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Investigating the industrial demand for scientific knowledge

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Investigating the industrial demand for scientific knowledge

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Abstract University-Industry knowledge transfer is a key factor for the economic development and competitiveness of regions. A low level of transparency on the market for academic knowledge is the major obstacle in exploiting the existing innovation potential of cooperation between research institutions and firms. This paper offers a methodological framework for exploring the industrial demand for scientific knowledge of research institutions, especially universities. As a direct survey among firms has major drawbacks we propose an inquiry of different intermediates, especially cluster managers. The applicability of the presented methodology is demonstrated with the case of a technical university in Germany. Finally, we introduce an illustration to contrast supply and demand. This constitutes a strategic tool for transfer relevant decisions of research institutions and allows to align governmental support to the real transfer potential that strengthens a region`s economic development.

Keywords: University-Industry Knowledge Transfer, Informational Gap, Cluster, Demand Determination

JEL Classification: I23, O31, D81

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1 Introduction and Research Question

The economic prosperity of a region largely depends on the existing economic structure and is usually measured as contribution to the national GDP. In general, economic growth can be reached either by attracting new firms or by supporting the present economy to exploit their existing innovation potentials. Knowledge-based innovations are a main driver for economic development of countries and a key factor in global competition. We consider the role of university-industry knowledge transfer (henceforth UIKT) in regional economic value creation. Over the last decade the literature has highlighted the growing role of research institutions as a source and driver of innovations. With their infrastructure and broad knowledge base they are able to develop innovative ideas on their own and, even more important, to support R&D-activities of the local economy. Economic policies already promote the cooperation between firms and research industries with the aim of improving the marketability of new knowledge and the implementation orientation of researchers. Except for multi-national firms the industry has often not the necessary financial capacity to carry out risky R&D in the long run. They profit from the systematic solution of usual technology problems or screen research results for opportunities. The better the integration of both partners, the higher the knowledge spillover between them, which generates a higher expected economic value.

Still, in many regions the commercialization potential of knowledge is insufficiently exploited. (Langford et al. 2006) Among many explanations for that observation the primary cause can be seen in the lack of available information (Yusuf 2008). We identify a low level of transparency on the market for academic knowledge as the major obstacle to exploit the existing potential of cooperation between research institutions and firms due to the following reason: At present, only few companies have information about the available technical infrastructure, the research foci, and the research quality of local universities. Even existing intermediates like cluster managers are faced with a limited access to scientific institutions. Simultaneously faculty members hardly know the specific research questions of firms and therefore, have limited information on potential industry partners. An improved matching requires exploring the demand as well as the supply side of that market.

Yet, there is no specialized literature concerned with the closure of the identified informational gaps. But, three bodies of literature might guide our investigation. First, as a quite young field, the research on the entrepreneurial university[1] analyzes the transformation process of universities towards a knowledge transfer-oriented agent. Here, a possible alignment to the industrial demand or, in other words, a stronger customer-orientation, is discussed critically.

[1] See e.g., Etzkowitz (2013), Urbano and Guerrero (2013), Slaughter and Leslie (1997) as well as Gulbrandsen and Slipersaeter (2007).

This might explain why universities` attempts to identify the industrial needs are limited in practice. Second, the research on university-industry linkages typically builds on surveys among existing cooperation, but does not focus on market transparency. As relationships are often underdeveloped and the goal is to estimate the potential for common innovations it is plausible to determine demand breadthways referring to the content (research foci) and not on existing coops. (D'Este and Patel 2007) Thus, we propose to investigate the demand among all relevant firms of a region based on the research foci of all structural units of local research institutions. Third, there is a broad literature on general demand estimation in marketing. We use standard marketing tools to explore the knowledge demand in a scientific context, particularly, techniques for online surveys and data analyses.

The special literature branch on matching research institutions and industries analyzes the aims of both sides and their mutual selection calculus but usually assumes availability of all information necessary to match. They only account for the information asymmetry with respect to the quality of researchers (Carayol 2003). Bekkers and Freitas (2008) find a wide range of active transfer channels between universities and industry on a national and international level and conclude that informational gaps are rather low. But, this result is driven by the large firms in their sample and not automatically valid for regions where most firms are small or medium. Siegel et al. (2003) identified several informational barriers to effective UIKT at the supply side. At most European universities the structures to manage a portfolio of intellectual property are not sufficiently established, and there is no experience regarding best practice. Additionally, academics deny UIKT as they fear a shift from basic to applied research and its influence on education. (Stephan 2001) On the knowledge market demand and supply side just do not possess sufficient information about each other. (Klerkx and Leeuwis 2008b) Often universities are even not able to identify the in-house commercialization potential.

This paper builds on Bühnemann and Burchhardt (2013) who investigate the potential for commercialization within research institutions, especially universities. Thy offered a methodological framework for determining this potential. Specifically, the paper highlights the importance of inventions, publications and third-party funds as objective indicators, and an additive value function is introduced to aggregate the informational value of all indicators to a single measure of the potential for commercialization. Finally, the applicability of the presented methodology is demonstrated with the case of a technical university in Germany. Bühnemann and Burchhardt (2013) thereby focus on the supply side. However, to derive profound policy recommendations we need to contrast supply with demand. This paper fills the gap and shows how the industrial demand for scientific knowledge can be systematically determined. As Bühnemann and Burchhardt (2013) we introduce a value function to receive a single measure for industrial demand. As a direct survey among firms has major drawbacks we propose an inquiry of different intermediates. We provide reasoning that cluster managers are suitable intermediates to estimate the demand for scientific knowledge.

Our paper is structured as follows: We start in section 2 with a literature review on technology transfer and discuss insights our investigation builds on. In section 3 we offer a methodology to estimate the industrial demand for scientific knowledge for the region of Saxony-Anhalt. An online questionnaire among all local cluster managers is developed to show the applicability of the proposed methodology. We present and discuss the data for Saxony-Anhalt in section 4. Section 5 concludes with the contrasting juxtaposition of demand and supply. We derive implications for firms, universities and local government to better use the existing transfer potential and thereby economically strengthen the investigated region.

