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The Geographic Scope of Public Cluster Policy

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Abstract

Whereas the positive externalities of industry agglomerations are beyond controversy and proofed in numerous studies, the radiance of public cluster policy remains vague. This paper addresses this issue and investigates the supraregional impact of 'leading-edge clusters', promoted by the German federal government as a part of the 'High-Tech Strategy 2020' starting in 2007. The study applies treatment and difference-in-differences estimation techniques to evaluate the scope of these governmental interventions within the market, using a unique balanced 15-year panel ranging from 1998-2012 encompassing all 150 German labour market regions. The selected and financially supported leading-edge clusters thereby encompass 21 of the total 150 German metropolitan areas, 69 regions are potentially affected by cluster regions due to their close spatial proximity to cluster locations. In particular, this study examines whether cluster regions show a different performance path compared to neighbouring cluster regions and whether neighbouring cluster regions differ from non-neighbouring cluster regions. The results suggest that public cluster policy matters in terms of regional GDP growth. However, positive externalities are geographically bound, implying that targeted regional subsidies do not necessarily spread across regional boarders and generate beneficial effects in neighbouring regions. The paper further clarifies the role of entrepreneurial ecosystems in enhancing regional wealth and corresponding cluster performance.

Jelcodes:O18,R11

The Geographic Scope of Public Cluster Policy

Whereas research on clusters has largely taken a firm perspective, this study investigates the supraregional impact of public cluster policy. Analysing government-driven clusters in Germany, this study examines the geographic scope of clusters from a regional perspective, considering the respective spatial proximity of labour market regions to cluster centres. The results suggest positive yet spatially limited externalities of clusters which are geographically bound within cluster regions. Thus, cluster initiatives augment the economic performance within yet not beyond their geographical boundaries, as neighbouring regions lack sufficient resources to benefit from potentially resulting spillovers. Consequently, comprehensive regional development strategies have to consider further policy instruments to expand the economic influence of those regional systems of entrepreneurship.

Keywords: public cluster policy, regional development, knowledge spillovers

JEL Classification: R11 · R58

1. INTRODUCTION

Public cluster policy has attracted increasing attention among policymakers within the last few decades. Taking famous high-tech clusters such as Silicon Valley (Saxenian, 1994) or the Research Triangle (Link, 1995) as a role model, many governments worldwide tried to establish similar industry hotspots and copy the well-known success stories. However, not only the selection of favoured industries but also the selection of corresponding regions became one of the major challenges of successful cluster policy. Audretsch (2015) describes the mission of local and state governments as the 'mandate […] to engage in the strategic management of their place to ensure prosperity and a strong economic performance' (p.112). The creation of competitive advantages by leveraging local resources and factors therefore constitutes an important element within regional policy. Although the spatial context plays a decisive role concerning the efficiency of political measures, the full scope of political interventions within the market and their implications on the regional endowment often remains vague. As positive externalities associated with these interventions might spill over to previously non-targeted neighbouring regions, the efficiency radius of political initiatives more and more moves into the focus of political interest. Due to their specific composition of members of new ventures and incumbent firms as well as research institutions and universities, especially government-driven cluster initiatives might not only enhance economic performance within but also across regional borders. While many studies focus on the effects of cluster existence on regional industry performance (Delgado, Porter, & Stern, 2014), firm performance (McCann & Folta, 2011), or patent activities (Fornahl, Broekel, & Boschma, 2011), there is still little known about the geographic scope and associated implications of public cluster policy.

This paper addresses this issue. Taking the 'High-Tech Strategy 2020', initiated by the German government in 2007, as the triggering event concerning cluster development in Germany, this study investigates the impact of public cluster policy on the overall regional performance in Germany. In accordance with the EU's 'Horizon 2020 Framework Programme for Research and Innovation', the general idea behind this political programme was the promotion of Germany as a worldwide innovation leader by supporting the development of future markets and technologies. Within this framework, the German Federal Ministry of Education and Research launched the 'Leading-Edge Cluster Competition' (Spitzencluster-Wettbewerb), an initiative to strengthen regional (cluster) development, consolidate resources, and promote technology transfer. In 2008 and 2009, 10 cluster initiatives, all focusing either on digitization, sustainability, health, mobility, or security issues, and accordingly 21 labour market regions (from a total of 150) have been selected by the government and granted access to public and private funds exceeding 1.2 billion Euros.

This study adds to the literature by providing insight into the geographic scope of public cluster policy as it investigates cluster policy effects on the regional endowment depending on their actual geographical proximity to cluster regions and corresponding cluster centres. Thus, this research fits into a growing literature linking public policy evaluation to spatial economics (Doblinger, Dowling, & Helm, 2016; Fontagné et al., 2013; D'Este, Guy, & Iammarino, 2012; Magro & Wilson, 2013; Morescalchi et al., 2015).

The dataset used in this study captures all 150 German labour market regions as defined by Eckey, Kosfeld, and Türck (2006) and covers a time period from 1998 to 2012. The study thereby distinguishes between three types of regions: cluster regions, neighbouring cluster regions, and non-neighbouring cluster regions. To consider potential treatment effects, difference-in-differences estimation techniques are applied to analyse the different performance paths of the defined regions, taking into account the actual treatment, i.e. the selection of cluster initiatives in 2008/09. The results confirm that public cluster policy does have a positive impact on regional economic performance, measured by local GDP as an output variable proxying regional wealth. However, due to their specific local factors and resources, only cluster regions are able to benefit from these positive externalities, indicating a limited spatial impact of these political subsidy programmes on the regional endowment. Thus, further political measures have to be adopted to guarantee a comprehensive regional development.

The study further finds evidence for a significant influence of pre-existing entrepreneurial ecosystems and their associated positive impact on successful cluster policy, which is in line with recently published papers on this topic (Brekke, 2015; Delgado, Porter, & Stern, 2010; Fritsch & Kublina, 2015; Huggins & Thompson, 2015; Segers, 2015). Universities and research institutions, acting as the nucleus of government-driven cluster activities, follow this entrepreneurial paradigm likewise and are actively shaping economic growth and performance. Following this strand of literature, the results clearly show that university-industry collaborations within regional clusters significantly contribute to fostering regional wealth, reinforce further growth, and thus support previous empirical results (Audretsch, 2014; Guerrero, Cunningham, & Urbano, 2015; Guerrero & Urbano, 2012).

The remainder of this paper is structured as follows. Section 2 focuses on cluster policy and corresponding cluster development, whereas section 3 deals with the rationale behind the strategic management of places. Section 4 describes the dataset as well as the employed estimation techniques. Section 5 summarizes and interprets the estimation results. A final section concludes.

