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“What do you offer?”: Interlinkages of universities and high-technology companies in science and technology parks in Berlin and Seville

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1. Introduction

The innovation process is characterized by interactive learning involving multiple entities (Lundvall 1988). The flow and exchange of information and knowledge spurs R&D activities and innovation enhancing regions' economic growth and competitiveness. Being aware of this process, government policies aim to stimulate and even plan inter-organizational interaction (Ibert 2010; Hewitt-Dundas 2011). In this respect, science parks have become prominent instruments of government infrastructure support to promote business-to-science relationships based on geographical proximity. Universities as sources of knowledge play a major role in science parks and in regions in general. They primarily contribute to the regional economy's competitiveness and innovativeness by providing access to new scientific knowledge, developing solutions for specific problems and by offering access to skilled talent, equipment as well as research techniques (Hewitt-Dundas 2011).

The purpose of this paper is to discuss the role of universities in two science parks in Berlin and Seville and their contribution to localized interactive innovation processes. Both case studies provide similarities in their development process, although, as we shall see later, distinct conceptual framework conditions regarding business-to-university linkages differ. In the case of science parks, the literature predominantly stresses the great significance of geographical proximity. In this paper, however, we focus on the discussion of the multi-dimensional character of proximity – integrating ‘relational proximity’ to the strict geographical interpretation of proximity. Thus, we aim to add further aspects to the ‘soft architecture of learning’ (Thune 2009: 9) within the regional and science park-related network of university-industry-government relations (“Triple Helix”) (Etzkowitz and Leydesdorff 2000: 109). Finally, we make some proposals for policy implications regarding how to more successfully stimulate business-to-university linkages and associated localized innovation processes in science parks in particular, as well as in regions.

2. Theoretical Background of Business-to-University Linkages

Based on a revival of initial ideas by Marshall (1919, 1920) and his notion of the industrial district, new ideas in the search for endogenous regional growth models began to flourish among regional economists, geographers and planners some 35 years ago. This tendency was propelled both by the economic crisis in the production logic of large-scale enterprises and criticism of traditional national state-led regional economic policies in the late 1970s. Alternative local and regional economic development strategies arose mainly from successfully operating SME-based regions in the so-called ‘Third Italy’ (Bagnasco 1977) and were adopted by different academic circles. New concepts like innovative milieus (Aydalot 1986), localized production systems (Bouchrara 1987),

new industrial spaces (Storper and Scott 1988), clusters of innovation (Porter 1990), regional innovation systems (Lundvall 1988, 1992; Braczyk et al. 1998) and learning regions (Florida 1995; Asheim 1997; Morgan 1997) were created. The mutual ideas of these concepts emphasized the importance of spatial proximity in generating innovation and knowledge (Kulke 2008). Although further crucial growth and developmental factors such as qualified human capital, local business culture, the educational system and infrastructure were identified, the firm still was considered to be the nucleus for economic progress in the capitalist logic (Moulaert and Sekia 2003).

This perspective was questioned and relativised by the Triple-Helix-approach (e.g. Leydesdorff and Etzkowitz 1996; Etzkowitz and Leydesdorff 1997). This concept suggests a closer look at university-industry-government relations and the different constellations between these three stakeholders in territorial innovation systems. Accordingly, dynamics of innovation evolve out of close linkages between the private sector, government laboratories and academic research groups (Etzkowitz and Leydesdorff 2000). In spite of the importance of the different linkages, it is observed that universities in particular ‘can play an enhanced role in innovation in increasingly knowledge-based societies’ (Etzkowitz and Leydesdorff 2000) and inhibit a ‘knowledge-hub-function’ (Youtie and Shapira 2008: 1189). Two policy measures are held responsible for the increase of knowledge transfer from universities to companies: on the one hand, purposive legislation designed to stimulate research joint ventures between universities and firms (e.g. the European Union Framework Programmes) and on the other hand, a major shift in the intellectual property regulation in favour of universities (e.g., enactment of the Bayh-Dole Act in 1980) (Mowery et al. 2001; Rafferty 2008; Grimm 2011).

Since then, manifold studies have concentrated on the nexus between universities and companies as a constituent property in realizing innovative environments (e.g. Adams et al. 2001; Poyago-Theodoky et al. 2002; Bercovitz and Feldman 2006). Most of them were carried out in the context of science parks (e.g. Siegel et al. 2003a,b,c; Kulke 2008), which are interfaces between industry, universities and other research institutions. Such territorially bounded entities provide an excellent research setting when examining the spatial dimension of these linkages.

With regard to the research question, science parks refer to property-based initiatives that consist of (1) a technology park, (2) an incubator and (3) at least one higher education institution (HEI). All three elements need governance that can be carried out by an informal team, a single on-site manager or an on-site management company (Grayson 1993).¹ Independent of the mode of governance, science parks pursue several objectives in terms of their impact on localized business-university relationships and the region in general. Objectives associated with inter-organizational linkages comprise the promotion of knowledge and technology transfer, facilitating the formation of new technology-based firms (NTBF), propelling the growth of existing high-tech firms, attracting new firms involved in cutting-edge technologies, and fostering strategic alliances. Regarding their regional impact, science parks aim to contribute to the regional economic development and the growth of employment, as well as to the regional identity and brand formation (Siegel et al. 2003c).

Academic discussion regarding whether spatial proximity is sufficient for university-industry knowledge transfer and technology offers ambiguous results. On the one hand, numerous empirical studies provide evidence that industrial innovations result from significant knowledge spillovers, which originated from the spatial proximity of universities as knowledge pools (Jaffe 1989; Jaffe et al. 1993; Acs et al. 1992; Fritsch and Franke 2004; Fritsch et al. 2008). These findings are coherent with the widely accepted explanation that knowledge spillovers tend to be localized due to their implicit and non-codified nature, of which the exchange requires face-to-face contacts between universities’ and companies’ representatives (Fugukawa 2006). On the other hand, several

¹ A comprehensive overview of the definitions and properties of science parks is provided by Chan et al. (2008).

studies rather contradict this perception by underlining that geographical proximity is neither a necessary nor a sufficient condition for innovation (Boschma 2005; Gallaud and Torre 2005). Furthermore, some researchers show that geographic proximity does not seem to be an important factor in science parks for strengthening business-science relationships (Vedovello 1997; Huber 2012).²

Thus, recent research has focused on detailed analysis of the complex and diverse relationship between learning, innovation and the multidimensional nature of proximity (Boschma 2005; Torre and Rallet 2005; Knoblen and Oerlemans 2006). It is argued that a better understanding of the interplay of the different dimensions of proximity may shed some more light on the complexity of collective learning on various spatial scales (Thune 2009). Different dimensions of proximity are considered in the literature (in particular geographical, social, cognitive, organizational and institutional proximity).

