innovations across industries and states. Yearly innovation rates for our sample are simply calculated as the number of firms that have introduced an innovation over all firms in a state's industry. Thereby, innovation rates are calculated on the basis of important innovations, i.e., innovations that required R&D expenditures. Figure 1 plots the evolution of innovation rates before and after the 1999 introduction of the state-wide cluster policy in Bavaria. Innovations rates are calculated separately both for industries that were targeted by the cluster policy and for industries that were not. A further distinction is made between Bavarian industries and industries in states that have not introduced a state-wide cluster policy.

Figure 1: The Evolution of Innovation Rates (Important Innovations)

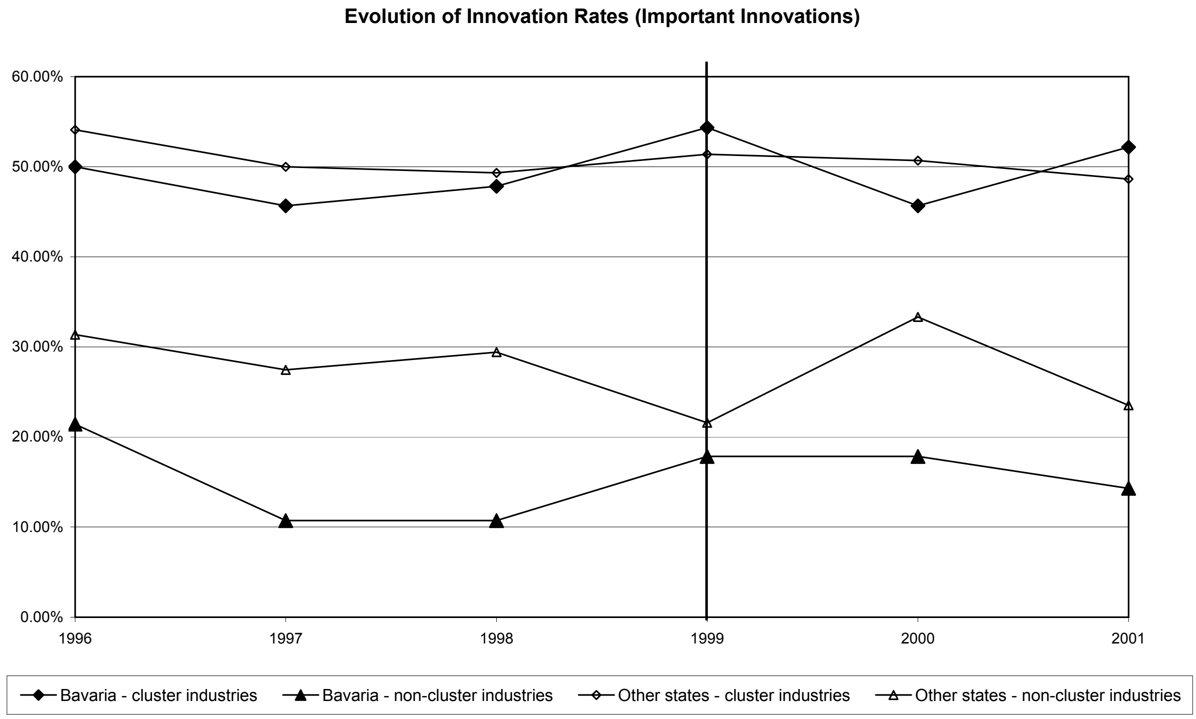


Figure 1 has three very striking aspects. First, innovation rates in industries targeted by the Bavarian cluster policy are higher than those for other industries, both in Bavaria and in the other German states. However, as these differences in the levels of innovation rates are later on wiped out in the difference-in-differences approach by the fixed effects, they are of no further importance in light of this paper. Secondly, innovation rates in the industries targeted by the Bavarian cluster policy show an increase in the year of the policy's introduction and even though this rate decreases slightly in the next, the rate continues to be as least as high every year after the initiative's introduction as it was prior to introduction. Thirdly, the same year (1999) that the Bavarian cluster policy was introduced, a clear peak in the innovation rates appears. To ensure that we do not just evaluate the short-term deflagration effect based on the Bavarian cluster policy's introduction, we will analyze its effect over a three-year time span. As discussed above, we do not want to extend the analysis beyond 2001 because other German states start introducing their own policies in that year.