2. CLUSTER DEVELOPMENT AND SPATIAL PROXIMITY

Over time, a large body of theoretical and empirical studies has dealt with regional innovation systems and corresponding implications for the regional economic development, highlighting the importance of innovation as a source of competitive advantage (Asheim, Smith, & Oughton, 2011; Capello & Lenzi, 2014; Vaz et al., 2014; Fagerberg & Srholec, 2008). Within this strand of literature, especially the concept of spatial proximity to the source of knowledge has attracted considerable attention, as it is particularly the tacit dimension of knowledge which inheres the potential for valuable spillovers within innovative ecosystems

(Basile, Capello, & Caragliu, 2012; Binz, Truffer, & Coenen, 2014). Since the transfer of tacit knowledge requires face-to-face interactions as well as trust-based relationships among involved entities, regionality is a basic prerequisite concerning the efficiency of knowledge spillovers and the generation of networks of innovation. Thus, Porter (1998) claims that 'the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, motivation – that distant rivals cannot match' (p.77).

The concept of entrepreneurship is closely related to regional innovation systems. The interrelatedness of innovation and entrepreneurship was perhaps first explained by Joseph Schumpeter in his Theory of Economic Development (1934) as he understood entrepreneurship as a basic requirement for innovation, facilitating aggregate economic growth. The knowledge spillover theory of entrepreneurship follows this direction in that it identifies new knowledge as the main source of entrepreneurial opportunities and entrepreneurs as the key drivers in commercializing new knowledge (Acs, Audretsch, & Lehmann, 2013; Acs et al., 2009). Hence, entrepreneurs act as knowledge filters, able to absorb relevant knowledge and transform corresponding ideas and concepts into economic knowledge (Acs & Plummer, 2005; Braunerhjelm et al., 2010). Audretsch and Lehmann (2005) incorporated a spatial dimension within this research field, suggesting that the geographical proximity to the knowledge source generates positive externalities – leading to the conclusion that the distance to the source of knowledge matters.

Regional clusters and underlying cluster policy as an increasingly important research field in regional economics constitute to some extent a synthesis of regional innovation systems and the entrepreneurial paradigm, as the existence of regional concentrations of universities and research institutions as the source of knowledge and new ventures and incumbent firms as the exploiter of disseminated knowledge form the basis of successful cluster development. The formation of clusters is driven by the assumption and growing evidence that regional agglomerations imply positive externalities, enhancing local productivity and finally regional prosperity and competitiveness (Porter, 2000). The original awareness concerning the benefits of clusters thereby dates back to Marshall (1890) and his influential work on the Principles of Economics. He identified three types of cost advantages associated with regional agglomerations: lower transportation costs for goods, simplified access to human capital due to labour market pooling, as well as an increased efficiency in transferring knowledge and ideas. Among others, scholars like Porter (1990), Krugman (1991), Ciccone and Hall (1996), as well as Ellison and Glaeser (1997) further developed the concept of agglomeration economies and considered the location of a firm, or the spatial dimension in general, as a core element in the creation of competitive advantages and linked the firms' proximity to one another to their actual productivity, hence their overall economic performance. Audretsch and Feldman (1996) finally examined the existence of spatially-mediated knowledge spillovers in various industries and concluded that the propensity of regional agglomerations and clustering is higher where industry R&D, scientific research, and skilled labour are the most important.

Recent studies on regional agglomerations took the well-known positive externalities of clusters as a starting point and investigated specific effects of clusters on a micro level, thus either focused on firms' overall or innovative performance (Beaudry & Swann, 2009; Garone et al., 2015; Libaers & Meyer, 2011; Maine, Shapiro, & Vining, 2010; Wennberg & Lindqvist, 2010), whereas the macro level and associated implications for the regional endowment did not attract that much attention (Feldman, 2014; Huber, 2012). Most of these studies postulate the growing importance of universities as the nucleus of cluster activities, indicating the decisive role of universities as the source of knowledge. Besides the production of new knowledge, universities also enhance the level of human capital within a region by well-educated students, leading to further regional competitive advantages, which in turn positively influence firms' location decisions close to regional clusters. The establishment of local university-industry collaborations, enabling firms to benefit from scientific knowledge and the associated labour pool, are likewise subject to proximity.

Over recent years, the concept of proximity within collaboration networks has attracted further attention, resulting into in-depth analyses of isolated and combined effects of different proximity dimensions on knowledge networks. Scholars thereby distinguish between five kinds of proximity: geographical proximity, i.e. determined by the co-location within the same spatial area, cognitive proximity, i.e. determined by the development of the same kind of knowledge, organizational proximity, i.e. determined by the belonging to the same corporate group, institutional proximity, i.e. determined by the same institutional form, and social proximity, i.e. determined by the level of trust (Balland, 2012; Balland, Boschma, & Frenken, 2015). Empirical studies focusing on various kinds of proximity conclude that different dimensions of proximity are interconnected and influence each other (Letaifa & Rabeau, 2013), yet especially social and geographical proximity are the key drivers concerning the development of research collaborations and knowledge networks (Broekel & Boschma, 2012; D'Este et al., 2012). As this paper tries to derive policy implications on cluster development issues, especially the spatial dimension of proximity, i.e. geographical proximity, is relevant for this study. Among the different kinds of proximity, spatial proximity is the only exogenous influencing factor which can be externally controlled by policymakers: the location decision of newly established government-driven regional clusters.

Despite the predominant consensus that the concept of geographical proximity plays a crucial role concerning the efficiency of knowledge spillovers, knowledge utilization, and knowledge commercialization, the answer to the question what the concept of spatial proximity really implies for regional policies and corresponding regional economic development strategies still remains rather vague. Insights into the mechanisms and effects of clusters are however crucial for policymakers to adopt adequate measures which secure a sustainable and above all comprehensive regional economic development. As the economy tends to be more and more knowledge-based, it is the task of politics to pave the way for future-oriented technologies and innovative activities since innovation constitutes one of the key drivers of growth performance. Consequently, the OECD (2015, p. 2) advices governments to 'play a key role in fostering a sound environment for innovation, in investing in the foundations for innovation, in helping overcome certain barriers to innovation, and in ensuring that innovation contributes to key goals of public policy'.

3. STRATEGIC MANAGEMENT OF PLACES

The economic rationale justifying public policy and corresponding political interventions within the market is considered as the failure of market participants to allocate scarce local resources efficiently (Bleda & Del Rio, 2013). In this context, public cluster policy is a collective term for regional, industrial, and technological policies, implying the mission to leverage resources, assets, and knowledge to enhance regional competitiveness. Porter (2000) condenses the aims of cluster policy to 'removing obstacles, relaxing constraints, and eliminating inefficiencies that impede productivity and innovation in the cluster' (p. 26). Consequently, governments play a crucial role in coordinating activities of various entities within the market to facilitate connectivity and finally the production of new products and services. Audretsch (2015) summarizes those measures under the term 'strategic management of a place', yet remarking that places should not be equated with markets, as markets might cross regional borders, claiming that 'places that undertake a concentrated strategy to influence market outcomes may enjoy benefits extending far beyond these initial investments' (p. 110).