Maskell et al. (2006) distinguish three dimensions of geographical proximity – vertical, horizontal and social. The vertical dimension emphasizes learning by interacting among companies in vertically integrated relationships, while the horizontal dimension underlines the process of learning by comparing and observing co-located competitors. Finally, learning processes created by unintentional exchange of information and frequent face-to-face interaction, also referred to as ‘local buzz’ (e.g. Bathelt et al. 2004), define the social dimension of geographical proximity. The idea of temporary geographical proximity adds another aspect to this debate (Gallaud and Torre 2004; Torre and Rallet 2005; Torre 2008; Maskell et al. 2006). It takes the changes in production and the advancements in transportation as well as communication technologies, which have modified the perception of distance, into account. As a consequence, the need for geographical proximity has become more temporary, which is realized through increased mobility (Torre 2008). Temporary geographical proximity in terms of industry gatherings such as conferences and trade shows are critical in developing and maintaining inter-organizational relationships. Therefore, these platforms are labelled ‘temporary clusters’ (Maskell et al. 2006: 2).

Social proximity is strongly linked to the concept of embeddedness (e.g. Granovetter 1985; Boschma 2005). It argues that economic relations and outcomes are heavily affected by social ties and social capital, respectively. Socially embedded relations between actors are defined by trust based on friendship, kinship and experience. The embeddedness literature emphasizes that the level of social embeddedness of a company’s relationships influences the firm’s interactive learning and innovativeness. Lundvall and Johnson (1994: 28) also refer to the great importance of ‘know-who’ in terms of social settings as a specific category within the concept of knowledge³, while, at the other end of the spectrum, too much social proximity may reduce learning capability.

Cognitive proximity is highlighted as another fundamental dimension of proximity that facilitates communication and learning between different entities. The effective transfer of knowledge requires the absorptive capacity to identify, understand and exploit new knowledge. Thus, firms and research institutions, for instance, search for partners with similar references and knowledge bases in order to process the exchanged knowledge successfully (Nooteboom 2000). It is, however, also argued that a certain cognitive distance should be maintained to enable interactive learning (Boschma 2005; Thune 2009).

² For a further discussion and a literature review about the role of the university as a driver for regional development see Back and Fürst (2011).

³ Lundvall and Johnson (1994) suggest a differentiation of economically relevant knowledge in four categories: ‘know-what’ referring to knowledge about facts, ‘know-why’ referring to scientific knowledge, ‘know-who’ referring to specific social relations and networking as well as ‘know-how’ referring to skills.

Organizational proximity is defined as the extent to which relations, i.e. the rate of autonomy and control, are shared in an organizational arrangement - within or between organizations. It facilitates interactive learning, since new knowledge creation is characterized by uncertainty and opportunism. For example, strong control mechanisms are needed to ensure intellectual property rights. Tightly managed networks with high organizational proximity not only coordinate transactions, but also facilitate the exchange of information and knowledge (Knoben and Oerlemans 2006). Too much organizational proximity, however, results in a lack of flexibility (Boschma 2005).

In contrast to the previously illustrated social proximity stressing social embeddedness on the micro level, the concept of institutional proximity is related to the institutional framework such as norms and values of conduct, which reduce uncertainty and transaction costs at the macro level. Institutions are distinguished between formal institutions (e.g. laws and regulations) and informal institutions (e.g. common language, cultural norms and habits). Furthermore, social, institutional and organizational proximity are strongly interrelated, as inter-organizational relations are deeply embedded in institutional settings (Boschma 2005; Thune 2009). Institutional set-ups influence the creation of new knowledge by defining what kind of knowledge is perceived as useful, finding knowledge, assessing its usefulness and enabling its exploitation to solve distinct problems. Thus, cognitive and normative rules, values, norms and traditions affect the perception of what is considered valuable and how to find and implement solutions (Thune 2009). This paper aims to examine the significance of proximity in its multiple dimensions in business-to-university relations in the science parks in Berlin-Adlershof and Seville-Cartuja.

3. The Berlin-Adlershof and Seville-Cartuja Science Parks

3.1 The case study Berlin-Adlershof

The Adlershof Science and Technology Park was founded in 1991. Today ca. 866 companies, 11 non-university research institutions⁴ and six natural science departments of the Humboldt-Universität zu Berlin (HUB) are located at the site. Approximately 425 high-technology companies primarily operate in the six key clusters: optics and photonics, material and micro system technologies, ICT, environmental technologies, energy and biotechnology. In total, ca. 14,100 employees work in the science park - about 11,500 of them in the private sector and ca. 2,600 at the university and non-university research institutions. Furthermore, roughly 7,900 students study and work in the science park. In 2010, all companies generated a total of € 2.1 billion in turnover (see Table 1) (WISTA-Management GmbH 2011).

Since its establishment in 1991, high-technology companies in particular have shown impressive growth. In the time period between 1996 and 2010, the number of these companies has more than doubled from ca. 200 to 425. Turnover has increased threefold from ca. € 190m to about € 580 m, while employment has also more than tripled from approximately 1,600 employees to ca. 5,000 employees (Suwala and Dannenberg 2009; WISTA-Management GmbH 2011). The large majority of the businesses, however, are relatively small. Nevertheless, most of them seem very successful on the national and international market. Insolvency rates have been very low (Kulke 2008). The OECD (2010) ranked the science park in Berlin-Adlershof among the 15 biggest science and technology parks worldwide and named it as one of the most successful high-tech locations in Germany.