6. Results

Table 1 reports the results of our estimations. The left panel of Table 1 shows the results of the linear probability model; the probit estimates are set out in the right panel. The dependent variable takes the value of 1 when the firm has either introduced an innovation in general or an innovation that required R&D expenditure, the latter reflective of a more important innovation. The coefficient of interest is the cluster variable coefficient, which can be interpreted as the impact of the state-wide Bavarian cluster policy on innovations in the targeted industries.

Table 1: Results

	Linear Probability Model		**Probit Model**	
	Innovation in general	Important innovation	Innovation in general	Important innovation
Cluster	0.0470	0.0658**	0.198*	0.287**
	(1.73)	(2.26)	(1.88)	(2.46)
lagged innovation	0.451***	0.491***	1.285***	1.435***
	(16.2)	(14.9)	(14.8)	(13.2)
lagged employees (log)	0.0678***	0.0606***	0.278***	0.254***
	(10.1)	(7.24)	(8.46)	(6.12)
Industry-level employment growth rate	-0.0205	-0.0446	-0.0502	-0.168
	(-0.69)	(-1.07)	(-0.58)	(-0.89)
State-level employment growth rate	0.0684	0.0859	0.311	0.342
	(0.73)	(0.87)	(0.64)	(0.78)
Constant	0.298***	-0.394***	-1.509***	-1.209***
	(3.15)	(-7.25)	(-3.57)	(-3.05)
Year dummies	incl.	incl.	incl.	incl.
Industry dummies	incl.	incl.	incl.	incl.
State dummies	incl.	incl.	incl.	incl.
Observations	1342	1312	1332	1307
Adjusted R-squared	0.38	0.42	0.325	0.362

Cluster-robust standard errors on the state level. t-statistics in parentheses.
*** statistically significant at the 1% level
** statistically significant at the 5% level
* statistically significant at the 10% level.

We find that the state-wide Bavarian cluster policy had a positive impact on innovation. The magnitude of the effects is economically meaningful. The interpretation of the linear probability models leads to the result that the introduction of the state-wide cluster policy increases the likelihood of innovation by a firm in the targeted industries by 4.7 to 6.58 percentage points. However, when taking innovation in general, the coefficient is not significantly different from zero. To interpret the coefficients reported in the probit model we have to calculate the marginal effects. As in Puhani (2008), we compute these marginal effects for a discrete change in the cluster variable from zero to one for all firms subject to the Bavarian initiative. In other words, we calculate the marginal effect as mean over the individual marginal effects of all firms in the treatment group. Standard errors are calculated by the delta method. Again, the calculated standard errors are the means over all individual standard errors. Doing this, leads to a positive marginal effect of the cluster initiative on the likelihood of innovation of 4.9 to 7 percentage points for innovation in general and important innovation respectively (cf. Table 4).

As robustness checks, we also run the regressions for West German states only as it is possible that development in East Germany, due to its different history, might be driven by factors other than those at play in West Germany. Furthermore, we run the regressions for the largest West German territorial states, i.e., Bavaria, Baden-Württemberg, North Rhine-Westphalia, and Lower Saxony. In these larger states, it should be possible to disentangle the effects of a state-wide cluster policy from the effects of the more narrowly defined local cluster policies that exist in all German states, whereas in the smaller states even a very local cluster policy might actually encompass the entire state. Table 2 shows that the coefficients of the cluster variable become somewhat smaller in the linear probability model, although the changes are not dramatic. In the preferred probit specification coefficients of the cluster variable also decrease slightly but remain significant, especially so in the sub-sample of West German territorial states. For the interpretation of those coefficients we again have to calculate the marginal effects. Doing this we can report increases of the probability to