Public policy strategies thereby have several different facets and affect the national, social, institutional, and economic environment simultaneously, aiming at augmenting the innovative and economic regional performance. Although innovation has become a decisive concept among politicians, the design of long-term institutional structures and corresponding innovation trajectories concerning university-industry collaborations is still at an early stage.

Braunerhjelm and Henrekson (2015) therefore suggest a more comprehensive approach, linking innovation and entrepreneurship policy. As knowledge and associated spillovers are necessary however not sufficient conditions for regional growth, the authors recommend a political focus on two complementary objectives: on the one hand, public policy should ensure vibrant connections between academia as the source of knowledge and the commercial sector; on the other hand, public policy should facilitate the exploitation of knowledge by incentivizing innovation, collaboration, and entrepreneurial venturing and in turn reducing regulatory, functional, and organizational burdens by providing an adequate infrastructure. Since regional preconditions for innovation might vary significantly, a differentiated approach is needed to promote innovation efficiently and enable economic development (Dodgson et al., 2011). Consequently, simplistic, one-size-fits-all policies are inappropriate within the predominant complex economic ecosystems as most regions inhere idiosyncratic settings concerning their local resources.

The 'High-Tech Strategy 2020' was a political approach to cope with these challenges and provide regional subsidization as well as networking support to foster innovation and finally regional wealth (BMBF, 2014). The 'Leading-Edge Cluster Competition' was launched in 2007 as a part of the 'High-Tech Strategy 2020' by the German Federal Ministry of Education and Research (BMBF) and supported in total 15 cluster initiatives which were selected in three rounds of competition. The outstanding role of this political intervention, compared to previous public policy measures is justified by the fact that the selection of subsidized clusters was not primarily accomplished by politicians but initiatives and corresponding regions had to apply for the respective contest rounds. Hence, instead of just selecting and subsidizing specific regions, this policy framework triggered a self-selection process of regions inhering sufficient prerequisites for a sustainable development of local innovation systems. The approach aimed at reducing information asymmetries and helped regions identify and allocate idiosyncratic local resources.

Interestingly, almost all cluster initiatives incorporated not only local universities but also universities located outside the actual cluster regions, indicating that regionality and spatial proximity might be an important however not necessarily imperative prerequisite for efficient university-industry collaborations. Thus, inbound effects in the form of knowledge spillovers are expected to be realized from both universities located within and outside the respective cluster regions as well as involved firms, establishing local innovative ecosystems. Vice versa, policymakers expect outbound effects from these innovation systems, fostering the regional economic development and finally regional wealth. The empirical and conceptual approach analysing these outbound effects is based on research focusing on the localization of knowledge flows as well as the corresponding commercialization through entrepreneurial activities (Mowery & Ziedonis, 2015; Plummer & Acs, 2014).

Authors like Hayter (2013) as well as Ghio et al. (2014) reviewed the extant empirical literature on knowledge-based entrepreneurship and the underlying knowledge spillover theory of entrepreneurship, highlighting the importance of networks and strategic alliances for the entrepreneurial success – as predominant in regional clusters. The literature in this field indicates that the formation and management of innovation networks increasingly gains complexity due to an increasing number of involved entities, an increasing density in terms of collaborations as well as a wider geographical distribution, which potentially impede the knowledge creation and transformation (Karlsson & Warda, 2014). As regional clusters often comprise more than one labour market region (see FIGURE 1), not only intra- but especially inter-regional flows of knowledge have to be canalized to establish cluster-wide knowledge bases and construct regional advantages (Asheim, Boschma, & Cooke, 2011). Huggins and Thompson (2015) consequently note a shift from the traditional focus on stocks of knowledge to dynamic flows of knowledge. Hence, knowledge flows are not restricted to any regional or national boundaries but might spill over into the region (inbound) as well as out of the region (outbound) – thus, in combination with today's interconnected corporate landscape, reinforces this study's research question.

Consequently, the role of policymakers concerning regional development and the corresponding strategic management of places consists of at least three interconnected dimensions. First, policymakers have to identify and support the development of relevant technological trends at an early stage to provide adequate resources. Hence, an intensive exchange between political responsibilities and market entities has to exist to be able to understand the specific dynamics as well as particular characteristics of any industry sector. However, as Asheim et al. (2011) claim, a sole copying of best practices is difficult or even impossible due to idiosyncratic regional attributes and the intangibility of regional assets which evolved over time within the respective regional context. Second, localized action is needed with respect to available local resources, existing innovative networks as well as barriers to innovation. Since regional preconditions for innovation have to be taken into consideration, tailor-made policy strategies instead of one-size-fits-all politics have to be implemented to stimulate the creation of new industrial activities and collaborations. Third, politics have to provide continuing support in removing obstacles and relaxing constraints within cluster networks. Nishimura and Okamuro (2011b) investigate the effects of direct and indirect support programmes of cluster policy and conclude that especially indirect support programmes have a strong impact on innovation outcomes, compared to direct R&D support. Thus, policymakers should rather act as boundary spanners who pave instead of predetermine innovation trajectories – as is also intended by the 'High-Tech Strategy 2020'.

Public cluster policy is consequently a form of regional policy which aims at leveraging local factors and resources to enhance a place's economic performance. Policymakers thereby have to take the underlying regional determinants into account to conduct adequate measures fitting into the respective idiosyncratic regional setting. It is important to note that even targeted political interventions might generate positive externalities within and beyond regional boundaries. Due to this interconnectedness, political measures should be coordinated to augment their effectiveness as well as their efficiency to fulfil Audretsch's (2015) mandate of policy as he postulates that 'policy can make a difference' (p. 125).

4. DATA, DESCRIPTIVES, AND METHODOLOGY

Sample and Variables

As the consideration of the spatial structure is particularly important in investigating the geographic scope of public cluster policy, this study employs labour market regions as the smallest spatial unit in the dataset to control for potential regional variations. Labour market regions are rather homogenous, economically integrated areas consisting of at least one administrative unit, i.e. either one rural district or county (Landkreis) and/or one urban municipality (kreisfreie Stadt), with a total population of at least 50,000 inhabitants, taking into account reasonable commuting times. According to Eckey et al. (2006), Germany can be divided into 150 labour market regions. As there is still a strong imbalance concerning the regional endowment of regions in East and West Germany (Audretsch, Heger, & Veith, 2015), the dummy variable east is included to control for these differences and avoid a bias effect (Fritsch et al., 2014).

