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by Andrea Hammer

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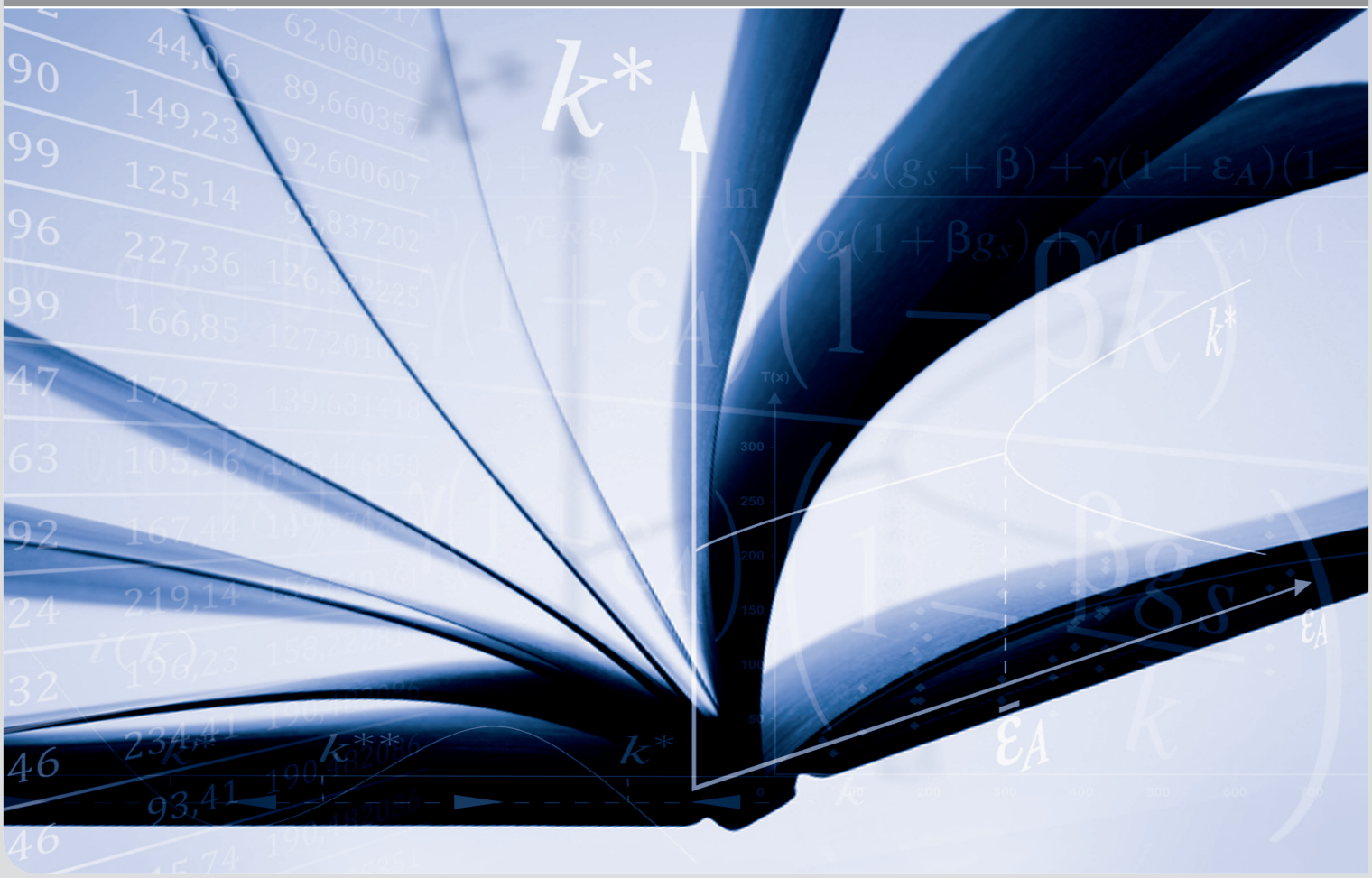

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# Innovation of Knowledge Intensive Service Firms in Urban Areas

Working Paper

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**Abstract**

This paper investigates the agglomeration of Knowledge Intensive Service (KIS) firms in urban areas. In accordance with the Regional Innovation Systems approach it is argued that cities provide crucial innovation advantages working as centripetal forces for KIS. Applying multivariate logit regressions to a company survey of the city of Karlsruhe, the second largest city of the German federal state of Baden-Württemberg, shows positive effects of local cooperation and urban infrastructures on the innovation probability of KIS firms. However, the effects vary with the type of innovation pursued, thus demonstrating a high complexity of local relations conducive to KIS firm innovation.

Keywords: Knowledge Intensive Services, Regional Innovation Systems, urban innovation, innovation in services, local cooperation, urban infrastructure

JEL-codes: O31, R12

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# 1 Introduction

In advanced economies knowledge has become a key factor for innovation and growth. However, economic activity relying primarily on knowledge as production factor, denoted as Knowledge Economy, is not evenly distributed in geographical space as it tends to agglomerate in urban regions. Analyzing the dynamics that lie at the ground of this empirically observable agglomeration pattern is of key importance in order to address regional disparities and derive regional policy implications.

This paper aims to contribute to the understanding of why Knowledge Intensive Services (KIS) – constituting a considerable share of the Knowledge Economy – agglomerate in urban areas and derive urban policy implications by empirically applying the Regional Innovation Systems (RIS) approach to technological and non-technological types of innovation. The data set that is used for the analysis originates from a company survey conducted by the city of Karlsruhe, the second largest city in the German federal state of Baden-Württemberg. While researchers so far have mainly attempted to analyse the location of KIS – namely their concentration in geographical space – and the factors explaining their emergence and growth, the spatial dimension in KIS analysis has been rarely addressed (Muller and Doloreux 2009). In accordance with RIS, it will be argued that, due to the cooperative nature of KIS firm innovation and urban innovation support infrastructures, cities provide crucial innovation advantages for KIS firms constituting urban centripetal forces. Being carriers of internal innovation activities (Camacho and Rodríguez 2005, Doloreux and Shearmur 2012), KIS are attracted by specific urban innovation opportunities. However, following a synthesis approach to innovation in services, the centripetal forces of urban specificities vary with the type of KIS firm innovation.

KIS comprise firms that are primarily engaged in service activities in which human capital is the major input (Miles 2008). A majority of the output of KIS is information in the form of technical and management consultancy as well as diverse specialist activities – e.g. financial management, marketing and advertising, staff recruitment and development, property acquisition and management (Wood 2002).[1]

Turning attention to the spatial distribution of KIS in advanced economies shows that they not only exhibit a tendency to concentrate in geographical space; their location pattern also reveals a strong preference towards urban or metropolitan areas. For Europe, Canada, the USA and the UK several studies indicate a concentration of KIS in urban and metropolitan regions (Ó hUallacháin and Reid 1991, Cooke et al. 2002, Keeble et al.

[1] According to NACE classifications, divisions of the sections 'Information and communications', 'Financial and insurance activities', 'Professional, scientific and technical activities' and the divisions 'Human health services', 'Creative, arts and entertainment activities', 'Libraries, archives, museums and other cultural activities' are defined as KIS (Gehrke et al. 2010).

2006, Krätke 2007, Shearmur and Doloreux 2008). In addition, a study on reurbanization and the Knowledge Economy in Germany, finds evidence that the current performance of urban agglomerations is directly linked to the growth and progressive geographical concentration of KIS (Gornig and Mundelius 2012).