Table 2: Results, West Germany and Large Territorial States

	Linear Probability Model				Probit Model			
	West German States		West German large territorial States		West German States		West German large territorial States	
	Innovation in general	Important innovation	Innovation in general	Important innovation	Innovation in general	Important innovation	Innovation in general	Important innovation
Cluster	0.0403	0.0521	0.0486**	0.0548	0.181*	0.246*	0.214***	0.254**
	(1.44)	(1.61)	(3.44)	(1.93)	(1.68)	(1.83)	(4.40)	(2.26)
lagged innovation	0.415***	0.452***	0.429***	0.459***	1.168***	1.306***	1.215***	1.345***
	(20.3)	(17.6)	(21.7)	(18.1)	(19.7)	(15.6)	(25.2)	(19.7)
lagged employees (log)	0.0756***	0.0691***	0.0744***	0.0715***	0.316***	0.295***	0.316***	0.308***
	(12.7)	(9.42)	(11.3)	(8.51)	(10.5)	(7.19)	(8.05)	(5.70)
Industry-level employment growth rate	-0.0499**	-0.0840***	0.197	0.390	-0.139**	-0.558*	0.293	1.512
	(-2.88)	(-3.45)	(0.63)	(1.58)	(-2.09)	(-1.88)	(0.15)	(0.64)
State-level employment growth rate	0.0493	0.0650	-0.484	-0.498	0.247	0.263	-1.966	-2.055*
	(0.48)	(0.50)	(-1.44)	(-2.06)	(0.43)	(0.49)	(-1.49)	(-1.91)
Constant	0.372**	-0.119	-0.00821	-0.150	-1.410***	-2.555***	-2.414***	-2.366***
	(3.02)	(-1.56)	(-0.096)	(-1.95)	(-4.02)	(-8.48)	(-11.3)	(-4.78)
Year dummies	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Industry dummies	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
State dummies	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Observations	1113	1089	895	876	1108	1089	880	876
Adjusted R-squared	0.38	0.42	0.39	0.44	0.327	0.364	0.333	0.384

Cluster-robust standard errors on the state level. t-statistics in parentheses.
*** statistically significant at the 1% level.
** statistically significant at the 5% level.
* statistically significant at the 10% level.

innovate between 4.6 and 6.2 percentage points (cf. table 4). This confirms our results of the baseline specification in Table 1.

Cluster policies, or industrial policies in general, are often criticized as being especially supportive of large firms that are already politically well connected (cf. Seabright 2005). To assess whether this is true, we add to our estimation an interaction term between the cluster variable and a dummy that takes the value of 1 if the firm has more than 500 employees. We use 500 employees as the cutoff point as it is common to define small and medium-sized firms as those with less than 500 employees. The results are shown in Table 3.

Table 3: Results, Large vs. Small and Medium-Sized Firms

	Linear Probability Model		**Probit Model**	
	Innovation in general	Important innovation	Innovation in general	Important innovation
Cluster	0.0416	0.0447	0.140	0.194*
	(1.47)	(1.54)	(1.36)	(1.77)
Cluster x firm size dummy	0.0237	0.0904**	0.582***	0.816***
	(0.82)	(2.72)	(5.61)	(6.34)
lagged innovation	0.451***	0.490***	1.280***	1.428***
	(16.2)	(14.9)	(14.5)	(13.2)
lagged employees (log)	0.0671***	0.0579***	0.269***	0.240***
	(8.71)	(5.82)	(7.46)	(5.36)
Industry-level employment growth rate	-0.0205	-0.0445	-0.0510	-0.169
	(-0.69)	(-1.07)	(-0.59)	(-0.89)
State-level employment growth rate	0.0683	0.0854	0.309	0.337
	(0.73)	(0.87)	(0.64)	(0.77)
Constant	0.302***	-0.383***	-1.453***	-1.114***
	(3.17)	(-6.37)	(-3.35)	(-2.65)
Year dummies	incl.	incl.	incl.	incl.
Industry dummies	incl.	incl.	incl.	incl.
State dummies	incl.	incl.	incl.	incl.
Observations	1342	1312	1332	1307
Adjusted R-squared	0.38	0.42	0.326	0.364

Cluster-robust standard errors on the state level. t-statistics in parentheses.
*** statistically significant at the 1% level.
** statistically significant at the 5% level.
* statistically significant at the 10% level.

These results confirm that the cluster policy is especially supportive of large firms. In the linear probability model the impact of the cluster policy on a large firm's likelihood to innovate in the targeted industry is 2.3 and 9 percentage points greater than it is for small and medium-sized firms, although only the coefficient in the model for important innovations is statistically significant.

In the probit model, the marginal effect of the cluster variable is of interest only for small firms. However, for large firms two estimated effects are jointly at play, which are the marginal effects of the cluster variable *and* the interaction variable. The difference between the effect on large and on small firms amount to 3.4 percentage points for innovations in general and 6.9 percentage points for important innovations (cf. Table 4). Those on-top effects for large firms are significant and economically important.