⁴ For example, Helmholtz Zentrum Berlin (HZB) incl. BESSY II, German Aerospace Centre (DLR), Ferdinand-Braun-Institut - Leibniz-Institut für Höchstfrequenztechnik (FBH), Fraunhofer Institute FIRST, Leibniz Institute for Crystal Growth (IKZ), Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI), Leibniz-Institut für Analytische Wissenschaften ISAS e.V., Brandenburg University of Technology, Cottbus (branch institution), Physikalisch-Technische Bundesanstalt (PTB) and Federal Institute for Materials Research and Testing (BAM).

The history of research and sciences in Adlershof dates back to the beginning of the 20th century. In 1909, the opening of the first airport for engine-powered aircrafts, Johannisthal, was the starting point for the location of the aeronautical industry and related research institutions at the site. Several research institutions, e. g. institutions of the German Laboratory of Aviation ('Deutsche Versuchsanstalt für Luftfahrtforschung') and further aerospace-related production companies (e.g., Erich Rumppler Aircraft Construction Company and the Fokker Airplane Factory) followed in the 1920s and 1930s (Mieg and Mackrodt in press).

| | Berlin-Adlershof | Seville-Cartuja |
|---|--|---|
| | Science and Technology Park | Science and Technology Park |
| Date of establishment | March 1991 | October 1993 |
| Area (in km ²) | 4.2 km ² | 6,7 km ² |
| Used space (m ²) in 2011 | 390,000 m ² | 349,000 m ² |
| Total employment | 14,148 | 15,065 |
| No. of companies (total) | 866 | 336 |
| No. of companies (high-tech) | 425 | 177 |
| No. of service companies | 302 | 159 |
| No. of media companies | 139 | n.a. |
| Employment in high technology companies | 5,007 | 7,857 |
| Employment in services etc. | 7,839 (incl. media city) | 3,996 |
| Turnover of companies | € 2.03 billion | € 1.91 billion |
| No. of higher education institutions (HEIs) | 1 (six departments of Humboldt-Universität zu Berlin) | 5 (e.g., University of Seville, EOI Business School) |
| No. of students | 7,900 | 8,000 |
| No. of non-university R&D institutions | 11 | 36 |
| Employment in HEIs and R&D institutions | 2,626 | 3,212 |
| Budget of HEIs and R&D institutions | € 230.3m | € 202.5m |
| Investments | € 2 billion (1991-2010) | € 2 billion (1992-2010) |

Table 1. Overview of the science parks' characteristics and figures in 2010

(based on WISTA-Management GmbH 2011; Cartuja 93, S.A. 2011)

After 1945, a great shift in the scientific and economic orientation of the site took place, as research and production in aerospace and aeronautics was strictly prohibited in post-war Germany. From the 1950s onward, the Academy of Sciences, which was the central research institution in the GDR, and several associated R&D centres, predominantly in natural sciences (physics, chemistry etc.), were located in Adlershof. A great share of research was conducted in close cooperation with industry. By 1989, more than 5,400 people worked in 15 research institutions of the Academy of Sciences in Adlershof. Adlershof also became the centre of TV production and broadcasting of the national television of the GDR, starting from 1956. In addition, the site was home to the Security Regiment Felix Dzerzhinsky of the armed forces of the GDR (Kulke 2008).

After 1990, the Adlershof experienced major changes. The facilities of the army were closed immediately. Facilities related to TV activities were dissolved and privatised. The Academy of Sciences of the GDR was also liquidated, and the restructuring of its research resources went in different directions. Eight of the former Academy of Science institutions that predominantly focused on basic research in natural sciences and technology were integrated into the public, non-

university research institutions of the Max-Planck Society, Fraunhofer-Gesellschaft and Leibniz Society. More than 30 per cent of the former ca. 5,400 researchers of the Academy of Sciences were absorbed by these R&D institutions (Mieg and Mackrodt in press). In contrast, R&D institutes that carried out industry-oriented research were dissolved. In some cases, they re-emerged as newly founded companies. In fact, more than 100 new companies were founded by former Academy of Sciences' employees and also located at the science park (Mieg and Mackrodt in press; Suwala and Dannenberg 2009).

Since the German reunification, the state of Berlin has primarily pursued an innovation-oriented and science-led regional economic development strategy to compensate for the severe loss of employment in manufacturing. As a consequence, several technology parks and incubators have been established. The Adlershof science park is the largest and most prominent project. In 1990, an urban planning concept for the restructuring of Adlershof was developed. Based on its tradition in natural sciences and media, the objective was to create an international centre of science, business and media - designed as an integrated city (Kulke 2008; Mieg and Mackrodt in press) (see Figure 1).⁵

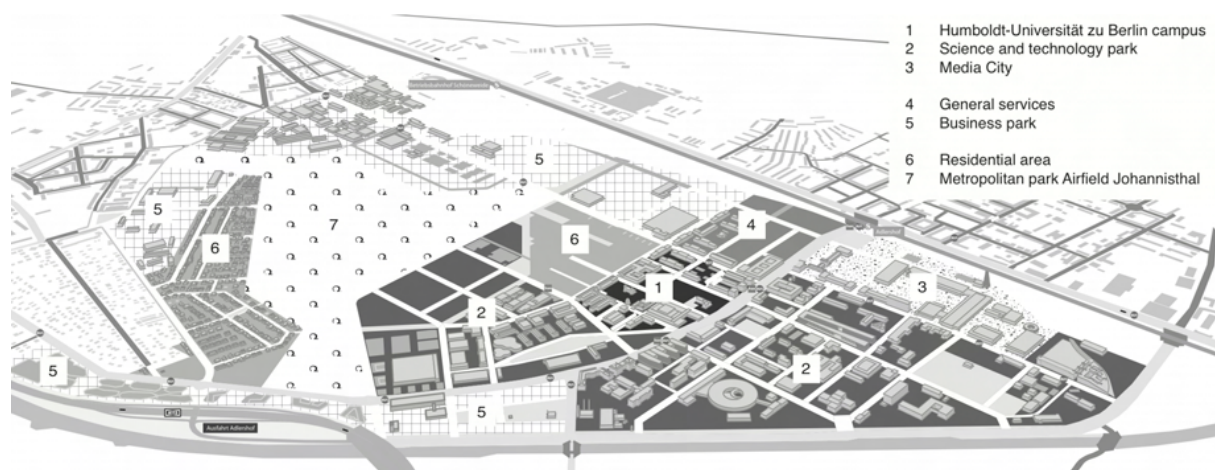


Figure 1. Conceptual plan of the Berlin-Adlershof science park
(modified by authors based on WISTA-Management GmbH 2012)