This study focuses in sum on ten cluster initiatives selected in September 2008 and January 2009 respectively[1]. In order to evaluate the performance paths of regions in dependence on their proximity to cluster regions, an adequate time structure has to be considered to be able to test for path dependencies resulting from the actual treatment, i.e. the selection of various cluster initiatives. To cover sufficient time periods before (1998-2008) and after the treatment (2009-2012), a panel structure within the dataset is used. The dataset

[1] The 'Leading-Edge Cluster Competition' consisted in total of three rounds of competition. The nomination of the winning cluster initiatives of the third round of competition took place in January 2012. As official statistics of the main variables are almost available with certain time lags, the clusters of the third round of competition were excluded from the estimations.

employed thereby represents an extension of the dataset utilized in Lehmann and Menter (2015).

As the general aim of political interventions within the market is increasing social welfare and the central role of cluster policy is fostering regional performance, the main variable of interest is regional wealth. Although GDP per capita is a common indicator for economic growth (Abadie, Diamond, & Hainmueller, 2015), the study deliberately takes total GDP as a measure for regional wealth. Since the reunification of Germany in 1990, especially East Germany faces massive migration outflows whereas popular regions like Munich, Hamburg, or Cologne are confronted with continuing migration inflows, resulting in potentially biased per capita ratios due to the demographic development within Germany.

The ongoing shift towards a more knowledge-based economy implies several changes not only for the knowledge production but also for the actual application of new scientific knowledge and critically affects regional economic development and cluster formation (Wolfe, 2005, p. 168). Due to this trend, research institutions and universities play a crucial role within cluster development and act as key agents within clusters. This study considers the influence of universities on clusters activities and controls for university-industry collaborations (UIC) which constitute an essential element within the technology transfer process (Perkmann et al., 2013). The intensity and quality of those collaborations is measured by university third-party funds provided by industry, taking into account the geographic location of universities. As knowledge does not necessarily spill over in a planned and organized manner, the study distinguishes between universities actually located and engaged within a cluster (UIC_wcwr), universities located within a cluster region however not engaged within the cluster (UIC_ocwr), as well as universities, engaged within a cluster yet not located within the cluster region (UIC_wcor). Besides producing and disseminating knowledge, universities also augment the level of human capital by educating a highly skilled workforce. Since especially natural sciences play a crucial role concerning scientific breakthroughs

(Guerzoni et al., 2014), the number of students in natural sciences (university size) as a proxy for the stock of the scarce resource 'human capital' within a region is included. The associated labour pool might thus be a stimulating parameter concerning the location decision of firms which might in turn lead to an increase in economic wealth (Schubert & Kroll, 2014).

Not only universities as the nucleus of successful cluster development but also the regional endowment has to be taken into consideration to investigate regional economic effects of cluster initiatives adequately. The existence of 'knowledge factories' is a necessary, however not sufficient prerequisite concerning knowledge spillovers, as scientific knowledge has to be converted into economic knowledge, i.e. new and innovative products, services or processes (Acs & Plummer, 2005). Hence, knowledge filters in the form of absorptive capacities of incumbent or start-up firms have to exist to exploit corresponding opportunities and increase regional growth. The number of patent applications in relation to the workforce is a valid and often used proxy to measure innovativeness, whereby high ratios indicate sufficient knowledge filters (Acs, Anselin, & Varga, 2002; Audretsch, Coad, & Segarra, 2014). Especially entrepreneurs may profit from a vibrant innovative milieu resulting in new firm creation (Modrego et al., 2015). The level of entrepreneurship is measured by the number of new business enterprises in relation to the workforce (May-Strobl, 2005). As regions compete among each other, the regional employment rate (employment) is a further proxy for the regional competitiveness, indicating high levels of human capital within a certain region (Andries & Czarnitzki, 2014; McGuirk, Lenihan, & Hart, 2015). To control for the already mentioned population fluctuation within Germany, the absolute change in population per region is included. The study further considers the regional density, to take the ongoing trend of urbanization into account.

Additionally, the study controls for several industry specifics. The selection of cluster initiatives was not independent from the type of industry. The 'High-Tech Strategy 2020' purposely focused on the development of future technologies and markets. Consequently, the study controls for industries, the selected cluster initiatives are engaged in: digital healthcare and biotechnology (health industry), renewable energies and climate issues (climate/ energy industry), digitization of production technologies (industry 4.0), as well as mobility (mobility industry). Other knowledge-intense industries such as the chemical industry, the electronics industry, the beverage and food industry as well as smaller niche industries such as lighting or optical industry (miscellaneous industries) are further considered. As innovative and complex industries have the tendency to concentrate at a single region (Steinle & Schiele, 2002), industries can be assigned to distinct regions.

Descriptive Statistics

This study distinguishes between three types of regions to investigate the geographic scope of public cluster policy: cluster regions, neighbouring cluster regions, and non-neighbouring cluster regions. Each type inheres information concerning the proximity to cluster initiatives and associated financial investments within the respective regions, ranging from close proximity (cluster regions) to far distance (non-neighbouring cluster regions). FIGURE 1 illustrates German labour market regions whereby 21 regions are directly affected by cluster initiatives (cluster regions), 69 regions are adjacent to cluster regions (neighbouring cluster regions), and 60 regions are not in the immediate vicinity of clusters (non-neighbouring cluster regions). It is important to note that some regions are affected by more than one cluster initiative, yet each initiative within the same region focuses on a different industry respectively. By controlling for various industries, those regional specifics are taken into account. Although differences concerning the regional endowment of regions exist, especially between East and West Germany, cluster initiatives throughout Germany have been selected and supported. The government thereby pursued two different targets: enhancing the economic development of low endowment regions and sustaining the existing momentum of high endowment regions.

[FIGURE 1 HERE]

To reveal further insight into the dataset, one-way analyses of variance (ANOVA) followed by Bonferroni tests for multiple comparisons are conducted. ANOVA thereby compare the differences of means among the groups by considering differences in the amount of variation between and within groups. Bonferroni tests finally allow correcting for multiple comparisons among the groups. TABLE 1 depicts the results of the ANOVA, displaying all relevant regional variables. The comparisons of means between the different types of regions reveal significant differences concerning total GDP, the core dependent variable of this study. Cluster regions show a significantly higher performance than all other regions, indicating the outstanding role of those regions with regard to the economic development of Germany. Being considered as the driving forces of economic growth, the 21 cluster regions account for more than 40% of the overall economic performance of Germany. Besides cluster regions, also neighbouring cluster regions economically outperform non-neighbouring cluster regions, indicating the potential relevance of spatial proximity to economic growth centres such as clusters. Whereas other economic performance parameters such as innovativeness and the level of entrepreneurship, both indicators for adequate knowledge filters and corresponding absorptive capacities within a region, show further significant differences between cluster and non-cluster regions, there are no significant differences concerning the employment situation and the associated level of human capital between the different types of regions. Cluster regions further profit from a high regional density which facilitates interactions between economic entities and enhances the creation of innovative milieus – the basis for the creation of regional competitive advantages (Lee, Florida, & Acs, 2004). As a consequence, cluster regions rather face migration inflows than outflows.