While KIS concentrate in urban areas, cities themselves become more important from a political perspective, as – especially in advanced economies – national governments have chosen to give up some of their powers in favor of cities. Hence, the balance of power, responsibility, and decision making authority between the national and the urban levels of government changes to the advantage of cities (Kresl and Proulx 2000). This development successively enhances the importance of regional, respectively urban, policy with respect to KIS as growth and development of urban economies depend on local abilities to generate and attract activities of KIS firms.

This paper is organized as follows. Section 2 presents the theoretical framework and the hypothesis derived with regards to the agglomeration behavior of KIS. Section 3 presents the survey data and develops a Knowledge Production Function that is used in order to test the hypothesis. The results are presented and discussed in Section 4. Section 5 discusses further empirical applications and policy implications, together with concluding comments.

# 2 Theoretical Framework and Derivation of Hypotheses

In this section a theoretical framework for analyzing the location of KIS in urban areas is derived. First, the RIS approach is introduced and organizations that are involved in innovation processes and shape the regional framework conducive to innovation are presented. Second, as RIS tends to be confined to manufacturing industries and thus to technological forms of innovation, the notion of innovation used in this paper is expanded referring to a synthesis approach that encompasses technological as well as non-technological types of innovation. Finally, RIS is applied to KIS firm agglomeration in urban areas and hypothesis regarding the innovation behavior of KIS firms and the effects of urban specificities on KIS firm innovation are deduced.

## 2.1 Regional Innovation Systems

Early illustrations of firm agglomeration are based on the concept of external economies scale, stating that proximity to other firms increases the productivity of a single firm (Marshall 1920). These entrepreneurial agglomeration advantages imply both pecuniary and technological, non-pecuniary, external economies of scale (Scitovsky 1954). In order to

explain firm agglomeration, researchers often refer to non-pecuniary economies of scale that – according to Rosenthal and Strange (2004) – extend over three dimensions, namely the industrial, the geographic and the temporal scope. However, with the exception of urbanization economies (Jacobs 1969), the concept of technological external economies of scale does not take into account the local framework of different types of geographical space – e.g. rural or urban environments.

As this paper addresses KIS firm agglomeration in a specific type of geographical area, namely the urban area, it is adequate to turn to approaches that incorporate local specificities. These approaches are summarized under the terms New Industrial Geography (NIG) or Territorial Innovation Models (TIM) emphasizing the role of local specificities and innovation opportunities in order to analyze firm agglomeration (Martin and Sunley 1996, Breschi and Lissoni 2001, Moulaert and Sekia 2003). The most established approaches that are compiled by the umbrella terms NIG and TIM are New Industrial Districts (see, for example, Bagnasco 1977, Becattini 1979, Garofoli 1981, Brusco 1982), Innovative Milieus (see, for example, Aydalot 1986, Perrin 1988, Maillat and Lecoq 1992, Camagni 1995), Cluster (Porter 1990, 1998) and RIS (Cooke 1992, Cooke et al. 1997).

Being based on two strands of scientific work, namely Regional Science and National Innovation Systems (NIS), the RIS approach emphasizes the role of regional interactions between organizations, spanning private and public sectors, in order to generate innovation (Cooke et al. 1997, Cooke 2001, Doloreux and Parto 2005). According to Asheim et al. (2011), RIS thus provides a unifying framework incorporating other NIG or TIM approaches. In contrast to the Cluster approach, RIS takes the region rather than the sector as a '...lens through which to observe the ways in which different sectors or even clusters interact with the regional governance and innovation support infrastructures as well as the national and global levels.' (Cooke et al. 1997, 476).

RIS is adequate for the purpose of this paper, as it matches three central criteria. Firstly, RIS focuses on the region as unit of analysis and is therefore applicable to urban environments (see, for example, Simmie et al. 2002, Strambach 2002, Tödtling 2002). Secondly, the notion of innovation and regional innovation processes within RIS is clearly defined and suitable for empirical application using quantitative data (see, for example, ERIS[2], REGIS[3], SMEPOL[4]). Thirdly, RIS addresses the local framework conducive to innovation and thus is able to take into account specific urban infrastructures.

The notion of innovation underlying RIS shows that innovation is an interactive as well as regional process shaped by organizations that act as cooperation partners and provide

[2]ERIS = European Regional Innovation Survey (Koschatzky and Sternberg 2000, Sternberg 2000)

[3]REGIS = Regional Innovation Systems: Designing for the future (Tödtling and Kaufmann 1999, Cooke et al. 2000)

[4]SMEPOL = SME Policy and the Regional Dimension of Innovation (Tödtling and Kaufmann 2001)

local infrastructures conducive to innovation. RIS has adopted the systems view of innovation that lies at the ground of the theory of NIS where an innovation system is constituted by organizations which interact in the production, diffusion and use of economically useful knowledge underpinned by an institutional framework (Lundvall 1992, Edquist 1997). These organizations encompass a set of private and public sector organizations including firms, higher education organizations and non-university research and development organizations (Freeman 1987). The systemic notion of innovation within RIS encompasses two perspectives. Firstly, innovation is a process that relies on a variety of factors that are internal and external to a firm (Doloreux 2002). Moreover, the interdependencies and feedback loops internal and external to the firm go beyond market relations and occur in networks giving innovation a team-like character (Tödtling and Kaufmann 1999, Asheim and Gertler 2005). Secondly, firm innovation is an evolutionary process contrasting the traditional linear model of innovation that oversimplifies innovation processes (Feldman 1994). This implies that, besides research and development, various starting points of innovation are possible.

Within RIS, regions which are defined '...as territories smaller than their state possessing significant supralocal governance capacity and cohesiveness differentiating them from their state and other regions.' (Cooke et al. 1997, 480), are regarded as places of innovation. Thus, a firm's capacity to innovate is partly determined by local organizations and a region-specific institutional framework (Shearmur 2011). However, the notion of regional institutions conducive to innovation within RIS is ambiguous (Doloreux and Parto 2005): While some studies refer to institutions as a set of regionally bounded rules, conventions and norms, especially empirical studies of RIS mostly relate to an organizational notion of institutions. Referring to innovation as a regional process, RIS also relates to the geographic scope of technological external economies of scale by adopting the idea of spatially bounded, tacit knowledge (Polanyi 1967). According to RIS, innovation occurs more easily, when geographical concentration and proximity are present, as the exchange of tacit knowledge requires intensive personal contacts which in turn are facilitated by geographical proximity (Storper 1997, Morgan 2004).

As innovation is an interactive and regional process, it is shaped by factors external to the firm encompassing cooperating organizations and a specific local innovation support infrastructure. The organizations that act as cooperation partners and that shape the local infrastructure conducive to innovation are firms, non-university research and development organizations, higher education organizations, industrial organizations, governmental organizations and finance providers (Cooke et al. 1997, Tödtling and Kaufmann 1999, Gertler et al. 2000, Doloreux 2002).

*Firms*: Within the region, firms take responsibility for generating and diffusing knowledge. They may be regarded as learning organizations which cooperate with other organizations

that share their environment. At the same time, firms take up different roles: beneath being collaborators, they also act as users, producers and competitors (Doloreux 2002). In accordance with the RIS approach, one central motivation of firms to cooperate with other organizations is to generate innovation. Cooperation is spatially dependent because of tacit, regionally bounded, knowledge relevant to innovation.