It was aimed at generating a dynamic and innovative growth process based on the geographical proximity of complementary units – universities, R&D institutions and the private sector (Kulke 2008). As such, the decision to integrate a university campus of the Humboldt-Universität zu Berlin was of fundamental significance. In 1991, the state of Berlin and the university agreed to relocate the spatially dispersed natural sciences' departments at the newly developed science park in Adlershof (Kulke 2008). As a result, since 1998, six major natural sciences' departments of the Humboldt-Universität zu Berlin moved successively to the new university campus in the Southeast of the city.⁶ Research institutions and university departments predominantly complement the science park's technology clustering strategy. As an illustration, BESSY II and the Leibniz Institute for Crystal Growth (IKZ) conduct research in material technologies and photonics, while the Fraunhofer Institute FIRST focuses on research in ICT. At the beginning of the science park's development, however, the proximity-oriented approach did not include any network formation strategy (Kulke 2008).

⁵ In 1991, the science park management company WISTA GmbH was established. Mixed-uses such as commercial activities, social infrastructure, residential areas and a park also were integrated into the development concept (Kulke 2008).

⁶ The new campus of the Humboldt-Universität zu Berlin in Adlershof successively grew in the following chronology: Department of Computer Sciences (8/1998), Department of Mathematics (3/2000), Department of Chemistry (10/2001), Department of Physics (4/2003), Erwin-Schrödinger Centre (5/2003), which contains the library, media centre, lecture and conference rooms as well as a cafeteria and a bookstore, and the Departments of Geography and Psychology (10/2003).

3.2 The case study Seville-Cartuja

The Cartuja Science and Technology Park was established in October 1993 at the former site of the Expo 1992 in Seville. Today, about 340 companies are located there. Approximately 177 of them are high-technology companies in the science park's major clusters: ICT, engineering, environmental technologies, biotechnology / agro-food, energy and health. Furthermore, 36 R&D institutions and five universities (e.g. the University of Seville and EOI Business School) with ca. 8,000 students reside in the science park as well.⁷ In total, roughly 15,060 employees work in the STP Cartuja - about 7,860 of them in high-technology companies. In 2010, the companies generated a total turnover of ca. € 1.9 billion (see Table 1) (Cartuja 93, S.A. 2011). In particular since 2003, the science park has experienced successful growth. In the time period between 2003 and 2010, the number of companies increased from 245 to 377. The turnover grew by more than 50 per cent to ca. € 1.91 billion, while the total employment also increased by about 60 per cent to 15,065 employees. About 342,000 m² of space is currently used, compared to only about 77,200 m² at the very beginning in 1999 (Cartuja 93, S.A. 2005, 2011).

The Cartuja science park derived its name from the monastery that is situated on the island. Already in 1989, before the Expo took place in 1992, the regional government of Andalusia contracted a team of scientists, which was led by Manuel Castells and Peter Hall, to design a redevelopment plan for the Expo site. According to PINTA⁸, a new model of technology parks was to be pursued. The model combined public and private applied research centres, institutions dedicated to the transfer of technology to the Andalusian economy and training centres in new technologies (Cartuja 93, S.A. 2010a). Two primary goals were defined: first, to use the high-quality infrastructure constructed for the Expo to promote applied research in the strategic technology fields in Andalusia (e.g. ICT, new materials, biotechnology applied to agriculture, food technology and environmental technologies), and secondly, to transfer and apply the new knowledge to the regional economy and on the international scale (Vázquez-Barquero and Carrillo 2004). The concept included three major elements (see Figure 2): 'Tecnopolis' – the science and technology park; a service hub (including public administration, business services and general services) and cultural as well as recreational activities (including a theme park, museums, sport facilities such as the Olympic Stadium and a park) (Cartuja 93, S.A. 1994).

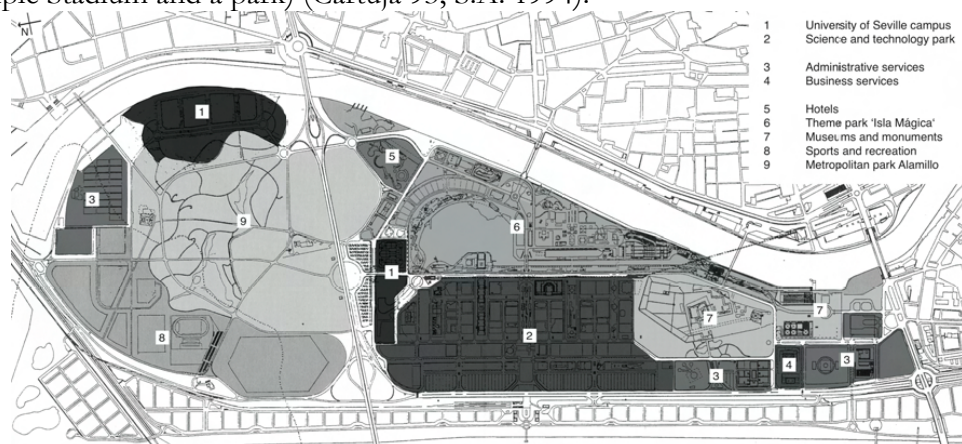


Figure 2. Conceptual plan of the Seville-Cartuja science park
(modified by authors based on Cartuja 93, S.A. 1994)

⁷ Prominent R&D institutions include the Andalusian Molecular Biology and Regenerative Medicine Centre (CABIMER), Andalusian Technology Institute (IAT), Centro Nacionales de Aceleradores (CAN), Scientific Research Centre 'Isla de la Cartuja' (cicCartuja) and the Institute of Microelectronics of Seville (IMSE).