[TABLE 1 HERE]

Methodology and Estimation Techniques

The descriptive statistics reveal significant differences concerning the regional endowment and corresponding regional economic performance depending on the respective type of region. To take those variations into account and investigate the actual effect resulting from the launched 'Leading-Edge Cluster Competition' in 2007, the treatment, a quasi-experimental design in the form of difference-in-differences (DID) estimations is employed. The rationale behind this estimation technique is the comparison of changes in outcomes over time between two groups, whereby potential differences might result from the treatment itself (Angrist & Pischke, 2008). The two groups thereby differ in that one group, the treatment group, is affected by the treatment, i.e. the selection of subsidized cluster initiatives and corresponding regions, and the other group, the control group, is not. Hence, time periods before and after the actual treatment have to be considered to estimate a potential causal effect of the treatment, the so-called treatment effect. The central assumption of the DID estimation refers to unobserved differences between the treatment and control group which should be the same over time in absence of the treatment. In other words, common economic trends should affect the treatment as well as the control group in a similar way, which is assumed to be given in rather balanced economies such as Germany (see Martin, 2012). DID estimations offer at least two benefits: the approach removes biases resulting from potential permanent differences between treatment and control group as well as biases from comparisons over time in post-treatment outcomes resulting from confounding factors to which the treatment and control group may be subject to (Lechner, 2011).

In order to implement this estimation technique, two dummy variables are introduced within the estimation: treatment group and treatment period. The interaction term between the variables treatment group and treatment period, treatment effect, finally represents the 'additional effect' of a treatment and therefore indicates if the political intervention in form of the cluster initiative affected diverse regions differently. As the dataset is divided into three subsamples and correspondingly three types of regions, two separate DID estimations are conducted. Model I to V capture possible treatment effects between cluster regions and neighbouring cluster regions, whereas Model VI to X address potential differences between neighbouring cluster regions and non-neighbouring cluster regions resulting from the treatment. This estimation strategy consequently reveals the interdependent relationships of all different types of regions. To examine isolated as well as comprehensive effects of the cluster initiatives, both DID estimations are subdivided into five specifications respectively – ranging from a sole focus on the regional endowment (first and second specification) to a focus on university engagement (third specification) and industry specifics (fourth specification) to a finally overall model (fifth specification). It is important to note that the variables UIC_wcwr as well as UIC_wcor are not included within the second estimation approach (Model VI to X) as only the value zero can be assigned to all respective regions. To control for heteroscedasticity and autocorrelation, cluster-robust standard errors are employed whereby clustering is on state – assuming error independence across regions (Bertrand, Duflo, & Mullainathan, 2004).

5. ESTIMATION RESULTS AND DISCUSSION

In this section, the results of the difference-in-differences estimations focusing either on a comparison of cluster regions and neighbouring cluster regions (Model I to V; see TABLE 2) or on a comparison of neighbouring cluster regions and non-neighbouring cluster regions (Model VI to X; see TABLE 3) are presented.

Except for Model III, all specifications of the first difference-in-differences estimation approach reveal, as indicated by the variable treatment effect, a positive and significant difference in regional wealth between cluster regions and neighbouring cluster regions. Hence, the findings suggest that the subsidization of cluster initiatives trigger diverging performance paths and therefore confirm previous empirical studies focusing on cluster performance and the resulting positive economic impact (Garone et al., 2015). Regional economic performance differences are thereby not only determined by the active participation within the 'Leading-Edge Cluster Competition', but also by the respective geographic location of a region, i.e. the location in East or West Germany. Fritsch (2004) compares growth regimes in East and West Germany by investigating market dynamics between 1993 and 2000 and concludes that vast differences in the levels of entrepreneurship exist. These path dependencies are still prevalent as indicated by the dummy variable east. Being located in East Germany constitutes a competitive disadvantage, resulting into significant lower GDP rates.

Model II reveals that the employment rate (employment), the proxy for the level of human capital within a region, i.e. the potential for knowledge creation, as well as the level of innovativeness within a region, i.e. the actual intensity of regional commercialization of economic knowledge, seem to have no significant influence on regional wealth. By contrast, the level of entrepreneurship enters the regression statistically significant and positive. Audretsch and Keilbach (2004) describe entrepreneurship as an important mechanism concerning the transformation of knowledge into diversity, the driving force of regional economic growth. Entrepreneurs thereby stimulate a selection process across available knowledge and as a result facilitate the spillover of knowledge and finally contribute to the commercialization process. Acs et al. (2013) consequently characterize entrepreneurs as a conduit for the spillover of knowledge, contributing to enhanced economic performance by allocating strategic resources. The estimation results further confirm the positive effects of high population density (regional density) on regional prosperity as suggested by the urbanization economics literature, which attributes density to lower costs of interaction, facilitating the establishment of knowledge networks (Glaeser, 1999; Glaeser et al., 1992).

Entities within knowledge networks are able to access, absorb, transfer, and apply knowledge and thus create value. The creation of economic knowledge is thereby attained through various sources such as incumbent firms or universities. An emerging strand of literature focuses on this specific role of universities pursuing and fostering entrepreneurial activities and thus shaping regional competitiveness (Audretsch, Hülsbeck, & Lehmann, 2012; Guerrero et al., 2015; Guerrero, Urbano, & Fayolle, 2014; Lehmann, 2015). Model III reinforces previous findings concerning the essential contribution of universities within the technology transfer process. On the one hand, universities enhance the level of human capital (university size) within a region and thus increase regional wealth (see Carree, Della Malva, & Santarelli, 2014). On the other hand, universities shape regional innovation systems and associated economic performance by collaborations with industry (see Cunningham & Link, 2014). The estimation results suggest that especially cluster internal university-industry collaborations within the region (UIC_wcwr) significantly contribute to wealth creation whereas university-industry collaborations outside the region (UIC_wcor) do not seem to have a significant impact on regional wealth. These findings are in line with Audretsch, Lehmann, and Warning (2005) who state that geographic proximity to university knowledge is critical as it reduces costs for accessing and absorbing knowledge spillovers and thus increases the potential for value creation. Cluster external university-industry collaborations (UIC_ocwr) as well seem to have no significant influence on regional performance.

Model IV focuses on the effects of knowledge-intense industries. The climate and energy as well as the mobility industry, both focus areas of the 'High-Tech Strategy 2020', enter the regression statistically significant and positive. Similarly, the food and beverage industry seems to have a positive influence on regional wealth. Being the fourth largest industry in Germany with more than 550,000 employees, total revenue increased by more than 40% within the last ten years. Moreover, smaller niche industries such as the lighting or optical industry seem to have an impact on regional performance.