2 Literature Review on Technology Transfer

There is a massive literature on UIKT which, according to Agrawal (2001), is classified in four categories: firm characteristics, university characteristics, geography in terms of localized spillovers and transfer channels. The first category offers some general insights on necessary preconditions to create and commercialize innovations, which include skilled staff, financial means and absorptive capacity (firms ability to use external research results influenced by various factors like connectedness). Moreover, Bishop et al. (2011) confirm that it is continuous involvement that matters, more than the extent of firms' R&D activities. This is in line with Schmidt (2005), who suggests that it is the persistent and sustained engagement in R&D that improves a firm`s absorptive capacity. Closely related is a further basic result which is important to our analysis. The propensity to conduct an R&D project with an academic partner depends on the 'absolute size' of the industry firm. Larger firms are more likely to collaborate as they have higher absorptive capacities. (Cohen et al. 2002, Mohnen and Hoareau 2003, Laursen and Salter 2004, Arundel and Geuna 2004 as well as Fontana et al. 2006).

The second literature category focuses on the determinants that distinguish successful from other research institutions. The balance between centralization and decentralization within academia, the design of appropriate incentive structures, and the implementation of appropriate decision and monitoring processes within the technology transfer office are central contributions of the literature on university characteristics (e.g., Debackere and Veugelers 2005). Our work contributes especially to the literature on monitoring and performance measurement.

The third category refers to transfer geography. Theoretical and empirical findings suggest that knowledge spillovers are regionally concentrated or, put differently, most innovative systems have a rather regional focus (Acs et al. 1992, Audretsch and Feldman 1996 and Anselin et al. 1997). Fritsch and Franke (2004), therefore, conclude that the level of knowledge spillovers constitutes a key factor for regional innovativeness. Numerous studies confirm that geographic proximity facilitates spillover effects between university and industry using evidence from e.g., patenting and publishing activities (Arundel and Geuna 2004, Levy et al. 2009). Broström (2010) additionally shows that proximate interaction is more likely to successfully contribute especially to R&D projects with short time to market. Bishop et al. (2011) also find that geographical proximity is crucial but only for direct problem solving cooperation as major transfer channel. On the basis of this literature we argue that public initiatives for regional development should focus on research institutions within and close to regions. Here, it is ultimately a question of distance and not of affiliation to administration districts.

The fourth literature category explores the different types of transfer channels and discusses their relative importance for economic value creation. We follow Reamer et al. (2003) who assign all transfer channels to five pathways of knowledge migration: (1) Cooperative research and development. (2) Licensing or sale of intellectual property (IP) and spin-offs. (3) Technical assistance. (4) Information exchange. (5) Hiring skilled people. The determination of the commercialization potential within universities typically concentrates on the second pathway as revenues from intellectual property can be measured well. In contrast Bühnemann and Burchhardt (2013) consider all transfer channels except the last one.

A second valuable body of literature concentrates on the role of intermediates for the UIKT. To create a sustainable linkage between research institutions and industry, among others, technology development, networking, and financing are necessary activities. Typically, intermediates perform these activities and thereby create value for all partners in a network. According to Dalziel (2010) trust is the main motivation for an independent often non-profit institution as intermediate. Accordingly, although their impact is difficult to measure, intermediation may be the most effective tool to foster the innovativeness of a region. The literature devotes a large role in technology transfer to intermediates, e.g., Howells (2006). Hoppe and Ozdenoren (2005) provide a bulk of empirical evidence demonstrating that uncertainty about the profitability of investing in new technology is the major source for intermediation to be profitable. Their theoretical argument is that the intermediate's expertise enables a better estimation of the value of new inventions and a better matching of the profitable innovators with suitable investors.

Klerkx and Leeuwis (2008a) provide an overview of various responsibilities: facilitate the formation and maintenance of innovation networks, articulate demand, coordinate, support the innovation process management, help building capacity with regard to competences needed for innovation, help acquiring necessary information and so forth. According to Howells (2006), intermediation is not limited to the improvement of connectedness but he suggests a systemic value in creating new possibilities and dynamism within a system. Yusuf (2008) adds the minimization of transaction costs for both universities and businesses as economic benefit and encourages the implementation of various intermediating mechanisms to guarantee the robustness of an innovation system. Bruneel et al. (2010) highlight that independent intermediates are superior in building trust between academics and industrial practitioners and promote the necessity of long-term investments in interactions. This literature also devotes a key role to the government as a market facilitator (Oughton et al. 2002). Local governments and the European Union are aware of this role in promoting intermediation. Since 2000 numerous national and regional programs have been initiated which include intermediation through industry-near cluster networks and through science-near technology transfer centers. The informational gap can be closed directly by universities but as literature proposes intermediates like e.g., cluster managements will perform superior in that task (Yusuf 2008). We refer to this research and argue that a determination of industries' knowledge demand can best be approximated by a survey among well-established intermediates.

Four literature implications are relevant for our analysis: First, it is important to work on both the demand and the supply side of the innovation system (Oughton et al. 2002). On the one hand governments should support firms in increasing its absorptive capacity, while, on the other hand we need efficient transfer structures within research institutions that set an appropriate framework for cooperation. Second, an efficient transfer unit must be implemented that uses a suitable mixture of all relevant transfer channels (Agrawal 2001). Third, an integration of activities from different sectors enhances network success (Rondé and Hussler 2005). Fourth, there is no cure all, policy measures should depend on the regional context (Azagra-Caro et al. 2006). This is in line with Oughton et al. (2002) who state strong complementarities between business, education and government spending on R&D. Especially in structurally weak regions local innovation strategies should increase both private and public sector investments in innovation activities. Despite the prominent role of public authorities the literature indicates that this effort only leads to sustainable regional development if universities and firms together take the responsibility to ensure cooperation (Siegel et al. 2003). On the part of universities a strong orientation and commitment towards technology transfer is required. This demands first for a central transfer unit, a balanced incentive scheme and an appropriate allocation of resources. Universities need to pursue long-term strategies to develop and sustain a high level of excellence and transparency in research. Firms, on the other hand, need to proactively pursue innovation as a part of their competitive strategy and screen universities for usable knowledge (Yusuf 2008). The following section is a first attempt to reduce the identified informational gap by determining the industrial demand for scientific knowledge.