⁸ Under the leadership of Manuel Castells and Peter Hall, researchers from various universities (e.g., Autonomía de Madrid, California-Berkeley, University of Seville and University of Malaga) and technicians of the Andalusian government participated in the project 'Proyecto de Investigación sobre Nuevas Tecnologías en Andalucía (PINTA)' (González Romero 2002). For further information see (Castells and Hall 1992).

After the end of the World Fair, the restructuring process began. In October 1993, the science park's management body, Cartuja 93, was established, and the science park's operation started.⁹ The unique characteristics of the Cartuja science park are three-fold. First, the science park is based on the conversion of the Expo'92 site equipped with high-quality facilities and infrastructure. Secondly, it is situated in the vicinity of Seville's historic city centre, which also transfers a certain urbanity to the science park. Thirdly, the shareholders of the managing company Cartuja 93 were positioned at various administrative levels, i.e. the regional government of Andalusia (51 per cent), the Spanish government (34 per cent), the City of Seville (ten per cent) and the provincial administration of Seville (five per cent) (González Romero 2002). Similar to Berlin-Adlershof, the concept of Seville-Tecnópolis is based on the combination of a technology park with high-technology companies alongside complementary research institutions and university faculties. Geographical proximity is aimed at lowering regional deficits in business-technology-science interaction (González Romero 2002). Consequently, the colocation of regional public administration institutions, multiple R&D centres and several faculties as well as research units of the University of Seville (School of Engineering and Faculty of Communication)¹⁰ are all critical prerequisites to the stimulation of innovation at the Cartuja science park (Cartuja 93, S.A. 2010b).

In summary, both science parks represent examples of large-scale re-development landmark projects, which are aimed at spurring interactive innovation processes and to promote endogenous regional economic growth in specific high-technology sectors. Universities and further R&D institutions are fundamental elements of the science parks. In the recent past, Berlin-Adlershof and Seville-Cartuja have evolved successfully, which can also be illustrated in quantitative terms, for example, by the number of companies, growth of employment and the companies' turnover (see Table 1). The Adlershof science park is characterized by a large number of micro and small companies. In contrast, Cartuja 93 was also heavily focused on the attraction of large national and international firms at the project's outset (González Romero 2002; Vázquez-Barquero and Carrillo 2004). Consequently, its company portfolio today includes several large national companies and branches of prominent international firms.

4. Interorganizational Networks at the Adlershof und Cartuja Science Parks

The data were collected within the EU Interreg project 'Knowledge network management in technology parks (Know-Man)'. In total, 54 NTBFs of different sizes and ages were surveyed at the two innovation sites from October 2010 to April 2011. The two case studies are characterized by a methodological mix of standardized questionnaires and expert interviews that aimed to analyze business-to-science interaction in the science parks with a special focus on co-located universities. In the questionnaire, the companies assessed the intensity of interorganizational interaction quantitatively. Here, relations were distinguished as informal, formal and human resources-related, in which various activities were analyzed (see Vedovello 1997).

The expert interviews examined the peculiarities of the businesses' relationships to universities and other scientific institutions in more detail. Important aspects of analysis were the origin, the evolution and the geographical scope of these linkages. In this regard, it was specifically focused on the importance of social and geographical proximity. Furthermore, additional prerequisites and framework conditions associated to other dimensions of proximity that define successful business-university interaction were assessed.

⁹ Cartuja 93 is a public company. It is responsible for the development and management of the science park's infrastructure and facilities as well as for the network management activities at the science park (Interview Cartuja 93, 23. November 2010).

¹⁰ The university's School of Engineering relocated to the Cartuja science park in July 1997, while the Faculty of Communication followed in September 2003 (Interview with Cartuja 93, 15 February 2012).

The majority of the companies surveyed at the two science parks are characterized as R&D intensive high-technology companies, which maintain strong or even multi-faceted long-term relationships to scientific institutions in general. Typically, firms take great advantage of the broad scientific and research infrastructure in the respective science park and region.¹¹

At the Adlershof science park, however, the intensity of business-university linkages appears to be relatively weak. Only in rare cases do companies strongly collaborate with specific university departments (e.g. the Department of Physics, Department of Computer Science and Department of Chemistry) and related research groups, respectively. Interaction mostly takes place in terms of informal relationships, e.g. personal contacts and student placements. Rarely have joint research projects or even general cooperation agreements been implemented. In contrast, many of the interviewed companies have instead stressed their informal and formal relationships to non-university research institutions co-located in the science park. Other studies have also detected a low significance of business-to-university inter-linkages amidst strong relations between the private sector and non-university R&D institutions. Personal networks of former employees of the Academy of Sciences, who now work at R&D institutions and companies have remained well-intact. Furthermore, strong (horizontal and vertical) links among co-located businesses have developed rapidly at the science park (Kulke 2008; Kulke and Wessel 2008).

The survey at the Cartuja science park reveals similar findings, although important details diverge. In contrast to González Romero (2002), who assessed the science park as having a weak role as a platform for interactive innovation activities caused by weak business-to-science interaction, we found instead that profound business-university ties have been established. The School of Engineering of the University of Seville is the central scientific partner in the science park overall, which was also underlined by González Romero (2002). Similar to Adlershof, rather informal forms of collaboration dominate (i.e. personal contacts, student placements and the use of equipment and laboratories). Nevertheless, mutual formal efforts such as general cooperation agreements, joint laboratories, contract research, joint R&D projects, and commercialization activities of research results in terms of university spin-offs, have all been realized on a larger scale. In contrast, cooperation with other co-located R&D institutions is rather weak and comprises mainly personal linkages.

In addition, the vast majority of the companies in both case studies also maintain strong relationships with scientific institutions outside the science parks – both regionally and even on a national and international scale. In fact, external relationships even appear to be more important to the companies than science park-based links. This corresponds with the discussion among scholars about the importance of permanent geographical co-location and the abolition of distance in collective learning (Boschma 2005; Gallaud and Torre 2005). The case studies reveal, however, that the dimension and purposes of business-university interaction diverge as a result of distinct geographical scales. Informal interaction, in terms of personal contacts and access to talent as well as equipment, is more important at the science parks. This supports other findings that highlight the access to skilled labour as a key driver of business links to universities (Hewitt-Dundas 2011).

