Regional Knowledge Transfer through Public Research Spin-offs[1]

by

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Abstract: Researchers that start their own business are assumed to locate close to the incubator organisation in order to benefit from spill-overs, thus transferring local knowledge into the regional economy. Empirical evidence on location patterns of public research spin-offs is rather limited, however, and mainly focuses on case studies for specific universities and regions. This paper provides for the first time a comprehensive analysis of the spatial distribution of new firm formations by researchers from universities and public research organisations, based on a representative data set for Germany. It shows that location patterns of public research spin-offs do not differ from other new firm formations. Proximity to the incubator is of little significance for location decisions while locations with a high number of potential customers and a large supply of high qualified labour attract spin-offs. In total, public research spin-offs rather contribute to an interregional than an intraregional knowledge transfer.

Keywords: Spin-offs, Technology Transfer, Location Decision, New Firm Formation, Public Research Infrastructure

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1 Introduction

New business ventures stemming from universities or public research organisations have attracted increasing amounts of interest in innovation policy over the last years. Significant contributions to knowledge and technology transfer is expected from such public research spin-offs. They are regarded as hubs that transfer research results into new products, new processes or new services. Regions that are sites for public research facilities are hoping that spin-offs will strengthen the local economy and increase innovation activities in the region. Spin-offs that stay in the region may benefit from linkages to and co-operation with their incubator. At the same time, they may build up links to other regional firms and thus contribute to spill-overs of new knowledge into the regional economy.

Silicon Valley or the Greater Boston Area are presumably the most prominent examples of such type of regional knowledge transfer through public research spin-offs (see Bania et al. 1993). But is this typical for an economy as a whole? Do public research spin-offs really stay close to their incubators, or do they leave the region? In this paper we address three research questions:

- Do public research spin-offs cluster around the institutions they have been associated with?
- What determines a spin-offs' decision whether to stay in the incubators' region or to move away?
- Which location characteristics attract spin-offs, and do these characteristics differ in comparison to non-academic firm creations?

Most of the literature on research spin-offs stress the spatial proximity between public research spin-offs and their incubator.[2] In a recent OECD compilation of spin-offs (OECD 2001), it is stated that "the spin-off phenomenon is at base a local phenomenon, as local innovation networks play a major part in it. These firms are linked to their home laboratories, to a few close customers, to support from local authorities." (Mustar 2001, 169-170). In this paper we will investigate into this assumption using data that cover the whole spin-off activity in an economy over a five year period.

There are several arguments why spin-offs from universities or public research organisations will cluster around the incubators' location. First, proximity to the incubator facilitates collaboration in research and the flow of tacit knowledge as it lowers transaction costs associated with such type of activity. Typically, spin-offs commercialise - at least to some degree - new knowledge produced at the incubator. Thus, they might depend upon further research results from the incubator and use contacts for learning and appropriating new

[2] On the relevance of spatial proximity in knowledge and technology transfer see for example Jaffe et al. (1993), Fritsch and Schwirten (1999), Varga (2000).

technologies and scientific findings into their business practice.[3] Spin-offs should therefore be interested in maintaining personal links to their former colleagues in order to ease knowledge exchange.

Second, researchers who establish their own enterprise might attempt to keep some formal relation to their university of research organisation that might range from co-operation in research projects, subcontracting in research or lectureships to further part-time occupation at the institution. Such formal relations provide some amount of income to the firm founders and might ease a subsequent return to public research in the case of failure of the spin-off. Thus, formal relations reduce the risk of the business venture. As such relations demand some degree of personal presence at the institution, a location close to the incubator will be preferred.

New ventures most often lack in capital at the time of starting the business. High uncertainty over their commercial success restrict access to external finance. At the same time, public research spin-offs may require laboratory equipment, high-level computer facilities and other types of physical research infrastructure. In order to minimise investment in fixed capital they might attempt to use the infrastructure of their incubator, at least in the first phase of business activity. Furthermore, especially in early stages of business activity demand for new products will vary considerably over time, and a large number of permanent employees may represent a severe financial burden. Proximity to the incubator also eases the temporal employment of students or young researchers and allows for reducing fixed costs as well.