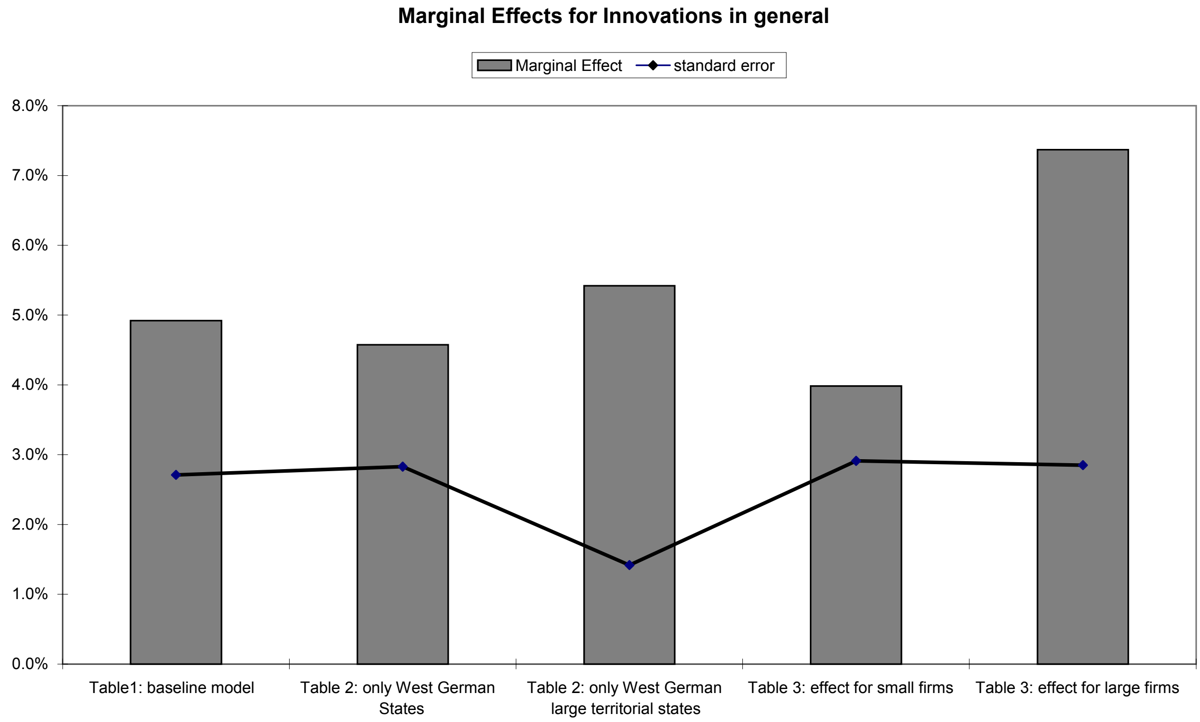
Table 4: Marginal Effects of the cluster variable – Probit models