3 Methodology

The design of our demand measure is guided by the ultimate target to contrast supply of scientific knowledge with industrial demand. From the governmental perspective with the aim to promote regional development a complete survey among all firms within that region might be interesting. There are two reasons for a limitation of that survey. First, the cost to receive a full sample of all firms will be prohibitively expensive. Even if costs could be kept low by using existing channels like the Chamber of Industry and Commerce or the Chamber of Crafts the size of the sample would be significantly limited by the low participation rate of entrepreneurs and managers.[2] Hence, a typical investigation of customer preferences would use a representative sample of the target group and make a projection on the total number. Second, as policy makers try to stimulate the innovativeness of their region one should concentrate on the knowledge-intensive part of the region`s industry, especially on technology-driven firms. Usually the lion`s share of firms has no demand for new scientific knowledge, respectively a cooperation would not generate any benefit. The selection of relevant firms is a substantial but non-trivial task.

We suggest screening the region for organizations that represent the target group as close as possible. In Germany e.g., during the last decade, the cluster initiative created different industry representative offices in almost all regions according to a clear pattern. The government evaluated the local economy and implemented a cluster for each knowledge-intensive industry sector where a region reached a critical mass of firms capable of competing internationally or at least nationally.[3] Based on existing competencies and studies of present and future market developments this concentration on core areas promised to deliver the highest synergies.

We provide several arguments that a survey among organizations representing these industrial core areas is a suitable approximation of firms` demand for scientific knowledge. Most important, for policy measures we only need to identify structural patterns or general insights. Thus, a medium level of demand information is necessary to e.g., propose a change in the

[2] E.g., Cycyota and Harrison (2006) as well as Frohlich (2002) estimate an average participation rate of roughly 30 percent which is in comparison to other experimental contexts even optimistic.

[3] Note, that although these core areas were result of scientific potential analyses of each region's economy there are no clear cut criteria in literature that substantiate that decision. See e.g., Hausberg et al. (2008) for the federal state Saxony-Anhalt.

scientific long-term orientation. The exact assessment of firms' current research demand is not needed and would significantly increase complexity. An investigation on the industry sector level shows the additional advantage that the influence of strategic behavior is reduced. Specifically, an independent organization, especially if publicly funded, is less likely to exaggerate the demand. If available, the survey can be conducted among different industry experts. Here the Delphi method can be applied. It is one of the most widely used and recognized instruments to make predictions and facilitate decision-making in almost all contexts (Landeta 2006). Despite a list of theoretical shortcomings using expert opinions to forecast e.g., local demand, has proven to be superior.

In order to estimate the explanatory power of a survey among cluster experts we need to check for two aspects: first, whether the existing cluster structure represents all economically relevant industries that are demonstrably knowledge-driven and second, whether each cluster really represents a significant proportion of existing firms. As often not all firms belonging to an industry sector are part of the cluster the percentage share is a suitable measure to control cluster manager`s predictive power. Additionally, one could question, whether cluster manager possess the necessary information to estimate the overall demand of firms they represent. Nevertheless, a possible distortion will be rather low if a cluster offers a broad range of support for free and has an intensive contact on a regular basis. Contrary, surveying experts might have significant advantages. In their role as an industry's gateway cluster manager will more likely be able to identify firms` technological developments. At the same time they are more familiar with structures and research foci of universities and thus might be more suitable to identify structural units that match firms` demand.

Having argued that the cluster managements are appropriate intermediates bundling industries' variety of interests we now discuss our methodology to survey demand. Demand approximation needs to be based on two dimensions in our context: the number of interested firms and the average firm demand. We propose a questionnaire which can be found in the appendix. The basic idea to reduce complexity and receive standardized information on firms' needs is to confront the regional demand with the existing supply of knowledge. This first requires transparency within near-by research institutions. Naturally, to receive the full picture we also integrate the opportunity to supplement demand for research areas and foci that are not covered by regional players.

The first part of the questionnaire raises information that is necessary to characterize a cluster and to determine their relative weight for the considered region. It contains the sum of employees in all firms and their economic power, the number of firms currently belonging to a cluster and their average annual expenditures for external R&D, subdivided into three standard size categories. The differentiation in size and the information on expenditures for R&D is used to discriminate their influence on the overall demand.[4] The second part of the questionnaire presents all foci of identified research units in the region of interest which enables cluster manager to get an overview of the competences each unit possesses. On this basis cluster managers estimate the number of represented firms for which the stated research foci are relevant. To account for possible demand uncertainty we allow cluster managers to state the number of firms in an interval. In case of perfect information the lower and upper boundary would just be identical. We suppose that stated intervals will have a narrow range as insights of cluster managers will be precise enough to specify a general relevance.

In contrast, the average firm demand dimension is likely to involve a higher uncertainty. Hence, cluster manager will not be able to state the demand intensity on an individual level. We allow for that fact by inquiring the qualitative demand along an interval in three standard size categories. A precise estimation of firms` demand would ask for the value that is created by research in a specified field. Nevertheless, we found that cluster managers are not able to satisfactorily approximate the financial impact of specific R&D. This is not surprising as even managements of firms cannot precisely determine financial consequences of their own research activities. We solve that problem by using the informational level cluster managers regularly possess. Hence, we ask them to judge the average influence of specific R&D on firms business in a range from 0 (no expected financial impact) to 100 (very high expected financial impact). This score measure should also indicate the monetary contribution of past R&D to business success, e.g. a revenue increase through product innovation or a cost reduction through process innovation. A separate specification for each size category allows us to contribute to the literature that assigns the highest innovation capacity to large firms, while the value of networking is greatest for middle-sized firms.

In case of perfect information the overall demand would be determined as the sum of firms` individual demand over all firms in all clusters. If information on firm level is not available an estimation of the demand for scientific knowledge must account for the number of firms as well as the size of the expected benefit from cooperation in a research field. The demand of cluster c for research in structural unit j is the number of firms that expose demand n_j^c multiplied by the average value that is generated through R&D in that field I_j^c. As we differentiate firms according to their size, we need to consider the sum over all three categories $s = 1..3$, where 1 represents micro firms (less than 10 full-time equivalent employees), 2 stands for

[4] There is a controversial discussion in literature about the relation between firm size and R&D spillovers. See e.g., Audretsch and Vivarelli (1996) as well as Godin (2006).

small firms (10-50 full-time equivalent employees) and 3 represents middle and large firms (> 50 full-time equivalent employees).