Finally, one may expect individual preferences by the founders of spin-offs to stay in the region they have worked so far. They may have built up social relations they do want to maintain, and costs of migrating to an other region may be perceived as too high.

There are, however, some good reasons why public research spin-offs may leave the region of the incubator. First, they need to establish customer relations in order to sell their products and services. As spin-offs often introduce products and services that are new to the market, close contacts to users, and re-design of products and services to meet specific demands is required. There might be only a few pilot users for the spin-off's innovation in the market, and it is rather unlikely that they are located in the same region as the incubator. Location decision of spin-offs can thus be described as the optimisation problem to minimise the sum of costs of interacting with users, interacting with the incubator, and acquiring factor inputs, first of all high skilled labour. If the demand for user interaction and high qualified labour that provides complementary skills to that of the founders is high - and is expected to raise over time - spin-offs are more likely to locate in a region different to those of the incubator.

The analyses rest on a unique data set on public research spin-offs in Germany that were established between 1996 and 2000. Out of a representative survey of more than 20,000 new firm formations in knowledge intensive industries, public research spin-offs are identified as

[3] On the role of face-to-face interaction for tacit knowledge exchange see for example Cohen and Levinthal (1989, 1990), Cowan und Foray (1997), Grabher (1993).

those new firm formations that have at least one researcher from a university or public research organisation among their founders (including persons working as technical assistants or teachers). For each spin-off the name and location of the incubator institution, the time of leaving the incubator, the relevance of new research results for starting the new business, the type of linkages to public research, and several firm characteristics are known. Incubators are those universities or public research organisations at which the researchers among the firm founders worked before they have started their own business.

The following section describes the data base of out analysis in more detail. Section 3 analyses the location pattern of spin-offs and the spatial distance between spin-offs and incubators. Section 4 discusses the determinants of a spin-offs' decision to locate distant to the incubator, using different threshold values. Section 5 deals with the determinants of location decisions of spin-offs that either move away or stay in the incubator's region and identifies differences in location determinants between spin-offs and other start-ups in the same business sectors.

2 Database

To identify the number and characteristics of public-research spin-offs we carried out a telephone survey (using a computer assisted telephone interview technique) of more than 20,000 firms that have been established in the years 1996 to 2000 in Germany. The database is a stratified random sample of the Mannheim Foundation Panels (see Almus et al., 2000 for more detailed information) which are constructed from firm level data made available by CREDITREFORM[4]. Stratification criteria are the year of establishment, the economic sector and the type of region.

The survey is restricted to "knowledge intensive industries". These cover R&D intensive manufacturing, technology oriented services such as software, telecommunication and engineering services, and knowledge intensive services such as management consulting, teaching, research and other producer oriented services. The relevant population contains about 322,000 start-ups which is about 20 % of all start-ups in Germany in the respective period of time. We assume that the vast majority of spin-off activity takes place in knowledge intensive industries. Prior data analyses showed that the overwhelming share of self-employed graduates work in these sectors. Moreover these sectors account for almost all R&D-activities in Germany (see Stifterverband 2002).

Each start-up had to state during the telephone interview how many of its initial founders were or still are working in public research institutions, and at which institution(s). A public research spin-off was then identified as a start-up with at least one founder who worked or is still working in a public research institution. Public research institutions consist of universities

[4] CREDITREFORM is Germany's largest credit agency and has the most comprehensive database of German firms at its disposal. The main business objectives of CREDTREFORM are to provide information regarding a firm's financial situation, and to handle collection orders (see Almus et al., 2000 for more detailed information).

(including technical colleges, so-called "Universities of Applied Sciences") and public research laboratories in Germany but also comprise institutions abroad.