*Non-university research and development organizations*: Following the reasoning of RIS, non-university research and development organizations (e.g. laboratories, non-university research facilities) function as regional knowledge providers and cooperation partners providing mainly research and development-based knowledge to firms.

*Higher education organizations*: Higher education organizations (e.g. universities) are sources of academic knowledge. Regarding this role, their content of research might be directed to areas that underpin the region's economic base and thus turn them into valuable cooperation partners with respect to regional innovation processes (Gunasekara 2006). However, apart from being sources of academic knowledge, higher education organizations also act as providers of academic education and regional system builders, thus shaping the local institutional framework (Caniëls and van den Bosch 2011). In their role as providers of academic education, higher education organizations act as educators, attractors and retainers of students, building the knowledge base for the local economy (Boucher et al. 2003). Acting as regional system builders, they consult the local economy and local policy makers, create spin-offs and participate in public debates (Benneworth et al. 2009).

*Industrial organizations and governmental organizations*: Industrial organizations (e.g. producers associations, chambers of commerce) as well as governmental organizations (e.g. business development agencies) are engaged in regional governance for innovation aiming to facilitate cooperation between organizations (Cooke 2001). They provide mainly innovation support services that promote technology diffusion or are oriented towards developing new and profitable economic activities at the regional level (Doloreux 2002). Examples for the innovation support services generated mainly by industrial and governmental organizations are science parks, technology transfer centres and innovation advisory agencies.

*Finance providers*: The activities undertaken by the different organizations introduced above are supported by regional financial competence, encompassing private and public finance as well as a regional credit-based system (Cooke 2001).

## 2.2 Innovation of Knowledge Intensive Service Firms

According to RIS, regionally bounded innovation opportunities constitute key centripetal forces of firm agglomeration. However, as the RIS approach tends to be confined to high-tech and manufacturing sectors (Strambach 2002, Doloreux 2002), the underlying notion of innovation within RIS is rather technological and thus does not address the peculiarities of services and their innovation modes. Applying RIS to KIS firms therefore requires examination and consideration of specificities regarding innovation in services. The definition and analysis of service innovation distinguish three approaches, namely the assimilation, the demarcation and the synthesis approach (Coombs and Miles 2000).

The basic idea of the assimilation approach is that service innovation is similar to innovation in manufacturing industries. This approach equates and thus reduces innovation in services to technologically oriented product and process innovation. Regarding the analytical framework this implies that empirical indicators that were originally developed with manufacturing in mind are equally applicable to services (Gallouj and Windrum 2009). In contrast to the assimilation approach, the demarcation approach stresses the differences between innovation in services and manufacturing, seeking to establish distinctive definitions and measurement methods for service innovation (see, for example, den Hertog 2000, Preissl 2000). The synthesis approach is based on the assumption that service innovation unveils hitherto barely noticed aspects of innovation that are distributed across the economy. Even as they are primarily observable in service firms, they also occur in manufacturing firms. The approach thus is based on the insights of demarcation writers and integrates them within a neo-Schumpetarian framework, addressing technological and non-technological modes of innovation.

According to Gallouj and Savona (2009), the synthesis approach currently is in an emerging and expanding phase, while the demarcation and assimilation approaches are in mature or even declining phases. It is hence adequate to refer to the synthesis approach when analysing the concentration of KIS in urban areas by taking into account technological and non-technological forms of innovation opportunities which – according to the RIS approach – constitute urban centripetal forces.

Following the synthesis approach, Tether and Tajar (2008) identify three modes of innovation – namely product research, process technologies and organisational cooperation mode – that are pursued, to a different degree, by service as well as manufacturing firms. While the technological forms of innovation involve internal research and development activities, cooperation activities with higher education organizations and non-university research and development organizations, the non-technological, organisational cooperation mode of innovation, relies primarily on cooperation with suppliers and customers as well as network activities as sources of innovation. The notion that different forms

of innovation rely on different knowledge resources internal and external to the firm is also confirmed by a study of Amara et al. (2009) who, in an exploratory study, analyse technological and non-technological forms of innovation in knowledge-intensive business services using an identical empirical framework. One central result of their analysis is that '...different forms of innovation tend to respond differently to the various types of knowledge resources available...' (Amara et al. 2009, 423).

## 2.3 Derivation of Hypotheses

Applying RIS to the research question – the concentration of KIS in urban areas – leads to the notion that innovation processes of KIS rely on factors internal and external to the firm. Factors external to KIS firms encompass cooperation activities with a variety of organizations – including other firms, higher education organizations, non-university research and development organizations – and the usage of innovation support services as well as financial support. Furthermore, as RIS has adopted the idea that a firm's capacity to innovate is partly determined by local specificities and regionally bounded, tacit knowledge, innovation of KIS firms is a regional process fostered by their geographical proximity to cooperation partners and specific urban infrastructures supporting innovative activities at the firm level. These specific urban infrastructures consist of regional financial competence and innovation support services generated mainly by industrial and governmental organizations. The innovation advantages provided by urban areas, shaped by local organizations and urban innovation support infrastructures, work as centripetal forces attracting KIS firms to urban environments. Taking into account a synthesis approach regarding innovation in services, the innovation behavior and thus the innovation advantages provided by urban areas vary according to the type of innovation pursued by the individual KIS firm. It can hence be expected that technological and non-technological forms of KIS firm innovation differ in their requirements regarding cooperation partners and their regional proximity as well as specific urban infrastructures aiming to support innovative activities at the firm level.

Summarizing the discussion, the adaptation of RIS to the agglomeration of KIS firms in urban areas leads to three hypothesis. While *Hypothesis 1* relates to the innovation behavior of KIS firms in general, *Hypothesis 2* and *Hypothesis 3* refer to the effects of the local framework on innovation activities of KIS firms.

*Hypothesis 1: KIS firm innovation depends positively on internal resources and cooperation with organizations external to the firm*
It is assumed that KIS firm innovation is positively affected by internal resources and

cooperation activities with external organizations. Internal resources encompass knowledge embedded in KIS firms and research and development activities. Cooperation activities with external organizations cover other firms, higher education organizations and non-university research and development organizations. However, the positive effects of internal resources and cooperation activities with organizations external to the firm are supposed to differ according to the type of innovation pursued by the individual KIS firm. In accordance with the findings of Tether and Tajar (2008) it is assumed that technological forms of innovation involve internal research and development activities, cooperation activities with higher education organizations and non-university research and development organizations, while non-technological forms of innovation rely on cooperation activities along a KIS firm's value chain.

*Hypothesis 2: KIS firm innovation depends positively on the utilization of specific urban infrastructures supporting innovative activities at the firm level*
Urban innovation support infrastructures, consisting of regional financial competence and innovation support services provided mainly by industrial and governmental organizations, are assumed to foster technological and non-technological forms of innovation within KIS firms.