The estimation results of Model V largely confirm previous findings. The participation within the 'Leading-Edge Cluster Competition' significantly contributes to diverging performance paths among cluster and neighbouring cluster regions. An important trigger concerning regional economic growth thereby is the level of entrepreneurship as well as the propensity of entrepreneurial interaction among regional entities. The existence of universities within regional innovation systems further stimulates regional wealth by so-called university spillovers. Universities supply regions with highly educated students, hence human capital, as well as knowledge produced and disseminated by academic researchers in collaboration with industry. Especially local collaborations within cluster structures and within the respective regions seem to foster regional economic performance whereas supraregional cluster collaborations and non-cluster collaborations seem to have no significant impact. As only the food and beverage industry as well as smaller niche industries remain significant, the influence of industries can only partially be confirmed.

[TABLE 2 HERE]

The second difference-in-differences estimation approach, investigating performance differences between neighbouring cluster regions and non-neighbouring cluster regions, reveals a different picture. There seem to be no significant differences across all model specifications between the performance paths of the two types of regions, as indicated by the variable treatment effect. These findings suggest that the spatial proximity to cluster centres does not significantly influence regional economic growth. Thus, assumptions concerning significant performance paths differences between all three types of regions, as derived from the ANOVA, cannot be confirmed by the regressions. Moreover, the geographic location of regions does no longer impact the regional economic performance significantly. One possible explanation for these results could be the above mentioned dependency of regions on adequate and sufficient knowledge filters. Although knowledge might spill over from cluster centres across regional borders, neighbouring regions might not be able to exploit and apply the respective economic knowledge and thus benefit from these spillovers – resulting on the one hand in varying performance paths between cluster and neighbouring cluster regions and on the other hand in no significant differences between neighbouring and non-neighbouring cluster regions (Hoekman, Frenken, & Tijssen, 2010; Morescalchi et al., 2015).

Model VII provides further insights into the linkages between regional economic performance paths and respective local resources. Whereas the first difference-in-differences estimation approach revealed a decisive impact of the level of entrepreneurship on regional economic performance, entrepreneurial activities do not seem to influence wealth in non-cluster regions significantly. However, the level of human capital significantly contributes to regional wealth. This leads to the conclusion that high endowment regions, i.e. cluster regions, focus on the exploitation and application of economic knowledge, hence are dependent on sufficient levels of entrepreneurial activities to increase regional wealth, whereas medium to low endowment regions, i.e. non-cluster regions, are more focused on the creation of a solid knowledge base to create the conditions for prospective regional growth. The concept of spatial density is thereby predominant within all model specifications.

The importance of high levels of human capital is further confirmed by Model VIII. The number of students (university size) enters the regression statistically significant and positive. Regional agglomerations of human capital constitute an important determinant within the regional development (Florida, Mellander, & Stolarick, 2008) and serve as a major source for knowledge-based entrepreneurial activities, leading to technological change (Qian, Acs, & Stough, 2013). The exploitation of resulting knowledge spillovers through university-industry collaborations additionally contributes to regional economic performance, as indicated by the variable UIC_ocwr. In this context, literature suggests that knowledge spillovers serve as a driving force of industrial clustering and geographic concentration of economic activities (Krugman, 1991). As depicted in Model IX, similar branches as in the first difference-in-differences estimation approach seem to foster regional wealth significantly: the climate and energy industry, the mobility industry as well as the food and beverage industry. Additionally, the electronics industry enhances regional growth significantly.

The comprehensive Model X largely confirms previous results, yet reveals a contrary picture concerning the influence of universities on regional prosperity. When controlling for a variety of potential influencing regional parameters, the significant impact of university spillovers can no longer be observed. Thus, sufficient regional prerequisites in the form of adequate local resources are strongly interrelated with the ability to access and absorb university knowledge to then transform these spillovers into economic knowledge and create value (see Qian & Acs, 2013). Consequently, augmented regional growth in less well-endowed regions is mainly triggered by the creation of human capital as well as the propensity for interaction among regional entities (regional density), suggesting that successful cluster policies have to consider geographic constraints (Singh & Marx, 2013) as well as idiosyncratic regional settings (Asheim et al., 2011).

[TABLE 3 HERE]

This research is, as all empirical studies, subject to a number of limitations. First, the measurement of proximity by defining different types of regions is eventually not appropriate in the context of clusters. However, integrating a spatial context within public policy by employing labour market regions and different types of regions as a proxy for self-contained regional ecosystems offers a good opportunity to combine spatial economics with public policy, since labour market regions and electoral districts are often congruent. Second, the measurement of local resources might not capture all relevant aspects concerning knowledge creation, knowledge accessibility, knowledge absorptivity and knowledge transformation. Especially the integration of firm-specific indicators, i.e. their ability to exploit knowledge, might be beneficial to broaden the derived picture of regional clusters. Third, cluster internal specifics concerning entity interaction and allocation of resources might provide further useful insights into the mechanisms of clusters.

6. CONCLUSIONS AND IMPLICATIONS

While the performance and associated positive externalities of clusters have attracted much attention among researchers at a micro level (Artz, Kim, & Orazem, 2016; Delgado et al., 2014; Lechner & Leyronas, 2012; Gilbert, McDougall, & Audretsch, 2008; McCann & Folta, 2011), the focus on public cluster policy and the associated macro perspective has hardly been raised (Ahlqvist, 2014; Boschma & Fornahl, 2011; Garone et al., 2015;

Nishimura & Okamuro, 2011a). And when it has, recommendations for policymakers did not include a spatial dimensions, although geographic proximity constitutes an important determinant within regional innovation policies (Benos, Karagiannis, & Karkalakos, 2015; Levy & Talbot, 2015). As policy-driven innovation networks in the form of clusters might be established within as well as across regional borders, corresponding externalities resulting from these intra- and inter-regional collaborations might likewise be not restricted to those regional boundaries. This paper addresses this issue and investigates the geographic scope of public cluster policy, taking into account the respective spatial distance of labour market regions to cluster centres. The results of this empirical study thereby confirm previous findings in that the establishment of regional clusters contributes to regional economic growth. However, generated positive externalities are restricted to regional boarders, implying that regional subsidies do not necessarily generate beneficial effects in neighbouring regions. The study further sheds light on the important role of entrepreneurial ecosystems, consisting of innovative firms and research-intense universities, in enhancing cluster performance as well as regional prosperity. The synergies of university knowledge and sufficient knowledge filters trigger value creation processes, which enable university-industry collaborations to stimulate regional growth and shape regional competitiveness. These stimuli require sufficient local resources to enable entrepreneurs to absorb and transform knowledge spillovers and thus enhance regional economic performance by commercializing economic knowledge.