Out of 20,112 complete observations we identified 2,218 public research spin-offs, i.e. about 11 % of all start-ups in knowledge intensive industries in Germany in the second half of the 1990s are spin-offs from public research institutions. The majority of public research spin-offs belongs to the service sector, the share of R&D intensive manufacturing is less than 20 % (Table 1). With respect to the total population, public research spin-offs are represented above average in technology oriented services.

The information gathered from all start-ups had to be restricted to a few main firm characteristics in order to keep total interview time low and match the costs available for the survey. The questions referred to the relevance of new research findings from public research for starting the business, current links to public research institutions, R&D activities as well as size and economic activity.

Table 1: Number of public-research spin-offs by sectors

	Public-research spin-offs	All start-ups	Share in all start-ups	Shares by sectors
R&D intensive manufacturing	395	4,506	8.8	17.8
Technology oriented services	923	7,661	12.0	41.6
Knowledge intensive services	900	8,074	11.1	40.6
Total	2,218	20,241	11.0	100.0

Source: ZEW – Spin-off-Survey 2001. All information is expanded for the German statistical population of knowledge-intensive industries.

3 Location patterns of public research spin-offs

One may assume that the location behaviour of public research spin-offs differs significantly from that of other start-ups. There might be special, close links to their incubator institution that suggest to choose a location nearby the incubator. As the location pattern of incubators is very likely to differ significantly from the location pattern of all start-ups, so will that of spin-offs differ. But location decisions of spin-offs have to take into account other criteria than minimising the distance to the incubator. The utilisation of localisation and urbanisation economies essentially influences the possibility of market entrance, and hence the cost structure and sales prospect of firms. Knowledge intensive industries with high access to production- and sales factors have better possibilities in agglomeration centres than in rural regions: a wide range of qualified personnel, diversified business structure, a high demand for high-quality products and services, high purchasing power of the population, high share of research and knowledge-intensive enterprises and excellent traffic and technological infrastructures. Disadvantages of agglomerations such as high rents and cost for land should be less important for public-research spin-offs.

Table 2 presents the location pattern of public research spin-offs in comparison to that of all start-ups, of start-ups in knowledge intensive industries and of the spin-offs' incubators. For each category of start-up, the share of firms located in agglomeration centres, other urban

centres, suburban regions and rural areas is presented. The location pattern of incubators refers to the regional distribution of institutions that have been stated as incubators by public research spin-offs, weighted by the number of spin-offs. Table 2 shows that the location pattern of public research spin-offs lies in between that of their incubators and that of other start-ups in knowledge intensive industries. While incubators are heavily concentrated in agglomeration centres and urban centres (80 % of all institutions), start-ups in knowledge intensive industries are mainly to be found in suburban regions and rural areas (62 %), i.e. they show a location pattern similar to all start-ups in Germany. This pattern reveals the regional distribution of demand in Germany.

About every second public research spin-off is located in an agglomeration or other urban centre. This is significantly lower than the respective share of incubators, but significantly higher than the same share for other start-ups. Location decisions of public research spin-offs thus seem to be driven both by the access to knowledge at their incubator and by the access to demand.

Table 2: Distribution of all start-up, start-ups in knowledge intensive industries, public-research spin-offs, and incubators of public research spin-offs by type of region (in %)

	All start-ups	Start-ups in knowledge-intensive industries	Public research spin-offs	Incubator Institutions
Agglomeration centres ≥ 300.000 inhabitants	29.9	31.7	41.4	61.2
Urban centres < 300.000 inhabitants	6.5	6.0	9.3	18.7
Suburban regions	39.5	42.1	34.9	14.9
Rural regions	24.1	20.2	14.4	5.2

Source: ZEW - Spin-off-Survey 2001. All information is expanded for the German statistical population of knowledge-intensive industries.