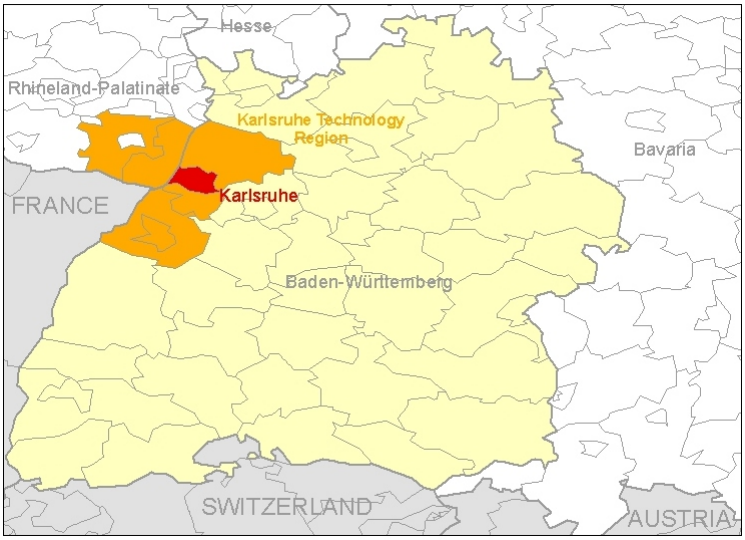
*Hypothesis 3: KIS firm innovation is positively influenced by cooperation with local organizations*
As RIS relies on the notion of regionally embedded knowledge, cooperation with *local* organizations external to the firm – other firms, higher education organizations and non-university research and development organizations – is assumed to have a positive influence on both, technological and non-technological types of KIS firm innovation.

# 3 Data and Model

This section presents the company survey conducted by the city of Karlsruhe and introduces a Knowledge Production Function (KPF) depicting that KIS firm innovation depends on internal resources, external resources and urban innovation support infrastructures.

## 3.1 Company Survey of Karlsruhe

Karlsruhe is situated in the German Federal State of Baden-Württemberg. With 298,542 inhabitants in 2013, it is the second largest city in Baden-Württemberg after the capital Stuttgart with 602,811 inhabitants (Statistical Office of the Federal State of Baden-




Source of Shapefile: ©EuroGeographics for the administrative boundaries

**Figure 1:** Geographic Position of Karlsruhe, Karlsruhe Technology Region and Baden-Württemberg

Württemberg 2014b). The economic structure of Karlsruhe is coined by service firms that contributed 74.3% to the city's gross value added in 2011 (Statistical Office of the Federal State of Baden-Württemberg 2014a). Figure 1 shows the location of Karlsruhe, which is the geographic center of the Karlsruhe Technology Region (KTR). The KTR is made up by regional political actors encompassing 11 cities – including Karlsruhe –, four rural districts and a regional association[5] aiming to optimize regional cooperation in several areas, including economic issues (Karlsruhe Technology Region 2014).

In 2012, 30.2% of the employees in Karlsruhe worked in KIS firms (Statistical Office of the Federal State of Baden-Württemberg 2014c). Table A.1 demonstrates the location quotients of KIS sections and divisions based on NACE industry classifications with respect to the federal state of Baden-Württemberg and Germany. In accordance with the studies referred to in Section 1, the city-data indicates a relative concentration of KIS with respect to the state levels: The NACE sections J 'Information and Communication', K 'Financial and Insurance Activities' and M 'Professional, Scientific and Technical Activities' show location quotients between 1.2 and 2.6, demonstrating a relatively strong concentration of KIS in Karlsruhe.

The data used in order to test the hypothesis derived from the application of the RIS approach to the concentration of KIS firms in urban areas originates from a company survey conducted by the city of Karlsruhe in August and September 2013. 2,656 firms

[5]The individual actors are: Karlsruhe (city), Baden-Baden (city), Bretten (city), Bruchsal (city), Bühl (city), Ettlingen (city), Gaggenau (city), Rastatt (city), Rheinstetten (city), Stutensee (city), Waghäusel (city), Germersheim (rural district), Karlsruhe (rural district), Rastatt (rural district), Südliche Weinstraße (rural district), Regionalverband Mittlerer Oberrhein (regional association).

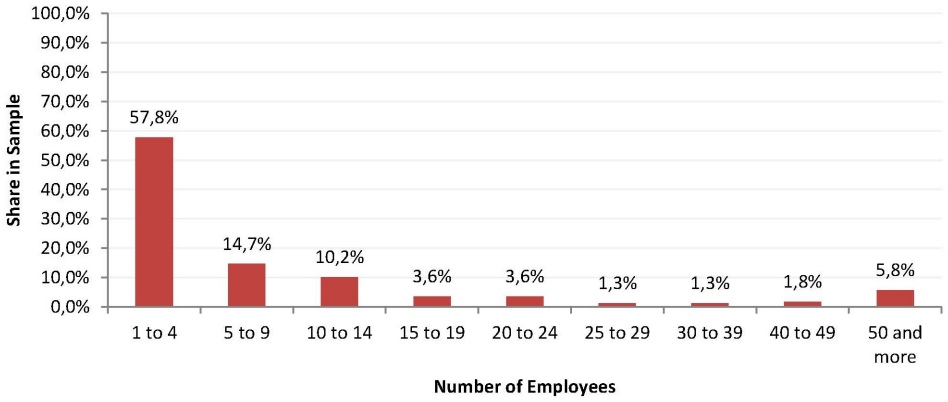



**Figure 2:** Firm Size of Knowledge Intensive Service Firms in the Sample

were invited to the online survey. With 478 firms participating, the response rate was 18%. As the survey was intended to serve as a base for a city-intern competence field analysis, it was designed as a complete survey. The choice of industries considered was in accordance with the Community Innovation Survey (CIS) of the European Union[6] that is conducted every two years. However, in contrast to the CIS, the company survey of Karlsruhe does not have a lower threshold concerning firm size, thus including micro-sized companies in the data set. Furthermore, the data set contains information about innovative activities, internal resources, the spatial dimension of value chains and of external organizations cooperated with as well as on the usage of city-specific innovation support infrastructures.

As missing data was not imputed, 225 complete questionnaires of KIS firms are available for analysis. Figure 2 shows the distribution of KIS firm size in the sample. The majority of firms has between 1 and 4 employees, followed by firms with 5 to 9 employees. Thus, microfirms with less than 10 employees account for 72.5% of the firms participating in the survey. However, as the share of microfirms in Germany ranges between 91.8% and 94.8% in the NACE sections J 'Information and Communication', K 'Financial and Insurance Activities' and M 'Professional, Scientific and Technical Activities', KIS microfirms are presumably under-represented in the sample (Destatis 2011).

## 3.2 Knowledge Production Function

The hypotheses are tested using a KPF. Initially developed by Griliches (1979), the KPF relates innovational output to the presence and volume of innovative resources. Since

[6]The CIS excludes KIS divisions that are likely to be subject to specific provisions or provided by public institutions. These are 86 'Human health services', 90 'Creative, arts and entertainment activities' and 91 'Libraries, archives, museums and other cultural activities'. Table A.1 provides an overview of all divisions defined as KIS.

its emergence, the KPF has been widely applied in empirical works analyzing innovation patterns of firms. The KPF that is used in order to analyze the survey data takes the following form:

$$I_{ij} = CV_i^{b_1} * INT_i^{b_2} * EXT_{ik}^{b_3} * URB_i^{b_4},$$

where *I* denotes the innovative output of KIS firm *i* regarding innovation type *j*, *CV* a vector of control variables, *INT* the internal resources, *EXT* the cooperation activities with external organizations in region *k* and *URB* the usage of urban innovation support infrastructures. The coefficients $b_1$ to $b_4$ will be estimated in the analysis.