Summarize the product of firm number and average demand for each size category yields $n_j^{c1} \cdot I_j^{c1} + n_j^{c2} \cdot I_j^{c2} + n_j^{c3} \cdot I_j^{c3}$. To account for the fact that a high demand of large firms might involve greater spill-over we multiply the demand in each size category with the average number of full-time equivalent employees e^c of firms belonging to the corresponding category. We denote the demand of cluster c for structural unit j as d_j^c with: $d_j^c = n_j^{c1} \cdot I_j^{c1} \cdot e^{c1} + n_j^{c2} \cdot I_j^{c2} \cdot e^{c2} + n_j^{c3} \cdot I_j^{c3} \cdot e^{c3}$. The overall demand for structural unit j then is the sum of clusters` individual demand over all considered clusters y. However, this would imply that all clusters have an equal weight. We control for structural differences and propose to take both the number of firms in a cluster N^c as well as their total number of employees e^c into consideration. We receive the following function that characterizes the demand for a certain field of research aggregated over all relevant clusters:

$$D_j = \frac{1}{\sum_{c=1}^{y} N^c \cdot \sum_{c=1}^{y} e^c} \cdot \sum_{cl=1}^{y} d_j^c \ , \qquad \text{with } D_j \in [0;100].$$

Obviously, if there is no demand for cooperation with structural unit j the resulting value is 0 whereas if all firms in all clusters state the highest possible demand we receive a value of 100. As we control for the number of firms and employees the resulting demand values will be rather small. This has no effect on the implications we derive since we are interested in the relative demand for each structural unit of regional research institutions. Nevertheless, as it is relevant for the matching of demand and supply we discuss this aspect in section 5. Our demand function directly applies if decision makers are able to state precise information. In case they provide intervals to account for uncertainty we could compare structural units based on two values (a demand value for the upper and the lower boundaries). Alternatively, one could calculate the arithmetic or geometric mean of the given demand intervals. This number is appropriate for a comparison if there are no structural differences in demand uncertainties between all research fields.

In summary our recommended demand measure accounts for existing informational uncertainties and controls for differences in firm size. The introduced value function assumes that all elements are additively separable analogous to the standard microeconomic demand function. As we see no indication for structural dependencies among demand of different clusters, this assumption should be basically fulfilled. Section 4 presents an empirical investigation for Saxony-Anhalt to test our proposed methodology before section 5 contrasts supply and demand on the basis of an empirical analysis of research supply at the Otto von Guericke University Magdeburg (Bühnemann and Burchhardt 2013).

4 Empirical Investigation

For the region of Saxony-Anhalt, a federal state in Mid-East Germany, a recent cluster potential analysis (Hausberg et al. 2008) identified key industries of which eleven are currently represented by state-funded clusters.[5]

We started our investigation with a pretest of our questionnaire - an in-depth expert interview with a cluster manager to check whether our target group fully understands all questions and is able to provide information with the intended level of detail. The valuable feedback was integrated in the questionnaire design. For our survey we then approached all knowledge-intensive industries with existing network structures.[6] Ten out of eleven participated, which is a remarkable response rate. Only the cluster "Chemie/Kunststoffe Mitteldeutschland" did not follow our request. Hence, one has to bear in mind that our results take not into consideration the chemical industry although it is one of the most influential. Nevertheless, all in all, the ten covered clusters are politically legitimated and represent a large proportion of the knowledge-intensive economy (Hausberg et al. 2008).

Figure 1 characterizes clusters on the basis of size and multidisciplinarity. The cluster BioEconomy is not illustrated because of missing values. The vertical axis shows the number of firms each cluster represents and the horizontal axis illustrates the total number of full-time equivalent employees in these firms. Therefore, the position of each of the nine clusters indicates their economic influence on the considered region. The further to the north-east the higher is the expected impact. It is also possible to gain insights on differing firm structures. Whereas cluster IT represents a small number of large firms cluster SMAB provides services for many rather small companies.[7] Simultaneously, it indicates why it is necessary to control

5 Saxony-Anhalt`s cluster structure analysis delivers broad industry information but does not specify their approach to determine profitable clusters. For a scientific methodology to set-up a regional cluster strategy see e.g. Feser and Bergman (2000).

6 Cluster **MAHREG** Automotive, Cluster Chemie/Kunststoffe Mitteldeutschland (**CHEM**), Polykum e.V. (**POLY**), Cluster Biotechnologie in Sachsen-Anhalt (**BioTech**), Netzwerk Ernährungswirtschaft Sachsen-Anhalt (**NE**), Cluster Sondermaschinen und Anlagenbau in Sachsen-Anhalt (**SMAB**), Cluster für erneuerbare Energien in Sachsen-Anhalt (**CEESA**), Cluster **IT** Mitteldeutschland, Cluster Kreislauf- und Ressourcenwirtschaft (**KRW**), Cluster **BioEconomy**, Cluster Solarvalley Mitteldeutschland (**SOLAR**). We thereby build on the existing cluster structure. This limits the explanatory power of our survey as some promising industries might not be represented.

7 Note that we controlled for different regional foci of some clusters. CHEM, IT, POLY, SOLAR and BioEconomy cover Central Germany, a considerably larger area than Saxony-Anhalt. Thus, cluster manager

for both dimensions, as they have obviously significant differences in their economic importance. For instance, as the economic impact of cluster MAHREG in Saxony-Anhalt seems to be significantly higher than of cluster SOLAR the overall demand must account for this. Instead to use the number of employees one could also take statistics on industries` contribution to regional GDP as proxy, if available.