There is obviously a significant portion of public research spin-offs that do not locate very close to their incubator but move at least to an other type of region. Table 3 shows the share of spin-offs located in different distances to their incubators. If a spin-off has more than one incubator, which is the case for about every second spin-off, the distance to the nearest incubator is used. More than one quarter of public-research spin-offs are located at least 75 kilometres away from their incubators, while only 55 % are within a 25 kilometres distance to their home institution. About a third of the public research spin-offs in Germany are located 50 or more kilometres away from the incubators' location. Spin-offs are not as much a local phenomenon as many case studies have suggested so far.

Table 3: Distribution of public-research spin-offs by distance to their incubator (in %)

Distance between firm and incubator	Public-research Spin-offs
Less than 25 kilometres	55.1
25 to 49 kilometres	11.4
50 to 74 kilometres	6.0
75 kilometres and more	27.4

Source: ZEW - Spin-off-Survey 2001. All information is expanded for the German statistical population of knowledge-intensive industries.

4 To leave or to stay at the incubator's region?

In this section, we investigate the determinants of a spin-off's decision to leave the region of the incubator. Region refers to the area around the incubator within which face-to-face contacts may take place on an ad-hoc base, i.e. travel distance is less than an hour. We use a alternative radiuses of 25, 50, and 75 kilometres, respectively, to demarcate an incubator's region. All spin-offs from an incubator that are located within this radius are regarded as having stayed in the region, while all other incubator's spin-offs are regarded to have left the region.

The decision to leave of stay is assumed to depend on five groups of determinants that represent different types of costs and benefits associated with the location decision:

- *Urbanisation economies* in the incubator's region reflect the level and quality of local demand. A high level of demand and economic activity are incentives to stay in the region rather than to leave. Urbanisation economies also cover the diversification of the labour market. Spin-offs will require high qualified labour and thus tend to locate in regions with a high supply of well-trained labour which can be found most easily in large agglomeration areas.

- *Localisation economies* in the incubator's region cover the potential for business relations for the spin-off. A high-tech orientation of the local economy, and a high number of start-ups in the same sector as the spin-off provide a favourable base for user-producer interaction and supplier links, and represent a competitive environment for the spin-off.

- The *type of incubator* affects to some extent the way of co-operation and the organisation of linkages between the incubator and the spin-off (see Beise and Stahl 1999 on the types of public research institutions in Germany). At universities, researchers are often strongly occupied with basic research, teaching and administration tasks that may leave rather little time for collaboration with spin-offs. Technical Universities often engage in technology transfer activities with large, established companies that may also limit their capacities. Technical Colleges ("Universities of Applied Science") are strongly teaching oriented but typically own separate resources for transfer activities, including contacts to spin-offs. Public laboratories consist of a several different institutions[5] but are similar in having a strong research orientation and sufficient resources for co-operation with spin-offs. Interacting the incubator's institutional affiliation with the technology specialisation of the spin-offs covers some additional aspects of the attraction of the incubator as a source of knowledge for the spin-off.

- *Characteristics of spin-offs*, such as size, age and sector of economic activity, control for firm heterogeneity and corresponding effects on location decisions. In this respect, the

[5] Fraunhofer-Society, Max-Planck-Society, Leibniz-Association, Helmholtz Research Centres, Federal and Länder Laboratories, Academies of Sciences and predominantly publicly financed independent research institutes.

time span between quitting the public research institution and establishing the spin-off firm is of special relevance as it increases the opportunities for future business contacts to potential customers as well as to other public research institutions and may thus increase the likelihood of starting the business at a location outside the incubator's region. Actually, only 47 % of all public research spin-offs in Germany start their business immediately after quitting from universities of public labs (including spin-offs with researchers who still own an occupation in public research). The remaining share had independent or wage employment in between.