**Table 1:** Variables of the Knowledge Production Function

| Variable | Scale Level | Description |
|---|---|---|
| **Dependent Variables** | | |
| I | Binary | Type of innovation; product, process, organizational or business model innovation |
| **Independent Variables** | | |
| **1. Control Variables [CV]** | | |
| A | Interval | Age of firm in years |
| S | Interval | Size of firm, number of employees |
| **2. Internal Resources [INT]** | | |
| KI | Interval | Knowledge intensity, share of employees with graduate degree |
| RD | Binary | Research and development activities |
| **3. External Organizations [EXT]** | | |
| VC | Binary | Vertical cooperation with other firms |
| HC | Binary | Horizontal cooperation with other firms |
| HEC | Binary | Cooperation with higher education organizations |
| RDC | Binary | Cooperation with non-university research and development organizations |
| **4. Urban Innovation Support Infrastructures [URB]** | | |
| AIS | Binary | Usage of any urban innovation support service |
| FIN | Binary | Usage of services of the L-Bank |

An overview on the variables and the descriptives is given in Tables 1 and 2. Furthermore, an extract of the questionnaire is available in Appendix B. Innovation *I* is a binary variable, indicating if a KIS firm has introduced at least one innovation within the last three years. Following the synthesis approach, the types of innovation considered in the analysis refer to technological – product and process – and non-technological – organizational and business model – innovations. Regarding the degree of novelty, the notion of innovation encompasses innovations 'new to the firm'.

The control variables *A* and *S* indicate age and size of a KIS firm. *A* is measured in years since the foundation of the firm, independent of the current legal form. *S* refers to the

**Table 2:** Descriptives

| | Min | Max | Mean | Standard Deviation | N |
|---|---|---|---|---|---|
| **Dependent Variables** | | | | | |
| Product Innovation | 0 | 1 | 0.44 | 0.498 | 225 |
| Process Innovation | 0 | 1 | 0.07 | 0.250 | 225 |
| Organizational Innovation | 0 | 1 | 0.39 | 0.488 | 225 |
| Business Model Innovation | 0 | 1 | 0.18 | 0.387 | 225 |
| **Independent Variables** | | | | | |
| **1. Control Variables [CV]** | | | | | |
| A | 0 | 117 | 16.52 | 14.798 | 225 |
| S | 1 | 1,500 | 17.48 | 101.461 | 225 |
| **2. Internal Resources [INT]** | | | | | |
| KI | 0 | 100 | 64.44 | 34.926 | 225 |
| RD | 0 | 1 | 0.44 | 0.498 | 225 |
| **3. External Organizations [EXT]** | | | | | |
| VC | 0 | 1 | 0.48 | 0.501 | 225 |
| HC | 0 | 1 | 0.33 | 0.471 | 225 |
| HEC | 0 | 1 | 0.25 | 0.433 | 225 |
| RDC | 0 | 1 | 0.06 | 0.242 | 225 |
| **4. Urban Innovation Support Infrastructure [URB]** | | | | | |
| AIS | 0 | 1 | 0.08 | 0.279 | 225 |
| FIN | 0 | 1 | 0.11 | 0.315 | 225 |

number of employees including the proprietor of the firm.[7] Regarding the effects of *A* and *S*, no assumptions are made.

The vector of internal resources *INT* includes variables *KI* and *RD*. *KI* relates to the knowledge intensity of a KIS firm that is depicted by the percentage of employees with a graduate degree ranging from 0% to 100%. *RD* is defined as a binary, indicating if a KIS firm has pursued any research and development activities, occasional or continuous, within the last three years. In accordance with *Hypothesis 1*, it is assumed that *KI* and *RD* both have a positive impact on technological and non-technological forms of innovation.

Vector *EXT* denotes cooperation activities with organizations external to the firm in the last three years. Variables *VC* and *HC* refer to cooperation with firms. While *VC* relates to vertical cooperation with suppliers or customers along a KIS firm's value chain, *HC* covers horizontal cooperation with firms that are not part of the value chain. *HEC* and *RDC* indicate any cooperation with higher education organizations or non-university research and development organizations. The conception of cooperation is broad, as it encompasses any form of knowledge exchange regarding *HC*, *HEC* and *RDC* and any exchange of knowledge that goes beyond a commercial relationship regarding *VC*. As derived in *Hypothesis*

[7] The data refers to the number of persons and not to full-time equivalents.

*1*, the variables *VC*, *HC*, *HEC* and *RDC* should have a positive influence on innovation depending on the type of innovation. Moreover, it is assumed that cooperation with *local* organizations – in geographical proximity to a KIS firm – does have a positive impact on innovation (see *Hypothesis 3*).

Vector *URB* represents the usage of urban innovation support infrastructures covered by variables *AIS* and *FIN*. *AIS* indicates the usage of any urban innovation support service consisting of services provided by the Steinbeis Association, the 'Innovationsallianz TechnologieRegion Karlsruhe', the 'Wirtschaftsstiftung Südwest, Gesellschaft für Beratungen und Beteiligungen' and the 'House of Living Labs'. The Steinbeis Association, headquartered in Stuttgart, aims to support knowledge and technology transfer (Steinbeis Association 2014a). Steinbeis is present in Karlsruhe with transfer centers at several higher education organizations and with transfer entrepreneurs (Steinbeis Association 2014b). Local industrial, higher education and non-university research and development organizations are partners of the 'Innovationsallianz TechnologieRegion Karlsruhe' that aims to impart research partners to local firms (Innovationsallianz TechnologieRegion Karlsruhe 2014). A local governmental organization, namely the business development agency of Karlsruhe, as well as local finance providers are founders of the 'Wirtschaftsstiftung Südwest, Gesellschaft für Beratungen und Beteiligungen'. The aim of these facilities is to promote local entrepreneurship, offering consulting services especially for small and medium-sized enterprises (Gesellschaft für Beratungen und Beteiligungen mbH 2014). The 'House of Living Labs', operated by the FZI Research Center for Information Technology – a non-profit institution for applied research in information technology and technology transfer –, serves as research environment for small and medium-sized companies supporting innovation in the domain of information technologies (FZI House of Living Labs 2014). As the urban innovation support services are assumed to be quite specific, they are introduced using the summarized variable *AIS*. Variable *FIN* indicates the usage of regional finance represented by the services provided by the L-Bank in Karlsruhe. The L-Bank Karlsruhe is the local branch of the state bank of Baden-Württemberg that has the objective to promote activities of small and medium-sized enterprises.

As formulated in *Hypothesis 2*, urban innovation support services and regional finance are assumed to foster innovation within KIS firms. It is hence expected that variables *AIS* and *FIN* positively affect technological and non-technological innovation of KIS firms.

# 4 Results

This section applies multivariate logit regressions in order to estimate the KPF using the survey data on KIS firms collected by the city of Karlsruhe. The results indicate that KIS

**Table 3:** Effects of Internal Resources, Cooperation Activities and Urban Innovation Support Infrastructures

| | Type of Innovation | | | |
|---|---|---|---|---|
| | **Product** | **Process** | **Organizational** | **Business Model** |
| **1. Control Variables [CV]** | | | | |
| A | -0.016 | -0.008 | 0.002 | -0.027 |
| S | 0.021* | -0.001 | 0.040*** | -0.007 |
| **2. Internal Resources [INT]** | | | | |
| KI | -0.001 | -0.007 | -0.009** | -0.005 |
| RD | 1.986*** | 1.321* | 0.683* | 0.612 |
| **3. External Organizations [EXT]** | | | | |
| VC | 0.400 | 1.249* | 0.600* | 0.968** |
| HC | 0.087 | -0.147 | 0.332 | 0.701* |
| HEC | -0.074 | 1.178* | -0.544 | -0.136 |
| RDC | -0.870 | -19.928 | -0.551 | -0.171 |
| **4. Urban Innovation Support Infrastructures [URB]** | | | | |
| AIS | -0.688 | -0.500 | -0.517 | 1.288** |
| FIN | -0.532 | 0.077 | 0.842* | -0.168 |
| **Model Fit** | | | | |
| -2LL | 236.997 | 89.807 | 256.262 | 187.028 |
| Chi-Square | 72.136*** | 20.412** | 43.993*** | 26.608*** |
| N | 225 | 225 | 225 | 225 |

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

firm innovation is positively affected by internal resources, cooperation with external organizations and the usage of urban innovation support infrastructures. However, the effects vary according to the type of innovation pursued by the individual KIS firm. Furthermore, the benefits from cooperation activities with external organizations are sensitive to distance.