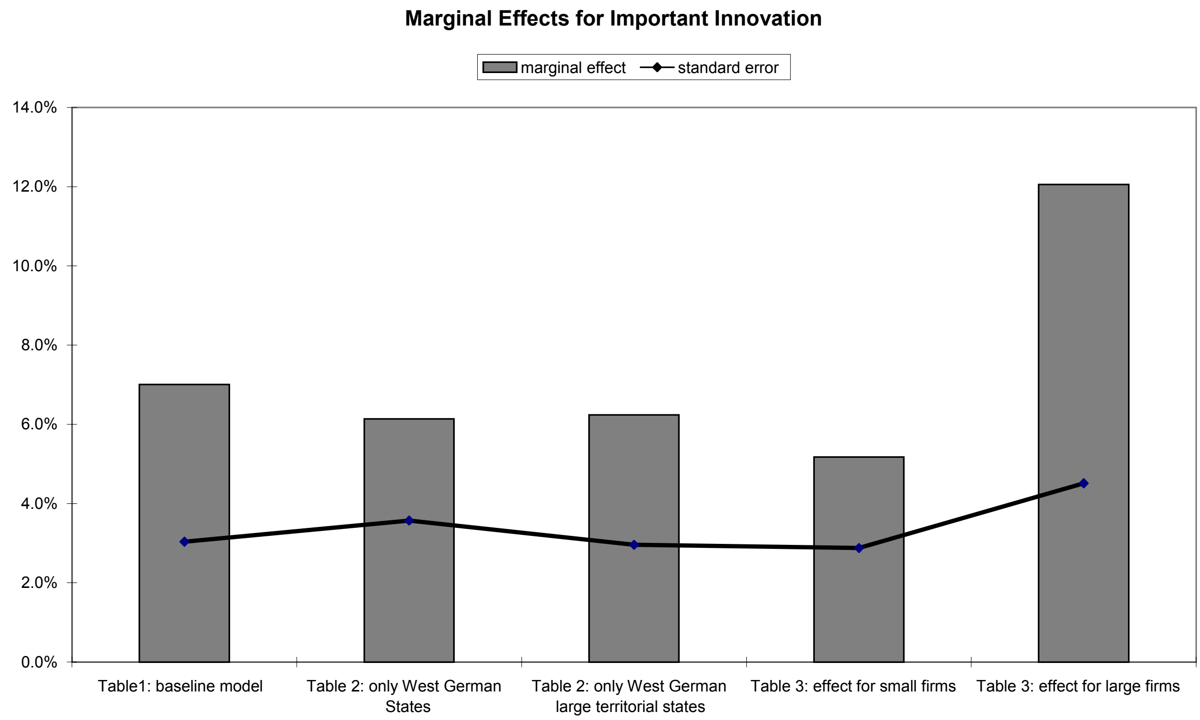
	Marginal effect	Standard error	t-value	p-value
Innovation in general:				
Table1: baseline model	0.049	0.027	1.810	0.086
Table 2: only West German States	0.046	0.028	1.599	0.126
Table 2: only West German large territorial states	0.054	0.014	4.128	0.023
Table 3: effect for small firms	0.040	0.029	1.392	0.168
Table 3: effect for large firms	0.074	0.029	2.381	0.068
Important Innovation:				
Table1: baseline model	0.070	0.030	2.339	0.043
Table 2: only West German States	0.061	0.036	1.716	0.109
Table 2: only West German large territorial states	0.062	0.030	2.181	0.075
Table 3: effect for small firms	0.052	0.029	1.856	0.071
Table 3: effect for large firms	0.121	0.045	2.549	0.056

Reported marginal effects and standard errors are the means of the individual marginal effects and standard errors of the treatment group.
Reported standard errors are computed by the delta method.

For an overview, all marginal effects reported in this section are summarized graphically in Figure 2.

Figure 2: Marginal Effects of the Cluster Policy





7. Conclusions

This paper presents empirical evidence for the success of an economic policy that aims to extend the geographic boundaries of a cluster. To do so, we analyze the "Cluster Initiative" introduced in 1999 by the Bavarian State Government, which was aimed at creating a

Bavarian-wide innovation network in support of state-wide knowledge flows. By means of a difference-in-differences approach, we find that the introduction of the Bavarian-wide cluster policy increased the likelihood of an innovation by a firm in the targeted industry by 4 to 7 percentage points, but that this effect is mainly driven by the increase in the likelihood of large firms to innovate.

Even though we identify a positive effect of the Bavarian Cluster Initiative on the likelihood of firms to innovate, we cannot answer the question of whether the 1.45 billion euro allocated by Bavaria to this program was a valuable investment. To answer this question, a cost-benefit analysis would be necessary that compares the cost of the program with the economic value of the innovations induced by the program. Furthermore, a comparison with the cost-benefit analyses of other programs aimed at stimulating innovation would be necessary.

From an academic perspective, it would be interesting to analyze in further research exactly what type of innovation impetus was stimulated by the cluster policy. Did the impetus for innovation come from related firms along the supply chain, from customers, or from universities? Furthermore, it would be interesting to take a closer look at outcomes other than innovation. For instance, cluster polices are often targeted not only at stimulating innovation within incumbent firms but also at stimulating innovative firm entry as it is known that many radical innovations are introduced by young firms (cf. Audretsch 1995).

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Appendix

Figure A1: Distribution of firms in the ifo innovation survey (years 1996-2001) by class size