¹¹ In the states of Berlin and Brandenburg, in a total of seven universities, 12 universities of applied sciences, one medical school, three art schools and more than 85 R&D institutions (including nine institutes of the Fraunhofer Gesellschaft, nine institutes of the Max Planck Society, seven institutes of the Helmholtz Association of German Research Centres, and 21 institutes of the Gottfried-Wilhelm-Leibniz Scientific Community) are located (Websites of Berlin Senate Department for Education, Sciences and Research (accessed 5 March 2012); Brandenburg Ministry for Sciences, Research and Culture (accessed 5 March 2012)). In Andalusia, in total ten public universities and nine business schools with ca. 241,000 students and ca. 34,200 graduates as well as more than 100 R&D institutions are located. Altogether, ca. 2,000 research groups conduct research at the scientific and higher education institutions in the region (Sources: Websites of Junta de Andalucía, Consejería de Economía, Innovación y Ciencia; Agencia IDEA (accessed 9 November 2011)).

In contrast, formal cooperation, for instance, in publicly funded R&D projects is realized instead through scientific partners located outside the science park. Hewitt-Dundas (2011) finds that non-local financial funding sources, such as national and EU research programmes (e.g. 7th EU Framework Programme), strongly affect non-local cooperation of business-university partnerships. Additionally, highly specialized high-technology companies, in particular those that cater to very specialized niche markets, must operate on a national or international scale. This considered, research partners also are most likely spread beyond the local scale. Figures 3 and 4 illustrate the geographical scope and interaction modes of the surveyed companies' business-to-science networks at the Berlin-Adlershof and Seville-Cartuja science parks.¹²

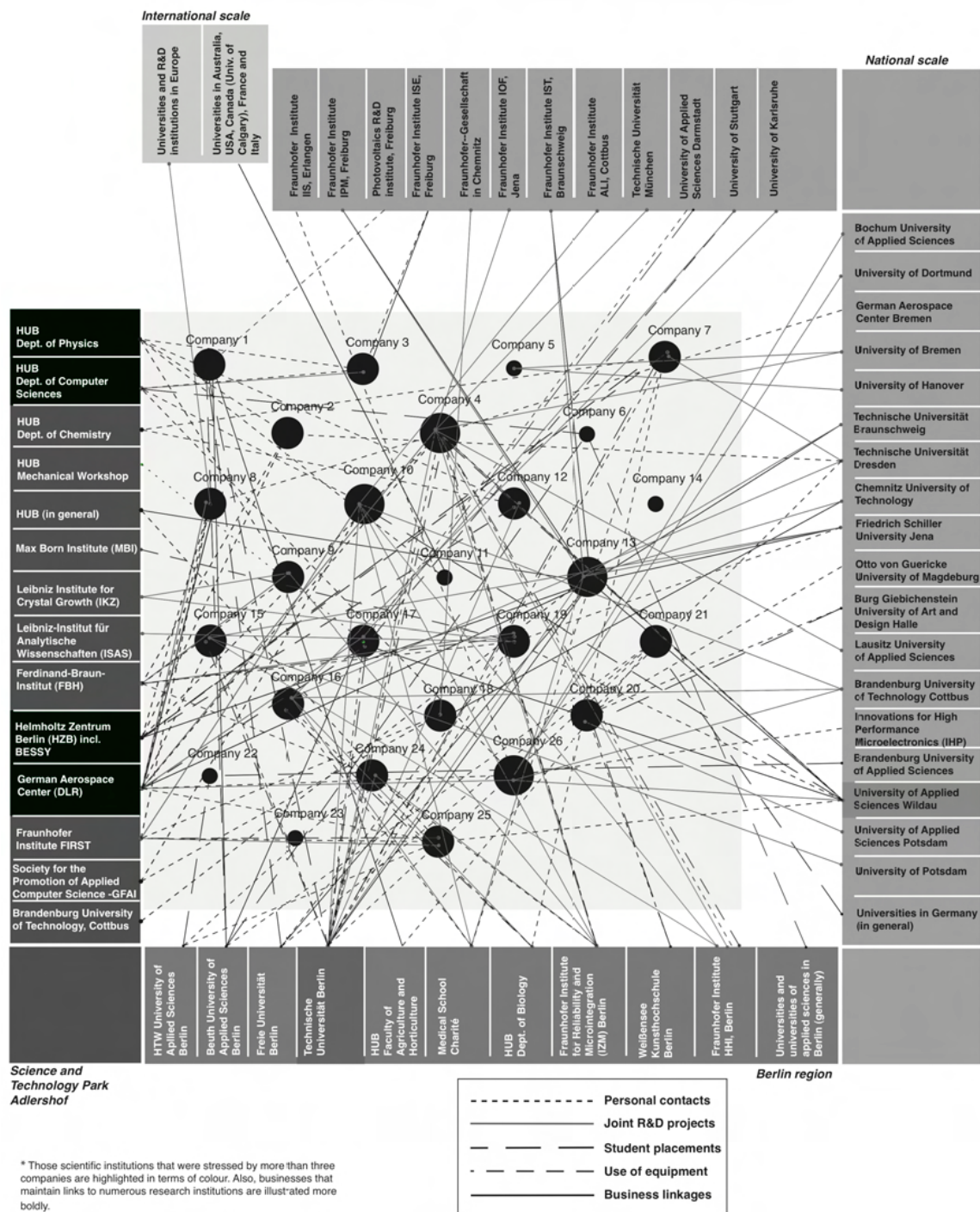


Figure 3. Business-to-science network at the Berlin-Adlershof science park

¹² The data and information material associated with the interviews were analyzed to the best of our abilities. However, the illustration of the companies' networks only provides a snapshot and does not claim to provide a complete picture.