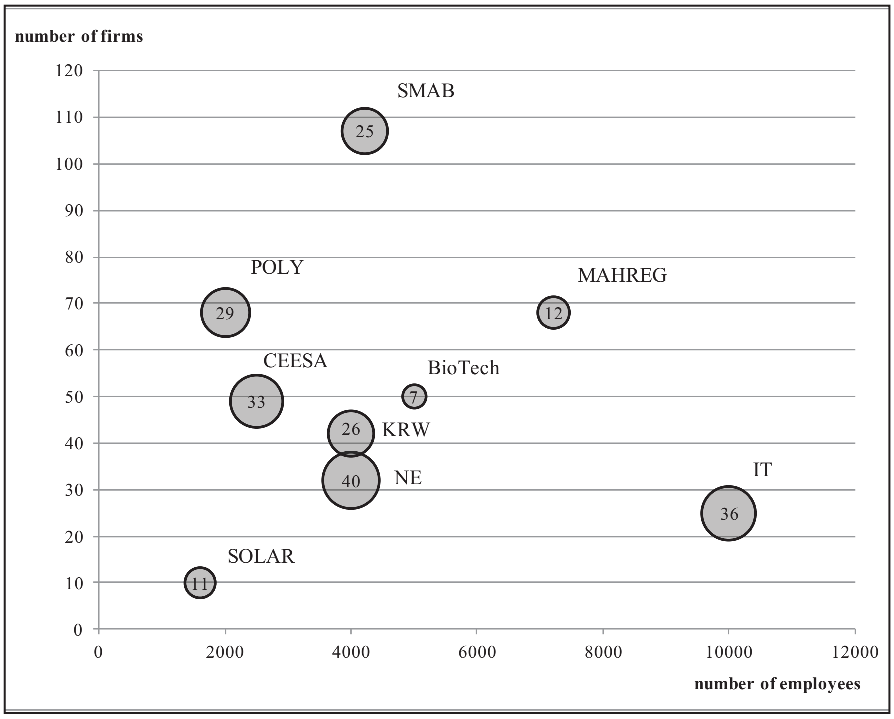

Figure 1: Cluster Comparison[8]

In addition to differences in size Figure 1 also provides rough information on clusters` demand. The size of each circle represents the number of research fields each cluster stated a demand for. Independent of the demand intensity it is an indicator for the R&D multidisciplinarity of clusters. As virtually no cluster expressed demand for one of the 50 structural units belonging to the medicine faculty we have taken these out of our analysis. Hence, the maximum number of linkages would be 63. This gives reason to conjecture that the IT industry, the food industry and the industry for renewable energies exhibit a high demand and thus provide high innovation potential to realize synergies. This number, though, does not account for the qualitative demand dimension. It rather indicates that some clusters see cooperation potential breadthways. It might be of considerable importance to support the networking of these clusters as they require research input from various fields and partners.

were advised to refer their answers exclusively to our region of interest. Nevertheless, it is only a rough indicator for the share of regional GDP as it ignores e.g., the personnel costs/total output ratio.

[8] As there is a missing value of cluster BioEconomy figure 1 only displays nine clusters.

Whether MAHREG, BioTech and SOLAR have only a low demand for scientific knowledge or they need intense linkages to a small number of partners can be analyzed with Table 1.

faculty	FWW		FIN		FMA		FMB		FVST		FEIT		FNW	
cluster	#	/ intensity	#	/ int.	#	/ int.	#	/ int.	#	/ int.	#	/ int.	#	/ int.
BioTech	1	0,6	0	0	0	0	0	0	5	6,8	2	2,8	2	6,5
SMAB	2	4,8	4	3,2	1	1	76	32,6	20	14,8	12	24,8	0	0
MAHREG	0	0	0	0	0	0	38	47,9	18	21	15	15	0	0
SOLAR	3	0,3	1	0	0	0	3	9,6	2	3,5	2	6,6	1	0
POLY	2	2,4	5	6,4	3	0	7	10,6	11	15	6	10	2	1,8
NE	10	16,8	4	7,6	1	1,8	2	4,6	5	9,5	2	3,4	1	1,3
IT	3	4,7	21	94,2	16	61,8	6	28,9	3	12	13	51,6	3	12,5
BioEcon	0	0	0	0	0	0	0	0	6	13,8	0	0	0	0
CEESA	2	2,8	4	43,4	4	26	17	59,3	10	67	15	74,2	2	8,3
KRW	2	4,4	2	3,6	1	1,3	4	8,3	6	15	1	1,2	0	0

Table 1: Quantitative and Qualitative Demand on the Faculty Level

The table shows the quantitative and qualitative demand of all clusters on the faculty level[9]. The first value in each column is the rounded average number of firms that perceive a general relevance to a faculty`s fields of research. The second value is the average influence of faculty specific R&D on the business of all firms that articulate demand within a given cluster. This illustration allows us to gain some general insights on the innovation potential of research cooperations between faculties and industries in Saxony-Anhalt. The BioEconomy cluster has only stated a low level of research relevance of the Faculty of Process and Systems Engineering. Some clusters like IT and CEESA confirm a high relevance and intensity over several faculties whereas e.g., the photovoltaic and biotechnology industries see only a low relevance over all faculties. We also find industries with a high demand for research foci of a single faculty and quite low demand for all others e.g., the specialization of cluster MAHREG for the automobile industry. From the university`s perspective we identify some faculties with a high demand distributed over several industries like FMB and FEIT while some others attract demand almost exclusively from a single industry (Faculty of Mathematics). Yet others are broadly confronted with a low demand like FWW and FNW.

[9] FWW (Faculty of Economics and Management); FIN (Faculty of Computer Science); FMA (Faculty of Mathematics); FMB (Faculty of Mechanical Engineering); FVST (Faculty of Process and Systems Engineering), FEIT (Faculty of Electrical Engineering and Information Technology) and FNW (Faculty of Natural Sciences). The Faculty of Medicine as well as Humanities, Social Sciences and Education (FHW) is left out since we observe almost no demand for their structural units.