- Type and intensity of *knowledge transfer* through spinning off is expected to affect the spin-off's demand for later interaction with the incubator or other knowledge sources. We distinguish the relevance of new research results obtained at the incubator, the relevance of special competencies appropriated during work at public research, and the relevance of concrete demand by firms for spinning off. Furthermore, the *knowledge intensity* of the spin-off, i.e. carrying out R&D and having formal knowledge interactions to public research, will influence the significance of transaction costs for keeping in contact to the incubator and thus affect location decision.

The effects of these variables on the spin-off's decision whether to stay or leave their incubator's region are estimated by probit regressions. For each public research spin-off we measure the distance between its location at the time of surveying (Autumn 2001) and the location of its incubator. If there is more than one incubator, the distance to the nearest incubator is used. Distances of 25, 50, and 75 km, respectively, are used as threshold values to separate leaving from staying spin-offs. The analysis is restricted to spin-offs from German public research institutions. A total of 2,077 observations are available. Table 4 presents the estimation results.

Spin-offs tend to move away from their incubator’s region if urbanisation economies in the region are less pronounced. All three indicator variables for the type of region show a positive sign, i.e. the probability to leave an incubator’s region is higher if it is not the centre of an agglomeration. Incubators located in smaller and more peripheral regions thus have a lower probability that firms spinning out of their institutions will stay nearby, i.e. spin-offs tend to transfer knowledge out of the region. Spin-offs from incubators that are located in rural areas tend to move away less than 75 km while spin-offs from incubators in suburban region show a high propensity to move to a rather distant location. But spin-offs are also more likely to leave their incubator’s region if the local level of income is high, but moving distance tends to be less than 50 km. This variable may grasp the effect that spin-offs avoid high land and living costs in agglomeration centres and move to suburban regions.

Localisation economies play no major role for explaining spin-offs decision to leave or stay. While a high level of start-up activity in the spin-off’s sector is an incentive to stay, the R&D intensity of the local business sector does not attract spin-offs. This is in contrast to the importance some strands of literature assign to local knowledge networks within R&D oriented firms as a major location decision.

The propensity to leave the region increases with the size of the spin-off and the time span between quitting from public research and starting the own business. The older a spin-off is, the more likely it is that it has moved away from the direct neighbourhood of the incubator, but the age does not affect the decision to leave the more extended region of the incubator. Spin-offs with an economics or business administration background leave the region significantly more often while all other disciplinary backgrounds show a similar effect upon the location decision.

Table 4: Determinants of spin-offs' decision to leave the incubator's region: Parameter estimates of weighted probit regressions

	Distance to incubator > 25 km	Distance to incubator > 50 km	Distance to incubator > 75 km
Urbanisation Economies in Incubator's Region			
Urban centre with population < 300.000	0.417 **	0.298 **	0.190 *
Suburban region of an urban agglomeration	0.350 **	0.326 **	0.401 **
Rural area (urban centre < 100.000 population)	0.385 *	0.374 *	0.264
Level of new firm formation	-0.019	0.021	0.052 *
Income level (purchasing power per inhabitant)	0.037 **	0.007	-0.004
Localisation Economies in Incubator's Region			
Level of start-ups in the spin-off's sector	-3.591 **	-2.296 °	-1.961
R&D intensity of the business sector	-0.632	-0.418	-0.321
Share of high qualified employees	0.002 °	0.002	0.003 °
Spin-off Characteristics			
Ln(number of employees in starting year)	0.115 **	0.101 *	0.086 *
Ln(age)	0.125 *	-0.032	-0.017
Ln(years between leaving incubator and start-up)	0.116 **	0.148 **	0.170 **
Discipline natural sciences	-0.113	-0.090	-0.059
Discipline engineering	0.105	0.168 *	0.070
Discipline economics and business administration	0.206 *	0.208 **	0.143 °
Discipline social sciences	-0.161	0.007	0.013
Type of Incubator by Spin-off's Sector			
Technical University & R&D int. manufacturing	-0.058	-0.081	-0.296 °
Technical University & technology-orient. service	0.171	0.096	0.095
Technical University & knowledge-intensive service	0.382 **	0.397 **	0.374 **
Technical College & R&D int. manufacturing	-0.348 °	-0.723 **	-0.797 **
Technical College & technology-orient. service	-0.050	-0.248 °	-0.149
Technical College & knowledge-intensive service	-0.020	-0.072	-0.172
Public Laboratory & R&D int. manufacturing	0.514 °	0.782 *	0.950 **
Public Laboratory & technology-orient. service	-0.207	-0.451 *	-0.256
Public Laboratory & knowledge-intensive service	0.497 **	0.461 *	0.538 *
Knowledge Transfer and Knowledge Intensity			
New research results essential for spinning off	0.118	0.089	-0.034
New research results important for spinning off	0.049	0.111	-0.012
Special competencies essential for spinning off	0.118	0.077	0.024
Demand by firms important for spinning off	-0.135	-0.083	-0.065
Spin-off uses incubator's infrastructure	-0.387 **	-0.228 °	-0.375 **
Joint R&D projects with public research institut.	0.095	0.010	0.027
Contract research to public research institutions	-0.215 **	-0.169 *	-0.153 °
Public research institution are clients of spin-off	0.059	0.100	0.034
Training of spin-off employees at public res. inst.	-0.194 **	-0.136 *	-0.097
Employing students from public research institut.	-0.047	-0.141 °	-0.236 **