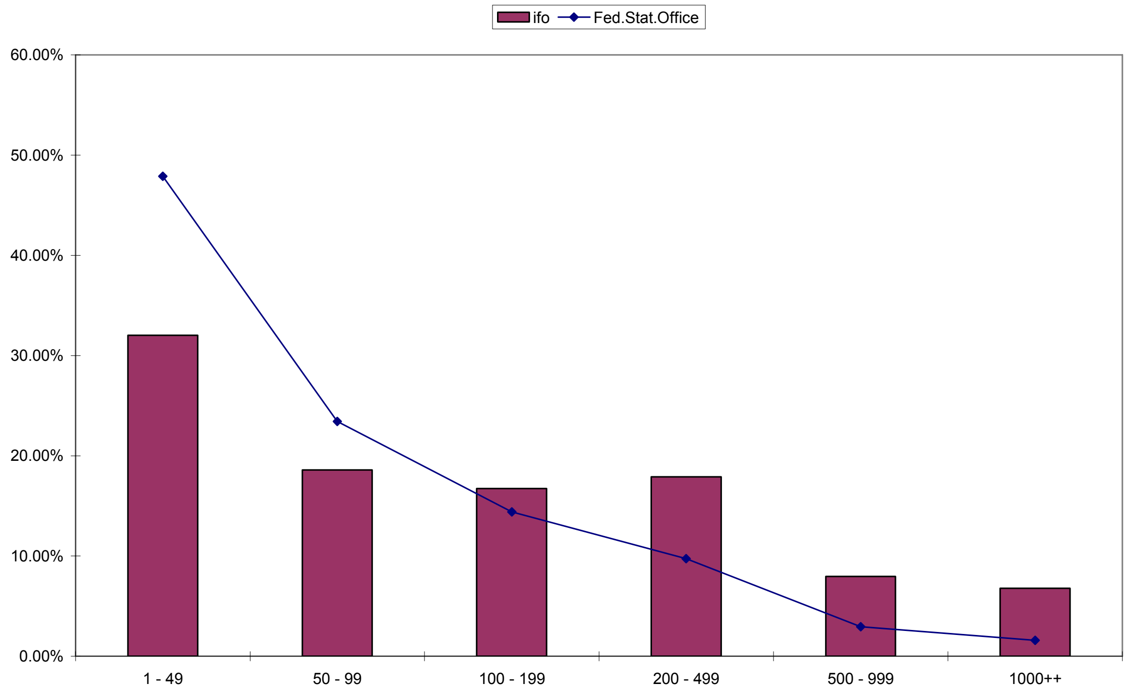

Figure A2: Distribution of firms in the ifo innovation survey (years 1996-2001) by industry

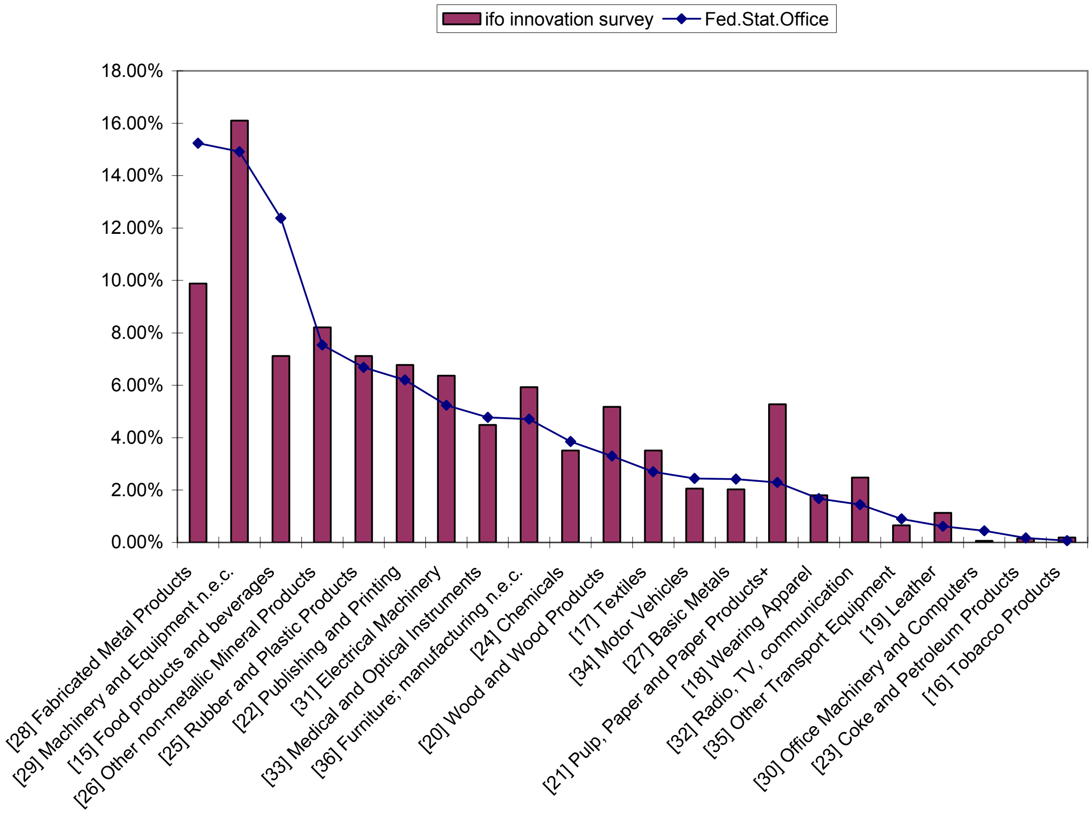

Figure A3: Distribution of firms in the ifo innovation survey (years 1996-2001) by state