Of course, it will be difficult to analyze demand if we provide that discussion on the level of single structural units. Therefore, we use the methodology presented in section 3 to combine both dimensions and control for the size of firms.[10] Prior to an application we need to check whether basic assumptions hold, viz. additive separability and relevance of clusters. First, a correlation analysis showed no incidences that individual clusters` demand depend on each other. Hence, we are able to aggregate the industries` demand with an additive separable value function. Second, we need to check whether the existing clusters cover the most important industries and therefore represent Saxony-Anhalt`s innovative capacity to a large part. Due to a lack of transparent evaluation systems of the regional economy on the industry level we cannot perfectly validate the established cluster structure. Nevertheless, we did not find any further economically relevant research-intensive industry and, thus, argue that our eleven clusters reasonably embody the demand for scientific knowledge. Third, the share of firms in each industry affiliated in the government promoted clusters is high, especially if we account for their size. Although there is no comparable source of information on the number of firms and employees per industry available for this region, cluster manager claim to represent a large proportion of their industry. Thus, we conclude that our measure should provide a good estimate of industrial demand. Table 2 gives an overview of the ten structural units facing the highest aggregated demand.

Rank	**Faculty**	**Unit**	**Demand**	**∅ Trend**
1	FMB	Material and Joining Engineering	3,99	increase
2	FMB	Manufacturing Engineering & Quality Management	3,54	slight increase
3	FMB	Mobile Systems	3,43	increase
4	FEIT	Automation Engineering	3,36	slight increase
5	FEIT	Electronics and Signal Processing	3,17	increase
6	FMB	Mechanics	2,79	constant
7	FVST	Process Engineering	2,74	constant
8	FMB	Industrial Science & Factory Automation	2,70	constant
9	FMB	Logistics and Material Handling Engineering	2,63	constant
10	FMB	Machine Design	2,45	constant

Table 2: Top Ten Units in Aggregate Demand

[10] We applied a preliminary version of the survey design presented in section 3 that uses the same logic of the value function to aggregate the qualitative as well as the quantitative dimension. Our questionnaire did not offer the opportunity to state demand in intervals and our estimation of the demand does not differentiate between proposed size categories.

Even among the top ten units that predominantly belong to the Faculty of Mechanical Engineering we observe significant differences in industrial demand. Although we need to carefully interpret the absolute demand value, in relation to the maximum value of 100 it indicates a rather moderate expected relevance of scientific knowledge for regional firms` businesses. In contrast, the relative demand has a high explanatory power. The ranking shows the current attractiveness of all units. A detailed analysis of the demand origin can then deliver more concrete information on the realization of that potential, e.g., whom to contact or which transfer channel to use. We also need to consider future expectations as it takes time to adapt competences and capacities. To enhance the predictive power we therefore include a question on the expected development of a cluster's demand within the next two years on a five point Likert scale with 1 representing a strong decrease and 5 representing a strong increase in demand. The right column of Table 2 contains an indicator for the future development of industries` demand. The underlying measure accounts for the differing impact of industries on research areas. We weight the trend value for each structural unit with the individual demand of a cluster. Among the top ten there are clear differences in the predicted trend. Whereas the top five even have a positive outlook the remaining can expect at least a constant demand within the next two years. As demand for specific knowledge has short time windows the implementation of an online survey on a bi-annual basis would be useful. Within a couple of years the resulting panel data enriched by the collection of realized cooperation results enables to derive cluster profiles and to evaluate the quality of cluster managers' predictions. Simultaneously, it might allow concluding on the effectiveness of taken measures. We hypothesize that deepening the cooperation paths and gaining further positive experiences of knowledge transfer will stepwise reduce the informational gap between both market sides. This in turn will lead to an increasing demand over time.

In the following section we build on the demand data presented in section 4 and the supply data from the study of Bühnemann and Burchhardt (2013). We provide a possible illustration to contrast both market sides and derive implications for research institutes as well as policy recommendations for local government.

5 Contrasting Supply and Demand

Figure 2 shows 63 structural units with demand on the vertical axis and supply[11] on the horizontal axis. Units from the medical faculty were left out as we did not observe any indus-

[11] The supply crucially depends on the weighting model for the indicators of total commercialization potential. Our comparison in Figure 2 is based on the average of all expert opinions (model 1 of Bühnemann and Burchhardt 2013).

trial demand for their research. Graphically these units would lay on the horizontal axis, as competences are present but regionally not demanded. Both market sides have diverging dimensions. Despite two different methodological approaches to determine a single measure for the demand and supply of scientific knowledge, we are able to provide an illustration that combines both dimensions. For a relative comparison we normalize demand and supply values. The structural unit with the highest (lowest) score receives 100 (0) and all others are evaluated proportionally in between. The absolute performance can therefore not be interpreted in Figure 2. However, a qualitative matching allows us to derive specific policy recommendations for each segment.