## 4.1 Effects of Internal Resources, Cooperation Activities and Urban Innovation Support Infrastructures on KIS Innovation

In what follows *Hypothesis 1* and *2* – assuming that innovation of KIS firms depends positively on internal resources *INT*, cooperation activities with external organizations *EXT* and the usage of urban innovation support infrastructure *URB* – are evaluated. Table 3 indicates the logit regressions for technological and non-technological forms of innovation. According to Chi-square tests all models are significant with respect to a constant only model.

The control variables *CV* used in the logit regression are firm size *S*, depicting the number of employees including the owner, and age *A*. While *A* does not significantly affect the probability of any type of innovation pursued by the KIS firms, *S* has a significant positive effect on the probabilities of product and organizational innovation. The positive coefficients indicate that the propensities of product and organizational innovations augment with the number of employees of a KIS firm.

### *Hypothesis 1*: Effects of Internal Resources and Cooperation with Organizations external to the Firm

*Hypothesis 1* assumes a positive effect of internal resources *INT*, encompassing knowledge intensity *KI* and research and development activities *RD*, on the innovation probability of KIS firms. However, *KI* shows a negative influence on the propensity of organizational innovation. This negative influence is counterintuitive and not in accordance with the assumption that knowledge is conducive to any type of innovation. A possible explanation for this finding is that the sample is characterized by microfirms. Indivisibilities regarding the workforce are likely to be more evident within small firms, where hiring an additional non-graduate employee for auxiliary works substantially decreases the degree of knowledge intensity. Thus, for samples containing a substantial share of microfirms the degree of knowledge intensity is not a reliable predictor for innovation and seems a misspecified variable. *RD* does have a significant positive impact on the probabilities of product, process and organizational innovation. Z-standardizing the coefficients[8] shows that – in accordance with *Hypothesis 1* – the impact of *RD* is especially high for product and process related forms of innovation and is of minor relevance for organizational innovation (Table A.2).

Regarding external resources *EXT*, *Hypothesis 1* suggests that KIS firm innovation is positively affected by cooperation activities with customers or suppliers (*VC*), other firms (*HC*), higher education organizations (*HEC*) and non-university research and development organizations (*RDC*). As depicted in Table 3, *VC* has a positive effect on the probabilities of process, organizational and business model innovation, thus supporting technological and non-technological modes of KIS firm innovation. Z-standardizing the coefficients (Table A.2) demonstrates that the effect of *VC* on the propensity to innovate is highest regarding business model innovation. Cooperation with other firms (*HC*) positively affects the probability of business model innovation. This finding suggests that KIS firms learn from other

[8]Logit regressions are based on the assumption of a latent, non-observable variable $z^*$ that leads to states which can be observed as dichotomous variable $z$. As $z^*$ is not empirically observable and therefore the error variance is not measurable, a constant error variance $\text{var}(\varepsilon)=\pi^2/3$ of $z^*$ is assumed. As the error variance of $z^*$ is fixed, total variance of $z^*$ differs depending on the variance explained. Thus coefficients are only comparable when they are standardized with regards to the standard deviation of $z^*$ (Best and Wolf 2012).

firms that are not part of their value chain, e.g. competitors, with respect to this specific type of non-technological innovation. Furthermore, cooperation with higher education organizations (*HEC*) positively affects the probability of an introduction of processes new to the KIS firms in the sample. Cooperation activities with non-university research and development organizations do not exert any significant influence on the propensity of product, process, organizational or business model innovation.

The results regarding the usage of internal and external resources show that KIS firms rely on different resources in order to innovate – according to the type of innovation pursued. Concerning technological forms of innovation, product innovation of KIS firms depends exclusively on internal resources while process innovation also relies on external resources, namely vertical cooperation and cooperation with higher education organizations. Both non-technological types of innovation rely on cooperation with suppliers and customers. However, while organizational innovation still involves internal research and development activities besides vertical cooperation, business model innovation relies exclusively on external cooperation partners, vertical and horizontal, in order to innovate. Different forms of innovation within KIS firms hence require different knowledge inputs: While product innovation relies exclusively on internal resources and business model innovation uses solely external resources, process and organizational innovation require a mix of both, internal and external resources, for innovation.

### *Hypothesis 2*: Effects of Urban Innovation Support Infrastructures

*Hypothesis 2* predicts a positive impact of the usage of urban innovation support infrastructures, comprising urban innovation support services *AIS* and regional finance *FIN*, on technological and non-technological forms of innovation within KIS firms. The logit analysis show significant positive effects of *AIS* on business model innovation and of *FIN* on organizational innovation.

These results indicate that urban innovation support infrastructures do have positive effects on specific innovation activities of KIS firms. The effects, however, depend upon the type of innovation pursued by the individual KIS firm. While technological forms of KIS innovation are not positively affected by the urban innovation support infrastructures considered in the analysis, non-technological are found to be positively influenced. Centripetal forces of urban innovation support infrastructures vary according to the type of innovation pursued.

## 4.2 Localness of Cooperation Effects

As demonstrated, KIS firms rely on internal and external resources in order to innovate. However, the usage of internal resources and the cooperation activities with external organizations vary according to the type of innovation pursued by the individual KIS firm. Regarding cooperation with organizations external to a KIS firm, *Hypothesis 3* states that cooperation with *local* organizations is sufficient in order to induce a positive effect on innovation. To verify this hypothesis, it is hence necessary to geographically adapt the KPF for process, organizational and business model innovation as these types of innovation rely, to a different degree, on cooperation activities with organizations external to the firm. In order to adjust the model regarding the geographical position of cooperating organizations, six multivariate logit regressions are performed, integrating the different geographic positions of cooperation partners (Table 4). While the City Models allow for cooperation partners in Karlsruhe only, the Urban Models take into account cooperation partners in Karlsruhe and the KTR thus describing a concentric extension of the region considered in the analysis.

According to Chi-Square tests, all local models are significant with respect to a constant only model. Before referring to the geographic patterns of external cooperation of KIS firms, it has to be pointed out that the coefficients of *RD* vary with expanding regional cooperation. However, controlling for interaction effects between internal research and development activities and external resources does not show significant results.

### *Hypothesis 3*: *Local* Effects of Vertical Cooperation, Horizontal Cooperation and Cooperation with Higher Education Organizations

The logit regressions in Table 4 show that effects of cooperation activities with external organizations are sensitive to distance depending on the type of innovation pursued and external organization cooperated with. Cooperation with customers and suppliers (*VC*) induces significant positive effects on the local levels regarding the probabilities of process and organizational innovation. However, there is no local effect of *VC* on the propensity of business model innovation. Cooperation with other firms (*HC*), that also is expected to have a local effect on business model innovation, does not induce significant positive effects on the propensity to innovate in the geographically adjusted model. Collaborative activities with higher education organizations (*HEC*) positively influence the probability of process innovation in the City as well as Urban Model.