Spin-off carries out R&D on a permanent base	-0.072	-0.123 °	-0.016
Share of researchers among spin-off founders	-0.317 **	-0.211 °	-0.158
Constant	-0.573	0.030	0.091
Number of observations	2,077	2,077	2,077
Wald chi^2	134.86**	145.86**	139.19**
Pseudo R^2	0.063	0.062	0.060

** (*) indicates significance at the 0.01 (0.5) level.

Spin-offs in knowledge intensive services (such as management consulting and teaching) are more likely to leave the incubator's region, especially if the incubator is a Technical University or a public laboratory. These spin-offs offer services that often demand face-to-face contact to clients for selling the service and therefore may prefer locations with high demand for their services. As Technical Universities and public laboratories are often located outside the main agglomerations in Germany, these spin-offs tend to move to more central locations. Spin-offs from public laboratories that specialise in high-tech manufacturing tend to leave their region, too, while high-tech manufacturing spin-offs from universities (which are the majority) are more likely to stay close to their incubator.

Spin-off tend to stay in the incubator's region if they use infrastructure of the incubator and if they place contract research to public research institutions (both to the incubator or to others). They are also more likely to stay if they use public research as a source for training their employees. Carrying out joint research with public research institutions does not affect, however, the decision to leave or stay. They same holds true if public research is a client of the spin-off. Spin-offs that employ students tend to stay within a 75 km circle of the incubator. The higher the share of researchers among the persons who established the spin-off, the higher the propensity to stay near to the incubator.

A striking result of the analysis refers to the knowledge intensity of the spin-off and the relevance of transferring new research results to the market by spinning off. All variables that measure these aspects are insignificant. The decision to locate close or further away from the incubator is not driven by the extent to which knowledge transfer is at the centre of the new firm formation. The demand by firms which might be expected to be a force that pulls a spin-off away from its home institution is insignificant, too.

5 Determinants of start-up location: Are public research spin-offs different?

The main concern of this section is to examine which factors affect the regional distribution of start-ups in research and knowledge intensive branches of manufacturing and services. We want to explain the number of such start-ups in German districts (Kreise) by looking at district specific variables. Only some of all relevant factors are observable and considered in our analysis.

We separate the start-ups of the time period 1996 to 2000 into the groups "start-ups in knowledge intensive industries" and "public research spin-offs". The last group is separated in

those which take their location in the incubator's region (less than 25 kilometres distance to the incubator) and those which left the incubator's region and locate in a 25 kilometres or more distance to the incubator.