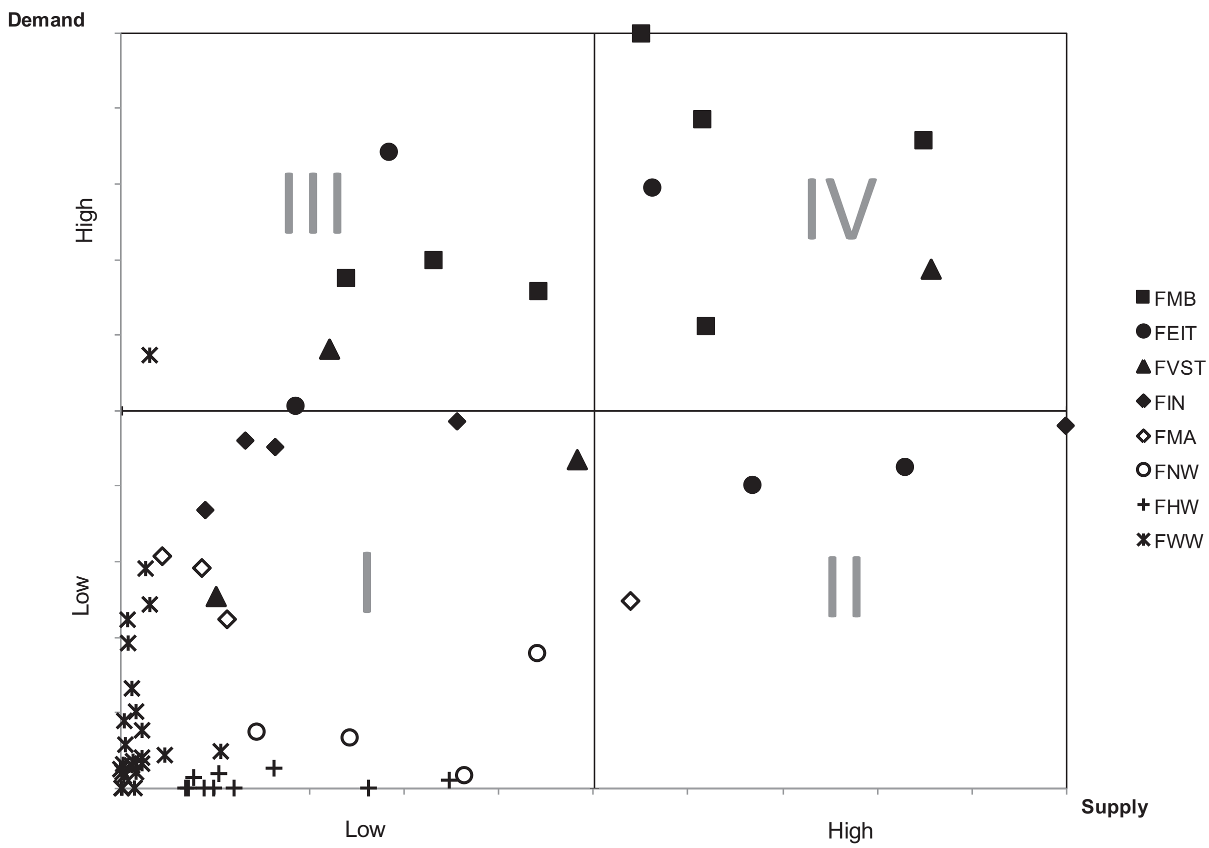

Figure 2: Contrasting Supply and Demand

Figure 2 divides the market for academic knowledge into four segments. Segment 1 represents structural units where research institutions perform relatively poor and current regional demand is relatively low. From the governmental perspective research in these fields should not be promoted as they will be less likely to positively influence the regional development of Saxony-Anhalt. Nevertheless, structural units with a positive forecast among them might be interesting in the future. From the perspective of universities it should be investigated whether there might be a national or international demand. As international university-industry linkages exist almost exclusively between large firms and top-level institutions and as for a poor current performance it is unlikely to become internationally competitive it directly implies that transfer funds in structural units of this segment should rather be cut back. The legend of Figure 2 shows the affiliation of units to one of the eight considered faculties. Almost all units belonging to the Faculty of Humanities, Social Sciences and Education (FHW as cross) and the Faculty of Economics and Management (FWW as star) are located in segment 1. Research in these fields is simply not transfer-affine. It is also not surprising that a majority of structural units with an emphasis on basic research are within this segment.

Segment 2 shows structural units with a comparatively good performance while industrial demand is rather moderate. Here, at least a national transfer campaign should be initiated as the necessary competences seem to exist but the regional development is unlikely. Nevertheless, a crucial aspect might also be whether research output and national cooperation have an expected positive effect on a region`s reputation. In general policy recommendations should not be strictly based on categories but rather the relative location and individual influences. For example two units from the Faculty of Electrical Engineering and Information Technology (FEIT as circle), electric energy systems as well as micro- and sensor systems, are among the top 5 in aggregate commercialization potential and attract medium demand. It is worth to analyze their matching potential in detail.

Segment 3 indicates research areas where regional demand is relatively high, but the university has rather low commercialization potential. This segment corresponds to the question marks of the BCG-matrix[12]. Whether promoting structural units in this segment or not (especially in case of promising demand forecasts) depends on the likelihood to develop a competitive offer within a short period of time. This requires a comprehensive in-depth analysis of competences and competitors. This decision under uncertainty must be based on a profound cost-benefit analysis. In this segment cooperation opportunities are rather selective, e.g., production and logistics (FWW) attract demand from various industries, few firms with high relevance and simultaneously a medium intensity from a multitude of firms. The rather low supply value results from no invention notifications and no public third party funds in the sample period. This must not constitute a low transfer potential, but it indicates that they might use other transfer channels and do not fully exploit their existing potential so far.

Finally, the segment 4 indicates a high transfer potential as current demand matches existing research foci. Here, it is important to examine the variety of existing cooperation. Local government would be interested in building bridges between university representatives of

[12] See Hedley (1977).

these high-demand research areas and firms. The demand structure has direct implications for the choice of transfer channels policy makers might support. For example all structural units from the Faculty of Computer Science (FIN as diamond) exclusively attract demand from the IT industry whereas research units from the Faculty of Process and Systems Engineering (FVST as triangle) have a broad demand base. This is one reason for a differentiation of governmental support measures. For universities with the transformation to a transfer-affine research institution ahead a concentration on segment 4 is especially valuable. It creates trust and can generate common value that might finance subsequent university-industry collaboration.

Our investigation of the market for scientific knowledge identified hidden potential to sustainably strengthen the economic power of a region. Saxony-Anhalt is lagging behind most other regions in Germany.[13] One reason might be the low level of total R&D expenditures which represent only 1 percent of Germany`s investments to R&D (BMBF 2012, p.415). In order to close the economic gap the local ministry of economics and science plans a change in strategy from supporting numerous small short-term projects to fostering a transfer unit that is able to sustainably strengthen the knowledge spillover to industry. Consequently, one of the central tasks of a transfer unit is building bridges to industry and thereby closing informational gaps. Our main contribution is a proposal of a methodology to improve transparency by determining local supply and demand. The identification of UIKT potential is just the first step. To realize this potential the local governments need to stimulate both market sides and promote establishing a variety of transfer channels. The literature on knowledge transfer provides many insights into the effectiveness of different transfer channels for various contexts.