The findings suggest several policy recommendations. First, targeted regional subsidies foster regional wealth within, yet not beyond the respective regions. As the associated positive externalities of political interventions are limited in space, the concept of geographic proximity has to be included within political considerations. This is especially important when it comes to the promotion of greater areas within a nation, e.g. financial support of low endowment regions in the eastern parts of Germany, since the sole initiation of flagship projects does not constitute a sufficient measure concerning a comprehensive regional development. Second, political interventions within the market have to be conducted with respect to the regional idiosyncratic prerequisites. One-size-fits-all politics or the copying of best practices are inappropriate political measures as they neglect local factors and resources which form the basis for a sustainable and above all comprehensive regional development. The differences in regional endowment might also be the reason why positive externalities generated within cluster regions do not necessarily spill over beyond regional borders: neighbouring cluster regions might not have sufficient knowledge filters to benefit from university-industry collaborations as cluster regions do. Thus, the geographic context within political interventions, i.e. the selection of targeted regions, is essential as the strategic goals of a political initiative have to be aligned with the respective regional endowment. Third, the decisive role of universities acting as the nucleus within regional clusters has to be considered by policymakers. Universities should not be regarded as substitutes for firm R&D, but rather as complementary entities within regional innovation systems, stimulating the creation of new industrial activities and collaborations. These political implications reveal the demand for a multifaceted strategic approach within public cluster policy and is in line with Audretsch's (2015) understanding of the strategic management of places claiming that 'there is no singular, universal policy approach that can be advocated which will work for every place in one nation, […], let alone for the entire world, it also means that each place needs to develop its own place-specific strategic approach' (p. 134).

This study shall serve as a further step towards integrating a geographic dimension within the public cluster policy framework and adds to the knowledge spillover theory of entrepreneurship by highlighting the importance of the spatial context within entrepreneurial ecosystems. Future research should follow this path as only a multifaceted approach might have the potential to shape overall regional economic development effectively. It is thereby crucial to consider not only the geographical but also the cultural context concerning proximity, as distance might be perceived differently within a European or US context.

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TABLE 1 – One-Way Analyses of Variance (ANOVA)

Variable	Type of region	Summary			Comparison of means	
		Mean	**Std. Dev.**	**Freq.**	**(1)**	**(2)**
Regional wealth	Cluster region (1)	44,978	36,060	315	-	
	Neighboring cluster region (2)	11,454	14,706	1,035	-33,524***	-
	Non-neighboring cluster region (3)	9,053	13,851	900	-35,925***	-2,401**
	Total	15,187	22,438	2,250		
Employment	Cluster region (1)	0.910	0.043	313	-	
	Neighboring cluster region (2)	0.909	0.051	1,021	-0.001	-
	Non-neighboring cluster region (3)	0.906	0.050	880	-0.004	-0.003
	Total	0.908	0.049	2,214		
Innovativeness	Cluster region (1)	14.673	12.717	313	-	
	Neighboring cluster region (2)	8.540	10.308	1,021	-6.133***	-
	Non-neighboring cluster region (3)	8.835	10.429	880	-5.837***	0.296
	Total	9.524	10.925	2,214		
Entrepreneurship	Cluster region (1)	182.243	33.849	313	-	
	Neighboring cluster region (2)	175.954	64.353	1,021	-6.289	-
	Non-neighboring cluster region (3)	172.441	36.191	880	-9.802***	3.513
	Total	175.447	50.998	2,214		
Population fluctuation	Cluster region (1)	-0.050	0.542	315	-	
	Neighboring cluster region (2)	-0.242	0.653	1,032	-0.192***	-
	Non-neighboring cluster region (3)	-0.211	0.609	885	-0.160***	0.032
	Total	-0.203	0.624	2,232		
Regional density	Cluster region (1)	581.289	415.625	315	-	
	Neighboring cluster region (2)	196.241	103.711	1,033	-385.048***	-
	Non-neighboring cluster region (3)	159.267	90.117	890	-422.021***	-36.974***
	Total	235.733	228.687	2,238		

The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

TABLE 2 – Difference-in-differences models estimating regional wealth (GDP)

	Model I	**Model II**	**Model III**	**Model IV**	**Model V**
Treatment group	**30,956*** **	11,359	**16,752*** **	**15,039*** **	-5,041
	(7,286)	(8,192)	**(5,779)**	**(5,660)**	(7,154)
Treatment period	**1,809*** **	**1,921*** **	**1,487*** **	**1,809*** **	**1,596*** **
	(231.98)	**(328.61)**	**(250.62)**	**(232.76)**	**(319.08)**
Treatment effect	**4,648*** **	**4,744*** **	1,227	**4,648*** **	**1,500***
	(1,176)	**(1,036)**	(890.99)	**(1,180)**	**(827.54)**
Employment		6,644			2,619
		(4,139)			(3,992)
Innovativeness		-20.63			-12.38
		(20.45)			(13.47)
Entrepreneurship		**19.44*** *			**12.66*** *
		(8.64)			**(6.02)**
Population fluctuation		197.23			-226.79
		(693.14)			(510.19)
Regional density		**52.66***			**38.56***
		(29.61)			**(20.49)**
University size			**0.85*** *		**0.75*** *
			(0.34)		**(0.32)**
UIC_wcwr			**0.20*** *		**0.20*** *
			(0.10)		**(0.10)**
UIC _wcor			0.04		0.05
			(0.04)		(0.04)
UIC _ocwr			0.00		0.00
			(0.00)		(0.00)
Health industry				1,729	7,407
				(4,592)	(4,736)
ICT industry				2,497	2,257
				(5,864)	(6,010)
Climate/ energy industry				**7,091*** *	4,569
				(2,837)	(2,797)
Industry 4.0				6,342	-247.61
				(4,828)	(4,485)
Mobility industry				**11,029*** *	3,423
				(4,713)	(3,271)
Chemical industry				3,554	-1,478
				(5,594)	(5,066)
Electronics industry				-1,433	-1,059
				(3,895)	(3,421)
Beverage & food ind.				**19,808*** **	**16,476*** **
				(5,365)	**(5,160)**
Miscellaneous industries				**7,669*** **	**5,388***
				(2,882)	**(2,850)**
East	**-13,364*** **	**-5,637***	**-11,018*** **	**-5,750***	-1,976
	(3,236)	**(3,290)**	**(2,673)**	**(3,197)**	(3,372)
Constant	14,845***	-6,969	12,296***	-3,306	-13,008*
	(2,314)	(8,974)	(2,096)	(3,407)	(6,986)
N	1,350	1,333	1,350	1,350	1,333
R2	0.27	0.33	0.42	0.27	0.45