The exogenous variables can be categorised into four groups: First, the degree of agglomeration economies in a district (ln of the population in the employment relevant age from 15 to 65, the employment density measured as employees over population, the travel distance in hours to the next international airport), second the districts knowledge and research base (number of inhabitants with an university degree, number of researchers in private firms, number of researchers in universities, and number of researchers in public research laboratories in relation to the number of population), and third some socio-economic variables (age structure, share of research intensive manufacturing to all manufacturing in employees, an index of purchasing power per inhabitant, unemployment rate). To control for the effects of regional stratification of our sample and for regional differences in the response behaviour we take some control variables into account.

The results of a negative binomial regression to explain the number of new firms out of the interested categories in German districts are given in Table 5. We find that the public research spin-offs, as well as all start-ups in knowledge intensive industries (= "all start-ups" in the following), are founded more often in agglomerated districts. The population between 15 and 65 years can be interpreted as the districts potential of firm founders. The coefficient of this variable is to be interpreted as the elasticity of the number of start-ups and spin-offs, respectively, in the district to the employment relevant population. For start-ups and for spin-offs the coefficient is significantly greater than 1, so number of foundations increases more than proportional with the founders potential. This is also true for the spin-offs with locate near their incubator, but not for those which leave the incubators region. For this last group we find the opposite relation. They leave the agglomerated regions which are the locations of their incubators not to locate in another agglomeration. They locate in regions with a lower level of start-up activity.

But what determines the location decision of the spin-offs which leave their incubators region? If we look at the results for the knowledge and research base variables we find that it's not the search for high qualified staff which leads them to do so. The number of all start-ups and of the staying spin-offs depends positively on the intensity of high qualified persons. This is not the case for leaving spin-offs. Also we find that the intensity of researchers in private firm has a significantly negative influence on the districts number of all start-ups and staying spin-offs but not on the number of leaving spin-offs. High capacities of private research in a district lead to high opportunities for researchers to found their own firm because there are a lot of attractive jobs for them. The wage level for research jobs, often in big firms, is high in such regions and so it's expansive to hire researchers. This argument seems not to be true for leaving spin-offs. Results suggest that for them it's not relevant to locate in a university area (with a high intensity of researchers in universities) but to locate in the neighbourhood of public research laboratories (with a high intensity of their researchers). In

Germany these institutions are often in suburban regions and not in the centres of agglomeration.

For some spin-offs the co-operation with university-researchers is relevant and they have a need for high qualified staff. They stay in the agglomerations near their incubator which is an university most. The spin-offs with a lower need for academically qualification and a lower co-operation level with universities leave those regions. But they locate in suburban districts with an research environment e.g. regions with public research institutes.

Table 5: Negative Binomial regressions for determinants of start-up locations of various start-up types

Variables	All start-ups in knowledge intensive industries	Public research spin-offs	Spin-offs staying in the incubator's region	Spin-offs leaving the incubator's region
Agglomeration Indicators				
Ln(population from 15 to 65 years)	1.1050 **	1.0515 **	1.2396 **	0.8981 **
Employment density	0.4422	-0.0697	-0.9401	1.3144
Travel distance to nearest intern. airport	-0.0015 **	-0.0014	-0.0026	-0.0008
Knowledge and Research Base				
Intensity of high qualified persons	0.0001 *	0.0001 **	0.0017 **	0.0001
Intensity of researchers in private firms	-0.0952 **	-0.0112 *	-0.0228 *	-0.0106
Intensity of researchers in universities	-0.0010	0.0035	0.0126 **	-0.0108 **
Intensity of researchers in other public research institutions	0.0174	0.0806	-0.0106	0.1613 **
Socio-Economic Structure				
Share of persons in age 25 to 50	0.4307	-0.0580	0.3397	-0.2509
Share of employees in R&D int. manuf.	0.5294 **	-0.2239	0.0328	-0.0650
Purchasing power per inhabitant	0.0372 **	0.0546 **	0.0525 *	0.0644 **
Unemployment rate	-0.0283 **	0.0028	0.0274	-0.0327 *
Control Variables for Response Behaviour and Stratification Effects				
Control 1 (dummy)	0.3843 **	0.3610 *	0.1206	0.6176 **
Control 2 (dummy)	0.1049	0.3507 **	0.8575 **	-1.1352
Control 3 (dummy)	0.0372	0.1804 *	0.5698 **	-0.0531
Constant	-2.7915 **	-5.6690 **	-8.0395 **	-5.7134 **
Number of observations	439	439	439	439
LR chi^2	998.87**	565.77**	373.05**	353.66**
R^2 adjusted	0.236	0.240	0.227	0.205