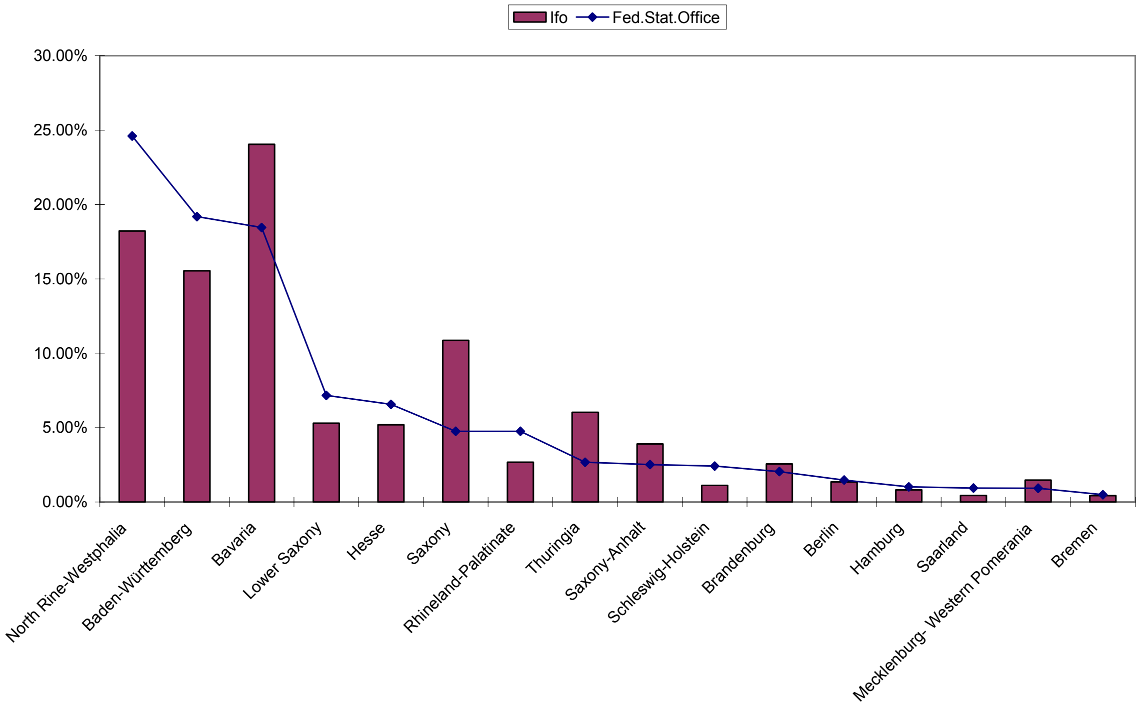

Table A1: Regrouping of Industries

	Regrouped industries	2-digit industries
Targeted by the Bavarian cluster policy	[1] Life sciences	[33] Medical and optical instruments
	[2] Information and communication technologies	[30] Office machinery and computers [32] Radio, TV, communication
	[3] New materials	[17] Textiles [24] Chemicals [25] Rubber and plastic products [26] Other non-metallic mineral products [27] Basic metals [28] Fabricated metal products
	[4] Environmental technologies	[20] Wood and wood products [31] Electrical machinery
	[5] Mechatronics	[29] Machinery and equipment n.e.c. [34] Motor vehicles [35] Other transport equipment
Other industries	[6] Tobacco and Food	[15] Food products and beverages. [16] Tobacco products
	[7] Apparel	[18] Wearing apparel [19] Leather
	[8] Paper and printing	[21] Pulp, paper, and paper products [22] Publishing and printing
	[9] Mineral products and coking	[23] Coke and petroleum products
	[10] Jewelry and furniture	[36] Furniture, manufacturing n.e.c.

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