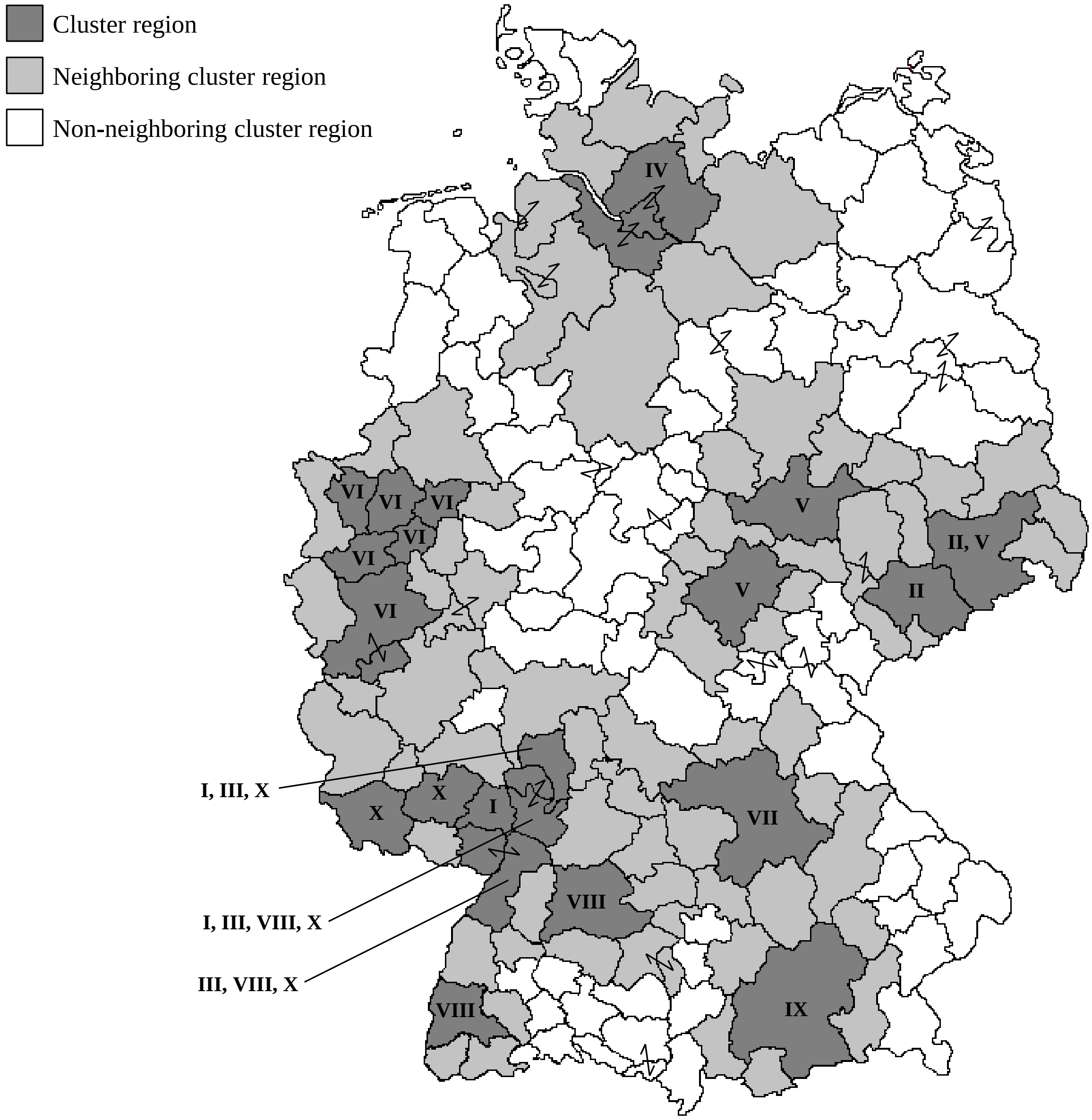
The endogenous variable is regional wealth measured by total GDP. Cluster-robust standard errors are in brackets. The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

TABLE 3 – Difference-in-differences models estimating regional wealth (GDP)

	Model VI	**Model VII**	**Model VIII**	**Model IX**	**Model X**
Treatment group	2,518	-1,076	2,399	1,557	-976.87
	(2,565)	(2,570)	(2,206)	(2,491)	(2,438)
Treatment period	**1,531*** **	**1,407*** **	**1,398*** **	**1,531*** **	**1,305*** **
	(335.34)	**(406.49)**	**(379.35)**	**(336.13)**	**(461.78)**
Treatment effect	278.59	414.32	237.28	278.59	346.70
	(407.48)	(370.10)	(383.64)	(408.43)	(348.94)
Employment		**9,241** **			**8,822** **
		(3,875)			**(3,782)**
Innovativeness		-10.98			-10.43
		(10.65)			(10.09)
Entrepreneurship		8.76			8.87
		(6.36)			(6.61)
Population fluctuation		-251.62			-313.17
		(519.36)			(542.53)
Regional density		**84.66*** **			**70.38*** **
		(28.89)			**(25.11)**
University size			**0.46** **		0.32
			(0.23)		(0.25)
UIC _ocwr			**0.00***		0.00
			(0.00)		(0.00)
Health industry				3,859	2,561
				(3,103)	(2,304)
ICT industry				4,357	2,252
				(3,558)	(3,523)
Climate/ energy ind.				**6,234*** **	**3,497***
				(2,289)	**(2,110)**
Industry 4.0				4,966	2,822
				(3,850)	(3,613)
Mobility industry				**11,052*** **	**8,029*** **
				(3,761)	**(2,782)**
Chemical industry				-1,007	276.33
				(2,127)	(1,731)
Electronics industry				**4,012***	**3,694***
				(2,282)	**(1,895)**
Beverage & food ind.				**5,501** **	**4,494** **
				(2,571)	**(1,916)**
Miscellaneous ind.				1,436	-241.48
				(1,376)	(1,158)
East	-3,391	1,758	-3,449	-1,687	1,748
	(3,497)	(4,741)	(2,999)	(3,793)	(4,626)
Constant	9,436***	-14,955*	8,568***	-553.54	-19,240**
	(1,181)	(7,905)	(1,263)	(2,450)	(8,547)
N	1,935	1,895	1,935	1,935	1,895
R2	0.20	0.28	0.21	0.20	0.28

The endogenous variable is regional wealth measured by total GDP. Cluster-robust standard errors are in brackets. The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

FIGURE 1 – German Labour Market Regions



#	Cluster	Industry focus	Cluster regions
I	BioRN	Health	Darmstadt, Ludwigshafen, Mannheim
II	Cool Silicon	ICT	Chemnitz*, Dresden*
III	Forum Organic Electronics	Climate/ energy	Darmstadt, Karlsruhe, Mannheim
IV	Hamburg Aviation	Mobility	Hamburg
V	Solarvalley Mitteldeutschland	Climate/ energy	Dresden*, Erfurt*, Halle*
VI	EffizienzCluster LogistikRuhr	Industry 4.0	Cologne/ Bonn, Dortmund, Duisburg, Düsseldorf, Essen, Wuppertal/ Hagen
VII	Medical Valley EMN	Health	Nuremberg
VIII	MicroTec Suedwest	Industry 4.0	Freiburg, Karlsruhe, Mannheim, Stuttgart
IX	Munich Biotech Cluster	Health	Munich
X	Software-Cluster	ICT	Darmstadt, Kaiserslautern, Karlsruhe, Mannheim

* East Germany