These results lead to four central conclusions regarding innovation types and cooperation partners. Firstly, cooperation along local value chains and thus the usage of local knowledge embedded in suppliers and customers is sufficient in order to generate process and

**Table 4:** Localness of Cooperation Effects

| | Type of Innovation and local Model | | | | | |
|---|---|---|---|---|---|---|
| | Process | | Organizational | | Business Model | |
| | City | Urban | City | Urban | City | Urban |
| **1. Control Variables [CV]** | | | | | | |
| A | -0.006 | -0.008 | 0.001 | 0.001 | -0.029 | -0.029 |
| S | -0.001 | -0.001 | 0.043*** | 0.043*** | -0.005 | -0.005 |
| **2. Internal Resources [INT]** | | | | | | |
| KI | -0.008 | -0.008 | -0.010** | -0.010** | -0.006 | -0.006 |
| RD | 1.377* | 1.296* | 0.848** | 0.835** | 0.876** | 0.863** |
| **3. External Resources [EXT]** | | | | | | |
| VC | 0.869 | 1.026* | 0.751** | 0.572 | 0.676 | 0.617 |
| HC | -0.466 | -0.482 | 0.508 | 0.594 | 0.330 | 0.427 |
| HEC | 1.392** | 1.337** | -0.476 | -0.475 | 0.029 | 0.015 |
| RDC | -19.826 | -19.845 | -1.898 | -1.759 | -0.537 | -0.488 |
| **4. Urban Innovation Support Infrastructures [URB]** | | | | | | |
| AIS | -0.823 | -0.697 | -0.474 | -0.468 | 1.251** | 1.274** |
| FIN | -0.047 | 0.066 | 0.728 | 0.765 | -0.372 | -0.327 |
| **Model Fit** | | | | | | |
| -2LL | 92.452 | 91.299 | 252.985 | 254.025 | 193.119 | 192.919 |
| Chi-Square | 17.767* | 18.919** | 47.270*** | 46.230*** | 20.517** | 20.717** |
| N | 225 | 225 | 225 | 225 | 225 | 225 |

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

organizational innovation within KIS firms. However, local knowledge embedded in value chains alone does not induce business model innovation. Thus, the centripetal effects of the local customer and supplier potential indicated in Table 5 – like the centripetal effects of urban innovation support infrastructures – vary according to the type of innovation pursued by the individual KIS firm. Secondly, as it was the case for vertical cooperation, horizontal cooperation on the local level is not sufficient in order to sustain firm level innovativeness regarding business model innovation. These findings concerning business model innovation are in accordance with Oinas and Malecki (1999, 2002) who state that local connections of firms are insufficient for sustaining firm-level innovativeness and that extra-regional contacts are of key importance, as they provide access to ideas, knowledge and technologies that are not available within the limited context of the region. Thirdly, the positive impacts of cooperation with higher education organizations on process innovation in the City and Urban Model indicate that – in accordance with the reasoning of RIS – the local higher education organizations underpin the region's economic base by their content of research regarding process innovation and thus constitute key centripetal forces with respect to this type of innovation. Fourthly, cooperation activities leading to

**Table 5:** Regional Vertical Cooperation Potential of KIS Firms

| Region | % of Suppliers [Mean] | % of Customers [Mean] |
|---|---|---|
| **City** | 29 | 25 |
| **Urban** | 41 | 40 |
| **State** | 60 | 61 |
| **National** | 94 | 92 |
| **International** | 100 | 100 |
| **N** | 225 | 225 |

specific types of innovation are unevenly distributed in geographical space. While for process innovation – constituting a form of technological innovation – cooperation with local external resources is sufficient in order to generate innovation, especially business model innovation relies on a combination of local and supra-local external resources. This uneven distribution of cooperation necessities in space according to the type of innovation pursued is probably due to different contact intensities required depending on the innovation type (McCann 2007) or to the combination of knowledge types, codified or tacit, necessary to induce innovation.

# 5 Discussion and Conclusion

Being a substantial part of the Knowledge Economy that characterizes advanced economies, KIS agglomerate in urban areas. Addressing this empirically observable concentration pattern towards a specific type of geographical space is of major importance as cities gain political power and as their growth and development depend on the ability to attract or generate activity of KIS firms. The application of RIS to the observable location pattern of KIS leads to the central statement that KIS are attracted by innovation advantages that are provided by urban areas. These advantages are shaped by local cooperation partners and an urban innovation support infrastructure consisting of specific urban innovation support services mainly provided by governmental and industrial organizations as well as regional finance. Refining RIS using a synthesis approach to innovation in services leads to the conclusion that the innovation advantages provided by urban areas – and thus their centripetal forces – differ according to the type of innovation pursued by KIS firms.

Regarding their innovation behavior, the analyses presented in this paper verify that KIS firms rely on internal and external resources. However, the differentiated approach concerning innovation types demonstrates that effects of cooperation activities and the local framework vary according to the type of innovation. While product innovation relies solely on internal resources, process, organizational and business model innovation are – to a

varying extent – positively affected by cooperation activities with customers, suppliers, competitors and higher education organizations as well as the usage of urban innovation support services and regional finance. Moreover, regarding the localness of cooperation effects, vertical local cooperation positively affects process and organizational innovation and cooperation with higher education organizations contributes to process innovation.

These findings indicate a high complexity of the relationship between the local framework and innovation activities of KIS firms as the confirmation of the hypothesis derived in this paper depends crucially on the type of innovation. Thus, the centripetal effects of innovation opportunities provided by urban areas vary according to the type of innovation pursued by the individual KIS firm.

Policy implications with respect to the strengthening of innovation opportunities for KIS firms in order to attract knowledge-intensive service activities to urban areas refer to two key levers. First, the urban cooperation potential provided by customers, suppliers and higher education organizations plays a key role in attracting KIS firms. Thus, fostering the agglomeration of vertically interconnected firms that provide sufficient vertical cooperation potential is of crucial importance in order to attract KIS firms. Furthermore, higher education organizations play an important role as they support process innovation within KIS firms. Promoting activities of higher education organizations that underpin the urban economic base renders cities attractive for economic activities of KIS firms. Second, urban infrastructures do have the potential to enhance innovative activities of KIS firms with regards to specific innovation types. It is hence advisable to generate infrastructures conducive to KIS firm innovation with regards to the type of innovation bearing in mind a presumably high specificity of urban innovation support infrastructures encompassing urban innovation support services and regional finance. As the existing urban innovation support services show low usage rates among KIS firms, it is recommended to policy makers to pay more attention to policies supporting innovation within KIS. This policy recommendation is in close accordance with Green et al. (2001) showing that service firms – compared with manufacturing firms – are less often the assumed targets of innovation policies and thus tend to be overlooked in activities aimed at promoting innovation.