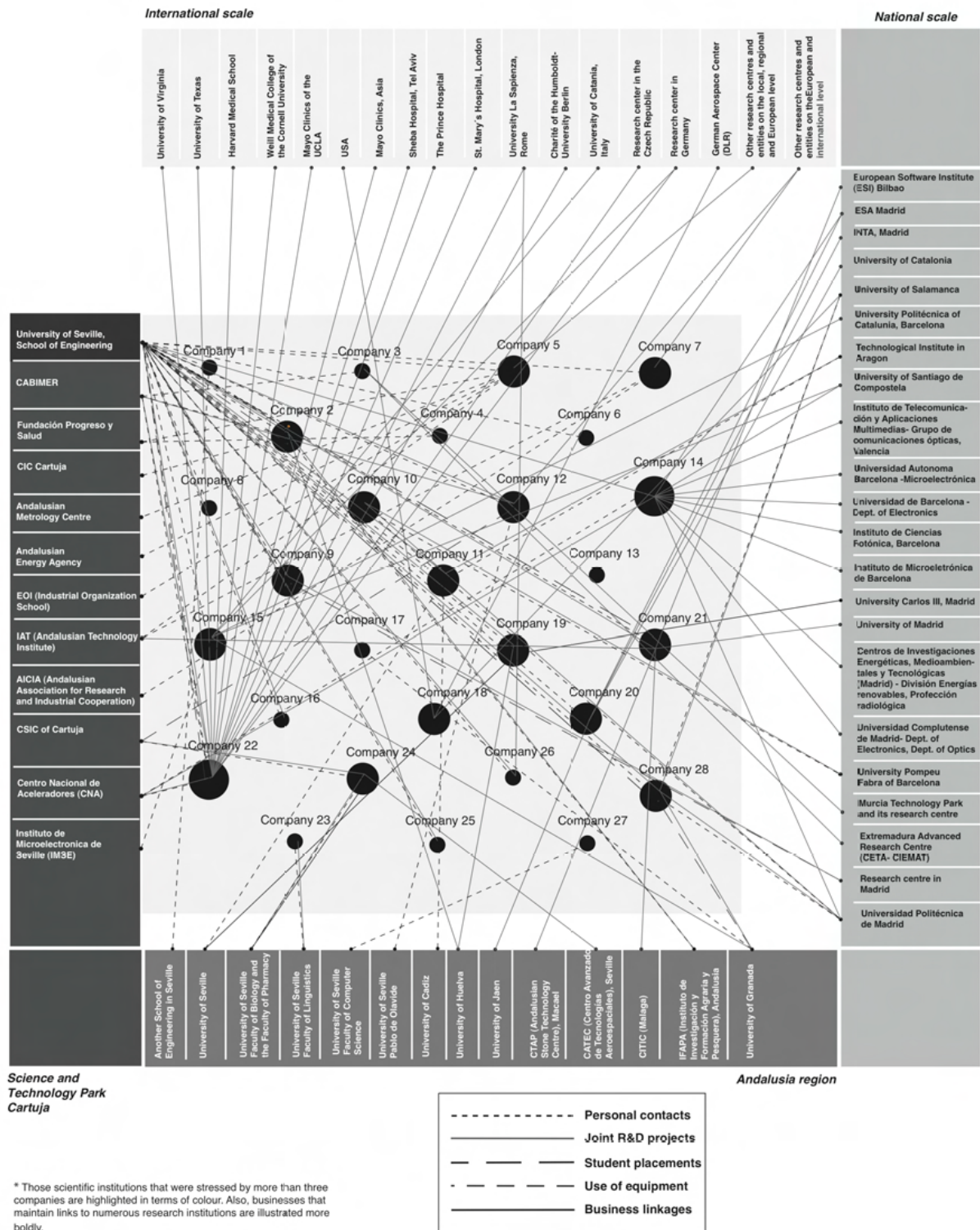


Figure 4. Business-to-science network at the Seville-Cartuja science park

In contrast to the initial concepts at the science parks' development, the geographical co-location of complementary scientific and business units alone does not suffice in establishing strong inter-organizational relationships (González Romero 2002; Kulke 2008). Although the university has been located for more than eight years entirely at the Adlershof science park linkages between businesses and university chairs remain relatively weak. The findings at the Cartuja science park, however, rather support the concept stressing the significance of geographical co-location.

The literature that discusses the relevance of the different dimensions of proximity and their specific interrelations, perceives geographical proximity instead as a complementary framework condition. It is rather argued that additional criteria (and dimensions of proximity) are critical for successful business-to-university interaction in science parks. Cognitive and social proximity are considered fundamental prerequisites for inter-organizational relations (Oinas 1997; Boschma 2005). Hewitt-Dundas (2011) even argues that the need for geographical proximity, in order to exchange knowledge, decreases as cognitive proximity among partners increases.

The two case studies show that social proximity is central to most of the innovation-related activities realized with universities and other scientific institutions in the science park and beyond. The overwhelming majority of interviewees consider previously established contacts to be fundamental for collaborative activities. Personal relationships are utilized frequently and intensely to establish inter-organizational relationships. These linkages are primarily based on personal ties to former work colleagues at universities or non-university research institutions or fellow students that currently hold a research position. Even referrals by other staff members are additional sources. Two examples from both sites illustrate the origin of university ties as a result of mutual professional and educational biographies:

Many of these relationships are based on personal contacts, in particular to former colleagues at the Academy of Sciences [of the former GDR] that work at Humboldt- Universität zu Berlin or at research institutions now. (Company 2, STP Adlershof)

Well, we have a lot of employees that have studied at the School of Engineering [of the University of Seville]. And their fellow students now work for some research groups at the university. (Company 11, STP Cartuja)

In particular, university and R&D spin-offs take advantage of their scientific background. Typically, interaction with mother scientific institutions at the science parks on informal, formal and human resource-based levels (e.g. personal relationships, joint research projects and staff exchange) remain very strong.