** (*) indicates significance at the 0.01 (0.5) level.

The most important factor to explain the location pattern of all start-ups and all kinds of spin-offs is the purchasing power variable. It seems to be the case that the level of regional demand is a very important determinant of the location decision. The main share of the public research spin-offs belongs to technology oriented or knowledge intensive service branches. Firms from such branches often serve local or regional demand of manufacturing or other service firms. For the districts whole start-up level in this branches it is relevant how research oriented the manufacturing industry is. The higher the share of research intensive branches is, the higher is

the number of all start ups. For the public research spin-offs this is not true. Here the districts share of research intensive manufacturing branches has no significant influence on the number of spin-offs located in the district.

The allocation of start-ups in space seems to be influenced more by "pull" factors as local demand as by "push" factors as human capital base and the regional level of research and science. For the public research spin-offs it seems to be a little different. For part of them the intensity of university researchers is important for their location decision. The other part locates in districts with a high intensity of researchers in other (not university) public research institutions. But also for this firms the purchasing power indicator is a central factor to explain their regional location patter.

6 Conclusion

The purpose of this paper was to examine the role of public research spin-offs for regional knowledge transfer by focussing on a very specific aspect in this process, i.e. the location decision of spin-offs. Regional knowledge transfer from public research to the regional economy through spin-offs is assumed to take place if the spin-off locates in the incubator's region. Based on a comprehensive data set on public research spin-offs in Germany we analysed their location pattern, their decision whether to stay or leave the incubator's region, and the factors explaining the locations chosen by spin-offs.

While large fractions of literature emphasise the local dimension of spin-offs (see Collan 2001, Clarysse et al. 2001, Schutte 2001, Massing 2001, Matkin 2001,), our results show that a significant part of spin-offs locate rather distant to their incubator. Only 55 % of all spin-offs stay within a 25 radius around the incubator. Their aggregated location pattern differs significantly from that of the incubators insofar as they show higher shares in regions outside the centres of agglomeration and urban regions, where most of the incubators are located.

Our results suggest that the location behaviour of public research spin-offs is not only supply oriented but also strongly demand driven. If the incubator's location is less attractive in terms of urbanisation economies, spin-offs are likely to move away. However, if they have strong formal relations to public research institutions and heavily rely on high qualified staff they tend to stay in the incubator's region. Spin-offs with a lower need for academic qualification and a lower level of co-operation leave the region. They typically locate in suburban districts with an research environment e.g. regions with public research laboratories.

With respect to economic sectors and associated scientific disciplines, the following picture emerges: Spin-offs in high-tech manufacturing, which most often have a natural science background, tend to rely on technology pushes from science and locate rather close to their incubators while service oriented spin-offs that typically have - among others - an economics or business administration background are those most likely to move away. Because the latter are by far much larger in number than the former, spin-offs contribute to interregional and not only to intraregional knowledge transfer. In the literature, however, analysis of spin-offs often

focus on high-tech manufacturing. This may explain the wide-spread view that spin-offs are a local phenomenon.

Overall, one should not neglect the role of "pull" factors for the spatial allocation of public research spin-offs as well as other start-ups in knowledge intensive industries. They seem to influence location decisions as much "push" factors such as the human capital base and the regional level of research and science.

7 References

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