In order to gain a deeper understanding of the agglomeration behavior of KIS in urban areas and to derive further policy implications, additional empirical applications are necessary. There are manifold indications that KIS are not a homogeneous group as they are diverse with respect to their activities and their innovation behavior (see, for example, Evangelista 2000, Tether 2003, Hollenstein 2003, Camacho and Rodríguez 2005). Thus, further research should incorporate the diversity of KIS. Additionally, the present contribution focuses on higher education organizations as providers of academic knowledge to local firms. However, as described before, the role of higher education organizations within RIS also expands to the provision of academic education and their role as regional

system builders. Especially their impact on the local labor market – shaping the urban knowledge base – should be addressed in additional studies. Furthermore, literature that deals with the notion of cities as environments fostering creativity often refers to subcultural scenes and a city underground in order to explain local innovation opportunities (see, for example, Cohendet and Zapata 2009). Taking this reasoning into account – which encompasses a broader notion of institutions – might also enhance the understanding of KIS agglomeration in urban areas. Finally, the uneven distribution of cooperation necessities regarding different types of innovation calls for further research incorporating contact intensities required for and knowledge typologies involved in innovation.

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# A Tables

**Table A.1:** Concentration of Knowledge Intensive Services in Karlsruhe 2012

| NACE - Sections and Divisions | Employees Karlsruhe | Location Quotient Baden-Württemberg | Location Quotient Germany |
|---|---|---|---|
| **J: Information and communication** | **12,127** | **2.5** | **2.6** |
| 58 Publishing activities | 2,104 | 2.3 | 2.6 |
| 59 Motion picture, video and television programme production, sound recording and music publishing act. | 107 | 1.1 | 0.4 |
| 60 Programming and broadcasting activities | 97 | 0.6 | 0.3 |
| 61 Telecommunications | 539 | 1.9 | 1.3 |
| 62 Computer programming, consultancy and rel. act. | 9,280 | 2.5 | 3.2 |
| 63 Information service activities | 2,060 | 8.1 | 6.8 |
| **K: Financial and insurance activities** | **11,143** | **2.0** | **2.0** |
| 64 Financial service activities, except insurance and pension funding | 5,515 | 1.5 | 1.5 |
| 65 Insurance, reinsurance and pension funding, except compulsory social security insurance | 5,043 | 5.6 | 4.7 |
| 66 Activities auxiliary to financial services and insurance activities | 585 | 0.8 | 0.7 |
| **M: Professional, scientific and technical act.** | **12,545** | **1.2** | **1.3** |
| 69 Legal and accounting services | 2,540 | 1.2 | 1.1 |
| 70 Activities of head offices; management cons. serv. | 2,943 | 1.0 | 1.1 |
| 71 Architectural and engineering activities; technical testing and analysis | 4,175 | 1.4 | 1.6 |
| 72 Scientific research and development | 1,776 | 1.5 | 1.6 |
| 73 Advertising and market research | 807 | 1.5 | 1.2 |
| 74 Other professional, scientific and technical act. | 250 | 1.1 | 0.8 |
| 75 Veterinary activities | 54 | 0.5 | 0.4 |
| **Other divisions** | | | |
| 86 Human health services | 12,039 | 1.1 | 1.0 |
| 90 Creative, arts and entertainment activities | 802 | 2.9 | 2.2 |
| 91 Libraries, archives, museums and other cultural act. | 649 | 4.1 | 3.3 |
| **Total Knowledge Intensive Services** | **49,305** | **1.5** | **1.5** |

Source: Statistical Office of the Federal State of Baden-Württemberg 2014c, Bundesagentur für Arbeit 2013, Gehrke et al. 2010; own calculations

**Table A.2:** Z-standardized Effects of Internal Resources, Cooperation Activities and Urban Innovation Support Infrastructures

| | Type of Innovation | | | |
|---|---|---|---|---|
| | **Product** | **Process** | **Organi-zational** | **Business Model** |
| **1. Control Variables [CV]** | | | | |
| A | -0.005 | -0.002 | 0.000 | -0.013 |
| S | 0.007* | 0.000 | 0.009*** | -0.003 |
| **2. Internal Resources [INT]** | | | | |
| KI | 0.000 | -0.001 | -0.002** | -0.002 |
| RD | 0.645*** | 0.269* | 0.150* | 0.289 |
| **3. External Organizations [EXT]** | | | | |
| VC | 0.130 | 0.254* | 0.132* | 0.457** |
| HC | 0.028 | -0.030 | 0.073 | 0.331* |
| HEC | -0.024 | 0.240* | -0.120 | -0.064 |
| RDC | -0.282 | -4.059 | -0.121 | -0.081 |
| **4. Urban Innovation Support Infrastructures [URB]** | | | | |
| AIS | -0.223 | -0.102 | -0.114 | 0.609** |
| FIN | -0.173 | 0.016 | 0.185* | -0.079 |
| **Model Fit** | | | | |
| -2LL | 236.997 | 89.807 | 256.262 | 187.028 |
| Chi-Square | 72.136*** | 20.412** | 43.993*** | 26.608*** |
| N | 225 | 225 | 225 | 225 |

*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

# B Questions

The survey was conducted online in German. The questions used in the multivariate logit regressions – in translation – are as follows.

**B.1** Since when, independent of the current legal form, is your firm located in Karlsruhe? *[Year]*

**B.2** How many employees, including the proprietor, are currently engaged at the firm location in Karlsruhe? *[Number of employees]*

**B.3** What is the share of employees holding a degree from a higher education organization (university, university of applied sciences, university of cooperative education) in your firm? *[Share of employees with a university degree]*

**B.4** Were any research and development activities pursued in your firm within the last three years? *[Yes/No]*

**B.5** Which innovations were introduced in your firm within the last three years? *[Introduction of a new product or service/Introduction of a new production, manufacturing or performance method/New methods for organization and management (e.g. procedures, processes, communication channels)/Introduction of new business models]*

**B.6** Apart from cluster and network initiatives, further initiatives support knowledge exchange and innovation activities of local firms. Which of the following services have you already used? *[Steinbeis Centers/Services of the Innovationsallianz TechnologieRegion Karlsruhe/Financial offers of the L-Bank/Forschungszentrum Informatik (House of Living Labs)]*

**B.7** Has your firm cooperated with suppliers or customers within the last three years? Cooperation with customers or suppliers is defined as a relationship that exceeds a normal business relation (e.g. information exchange). *[Yes/No]* **B.8** If yes, please indicate the form of cooperation and the geographic position of your cooperation partners. *[Karlsruhe/Other KTR/Germany: Baden-Württemberg/Germany: Other federal state/Foreign country]*

**B.9** Has your firm cooperated with other firms (Firms with which no business relationships exist, e.g. competitors, companies within the same industry, cluster) within the last three years? Cooperation with other firms is defined as any form of relationship. *[Yes/No]* **B.10** If yes, please indicate the form of cooperation and the geographic position of your cooperation partners. *[Karlsruhe/Other KTR/Germany: Baden-Württemberg/Germany: Other federal state/Foreign country]*

**B.11** Has your firm cooperated with higher education organizations (universities, universities of applied sciences, universities of cooperative education) within the last three

years? Cooperation with higher education organizations is defined as any form of relationship. *[Yes/No]* **B.12** If yes, please indicate the form of cooperation and the geographic position of your cooperation partners. *[Karlsruhe/Other KTR/Germany: Baden-Württemberg/Germany: Other federal state/Foreign country]*

**B.13** Has your firm cooperated with non-university research and development organizations (e.g. Fraunhofer Institutes, Max-Planck-Institutes, Leibniz Association) within the last three years? Cooperation with non-university research and development organizations is defined as any form of relationship. *[Yes/No]* **B.14** If yes, please indicate the form of cooperation and the geographic position of your cooperation partners. *[Karlsruhe/Other KTR/Germany: Baden-Württemberg/Germany: Other federal state/Foreign country]*

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