There are several limitations to our empirical study that need to be mentioned. First, there is a short time lag between demand and supply data. Whereas our demand survey is up-to-date, the commercialization potential survey is based on the period 2007 to 2011. Second, our study exclusively focused on the OvGU. Although it is one of the major research institutions in that area it would be of great value to include all other research institutions into analysis. Transparency among all relevant players and an alignment of all activities would best stimulate knowledge transfer as the study by Geuna and Muscio (2009) underpins. They indicate a need for regional offices rather than small offices in individual universities to reach a critical size for a network to be effective. Third, our analysis only focuses on transfer activities. A general decision on the strategic orientation of universities must consider a balance of all tar-

[13] Statistics like the average per capita GDP (Statistisches Landesamt Baden-Württemberg 2014) and per capita income (Statista 2014) confirm this inferior position as Saxony-Anhalt is constantly among the three worst federal states.

gets. Policy recommendations for the region of Saxony-Anhalt should account for this aspect. Fourth, with the chemical industry the second most important industry for Saxony-Anhalt`s innovativeness did not participate. Their inclusion might have a significant impact on outcomes. Fifth, of minor importance is a possible distortion of firms with a broad value chain that might be affiliated to more than one cluster. If several representatives account for their demand this could lead to an overestimation of total demand.

6 Conclusion

This research study strengthens the importance and public perception of university-industry knowledge transfer for regional development. It shows that transfer strategies need to be based on both, the industry and science perspective. We investigated the demand for scientific knowledge and proposed an inquiry of cluster manager as intermediates to reduce the informational gap. Using the example of Saxony-Anhalt we demonstrated the applicability of our methodology and provided a possible illustration of the demand and supply matching. On this basis we derived clear policy recommendations to support the knowledge transfer from universities to industry. First, depending on the multidisciplinarity of industries we recommend the use of different transfer channels. Second, the identification and promotion of flagship cooperation areas will create trust and foster the mutual exchange of information. Third, if all research institutions of a region are evaluated the expected economic value of knowledge transfer might be one basis for governmental support. Decision makers within the research institutions might use our matching grid as decision tool for future transfer strategies. Simultaneously, economy profits from enhanced transparency as it facilitates to find suitable partners and indicates interesting arenas for future research.

The specified methodology is an important basis for the development of a transparent platform for all players on the market for scientific knowledge. In recent years politics demands and promotes more transparency in technology transfer. This paper constitutes a first step towards the EU-requested evaluation system.

For future research it might be interesting to contrast the results of our study with a direct survey among existing firms. This could strengthen or disprove the eligibility of cluster manager as source of information. Additionally, our study has explored indicators for cluster politics as avenue for further research. The establishment of clusters on the basis of objective criteria is an important prerequisite for the validation of our approach but still unsatisfactorily covered.

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Appendix - Structure of the „Cluster Manager"-questionnaire

First page:

Dear Cluster Manager,
the project „Pro-Active Science Transfer“ aims to strengthen the link between economy and science in Saxony-Anhalt. In the first step the current transfer potential of all structural units of the Otto von Guericke University Magdeburg (OvGU) was analyzed. For a successful knowledge- and technology transfer we now need to investigate the demand of the regional economy. Therefore, we ask you as a representative for a certain economic branch to evaluate the relevance of the research foci for each structural unit we identified at the OvGU.

To contrast supply and demand of scientific output enables to develop strategic measures for an improved transfer at the OvGU.

Thank you very much for your support!

page 2:

Which cluster do you represent? [please choose one]

- ➔ Cluster Biotechnology Saxony-Anhalt
- ➔ Cluster chemistry/synthetics Central Germany
- ➔ Cluster for renewable energies Saxony-Anhalt (CEESA)
- ➔ Cluster IT Central Germany
- ➔ Cluster recycling and resources management
- ➔ Cluster automotive (MAHREG)
- ➔ Cluster special machines and plant construction Saxony-Anhalt (SMAB)
- ➔ Food industry network Saxony-Anhalt
- ➔ Excellence cluster BioEconomy
- ➔ Excellence cluster solar valley Central Germany
- ➔ “Polykum e.V.” polymeric development and plastics engineering Central Germany

page 3:

How many firms currently belong to your cluster, subdivided into three categories according to their size, and what is their average annual revenue?

Micro-firms (<10 employees)	*[number]*	*[revenue in €]*
Small firms (10-50 employees)	*[number]*	*[revenue in €]*
Middle & large firms (>50 employees)	*[number]*	*[revenue in €]*

How many individuals are currently on aggregate employed in all firms that belong to your cluster?
[number]

What are the average annual expenditures for external R&D of the firms your cluster represents subdivided into the three categories?

Micro-firms (<10 employees)	*[expenditures in €]*
Small firms (10-50 employees)	*[expenditures in €]*
Middle & large firms (>50 employees)	*[expenditures in €]*

up to 113 inquiries with the following pattern:

Faculty for mechanical engineering of the OvGU

Research foci of structural unit: Mechanics
Represented by Prof. Dr.-Ing. Albrecht Bertram

- crystal and composite material
- texture development for mechanical deformation processes
- modeling of disruption, deterioration and fatigue
- visco-plasticity of high temperature alloy
- vibration engineering, supervision and adaptive vibration disruption
- automatic balancing of inflexible rotors
- modeling, calculation and optimization of adaptive mechanic systems
- high performance computing, accurateness and reliability of numerical methods
- creeping and deterioration mechanics, micro-polar continuum
- mechanically blown foam, functionally graded ceramic, sandwiches, laminate
- adaptive structural systems
- multifunctional construction material systems
- vibroacoustics

For how many firms in your cluster are the research foci above of structural unit "Mechanics" relevant?
[Interval evaluation from 0 to max]

How large is the average influence of research in the special field described above on the value created in the firms you are representing (e.g. revenue increase through product innovation or cost reduction through process innovation)?
[Choose the level in the interval between 0 (no influence) to 100 (very high influence) for each firm category]

Micro-firms (<10 employees)	*[scroll bar 0% to 100%, 100 steps]*
Small firms (10-50 employees)	*[scroll bar 0% to 100%, 100 steps]*
Middle & large firms (>50 employees)	*[scroll bar 0% to 100%, 100 steps]*

How will the research demand of the firms your cluster is representing develop within the next two years? [Please choose one]

- ➔ strongly decreases
- ➔ decreases
- ➔ constant
- ➔ increases
- ➔ strongly increases

last page:

Is there a demand for research areas and foci that are not covered by the OvGU so far? If so, describe them in detail and evaluate their relevance analogous to the prior structural units?
[open answer box in combination with the question block above]

Thank you very much for your support!

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