We have very good relationships with the Departments of Physics and Computer Science based on our previous university contacts. This comprises talent, but we also realize joint research projects and staff exchanges, which is facilitated by the TransferBONUS programme.¹³ (Company 7, STP Adlershof)

The basis of the company is basically the School of Engineering of Seville, because the knowledge comes from there. (...) For us, the university is the key in everything, regarding the installations, possibilities of knowledge, possibilities to do projects, cooperation etc. (...) Pretty much priceless, also for the philosophy, as two of the partners are professors there. (Company 20, STP Cartuja)

At the same time, several spin-offs that were interviewed in Berlin-Adlershof originate instead from research and university institutions located outside the science park. Their linkages to these external institutions also are very strong. Thus, our findings strongly correlate with previous studies that underline the strong interrelation of social embeddedness and economic relations in localized innovation networks. Accordingly, these networks are less likely to evolve because of a need for face-to-face relations to exchange knowledge. Their formation is rather due to mutual professional, academic biographies or the simple fact of belonging to the same social and family network (Torre 2008). In addition, we have found that companies not possessing these kinds of personal ties generally experience great difficulties in gaining access to the universities at the science parks.

¹³ The TransferBONUS programme is a financial support scheme provided by the Investitionsbank Berlin (IBB). The innovation voucher is primarily dedicated to initiate small joint projects (max. 15,000 €) between SMEs and scientific institutions in the State of Berlin (Source: Website of IBB, accessed 2 April 2012).

In some cases, collaborative relationships evolved without prior personal contacts. Companies were looking for additional expertise in order to gain access to new expertise, to find specific solutions and to join larger research projects. Here, organizational proximity embodied by specific intermediary organizations played an important role in facilitating the formation of business-to-science and business-to-university linkages, respectively. At the Berlin-Adlershof science park, for example, the science park's management organization WISTA GmbH, as well as locally-rooted networks such as the business organization Technologiekreis Adlershof and the optical cluster OpTecBB, generally spur the development of personal relationships, which may result in interactive learning. At the science park in Seville, mostly young micro-companies, which have recently developed at the site, stress the broker role of the science park management body Cartuja 93 and other public intermediary institutions such as CTA and FIDETIA.¹⁴ Generally, intermediary organizations facilitating the interaction between industry and sciences play a slightly stronger role at Seville-Cartuja than at Berlin-Adlershof.

It's always easier when you know each other beforehand, when you know who you have to talk to than when you have to ask through the university in order to find the right person. (...) That's the reason why we are in various boards and networks such as OpTecBB. Not because we're expecting big business, but to get to know beforehand who works in what field and who could contribute to solutions in certain problems at some point. (Company 9, STP Adlershof)

About 50 per cent of the connections came from the contacts I had from my previous research work experiences. The other 50 per cent of the relationships came through contacts to CSIC or are referred by the CTA, for example. Also, through a networking event initiated by the research group of CABIMER, they facilitated the meeting of companies and researchers. (Company 12, STP Cartuja)

In addition, financial support schemes of the respective regional and national governments as well as the European Union (e.g. the 7th Research Framework Programme) strongly contribute to enhanced business-to-science interaction (e.g. transfer of talent, spin-off support and joint R&D projects). They provide some certainty to the involved organizations due to the high degree of control (e.g. related to intellectual property). Joint activities, however, are not limited to the science park level. The geographical scope rather correlates with the institutional scope of the support programmes. Industry gatherings such as conferences and trade shows are important 'temporary clusters' (Maskell et al. 2006) to create and maintain non-local inter-organizational relationships ('global pipelines') (Bathelt et al. 2004: 41).

Another central criterion that defines the norms of the institutional framework of localized business-to-university relations is a mutual understanding of work culture and the capability to pursue a systematic business approach. In the case studies, the institutional distance between the companies and the universities is perceived as one of the major obstacles inhibiting stronger interaction. Three examples showcase the difficulties in combining the different work ethics of the universities and the NTBFs:

The institution is the problem. They are structured that you can't work with them – to the point of very different ideas about the costs for certain activities. (Company 20, STP Adlershof)

Sometimes it's like the university and the company don't speak the same language. (...) What happens is that the University [of Seville] is a very rigid element, which takes a lot to understand the concepts of a private company. (Company 16, STP Cartuja)

¹⁴ Corporación Tecnológica de Andalucía (CTA) is a private foundation promoted by the regional government of Andalusia. It focuses on the promotion of inter-organizational collaboration between science and the private sector in the region. Fundación para la Investigación y el Desarrollo de las Tecnologías de la Información en Andalucía (FIDETIA) is a teaching and research foundation. It is dedicated to knowledge transfer and innovation between science and businesses in particular in ICT. It is part of the Faculty of Computer Science of the School of Engineering at the University of Seville (Websites of CTA and FIDETIA, accessed 5 March 2012).

The lack of institutional proximity is generally a universal obstacle in both case studies. Interaction usually takes place on the personal level between university researchers and company staff. As a consequence, too much institutional distance can be supplemented by social proximity, which is indicated by individual interviewees.¹⁵

The relativeness of the universities' research and training foci to the companies' activities is critical for interaction as well. The companies' demand primarily focuses on scientific partners in practical-oriented and applied research. These are basic prerequisites in order to create market-oriented solutions. In fact, one of the reasons for the relatively weak business-university interaction at the Adlershof science park appears to be the great cognitive distance between companies and the university's natural sciences' departments, which heavily concentrate on basic research. At Berlin-Adlershof, specific non-university R&D institutions instead match the firms' need for more market-oriented research, which has resulted in stronger interaction. One entrepreneur in Berlin illustrates the greater cognitive proximity to co-located non-university R&D institutions in comparison to the university:

Products that we develop have to be marketable. (...) We want the scientific background being proved. We also want the people's expertise, if it is useful and first applications that we can bring on the market, of course. There we want to be able to say we have tested this device there and there, and that's why it's good. (...) It works very well with such institutions that work in the same field like Ferdinand-Braun-Institut. But you can't do it with the Humboldt-Universität that, for example, focuses on nuclear physics. (Company 19, STP Adlershof)

Generally, it is evident that the entrepreneurial role has not been fully incorporated by most universities due to the primary focus on teaching, research and third-party funds-related criteria in university benchmarking (Back and Fürst 2011). Already, the university's deficits and passive behaviour have resulted in a search for co-located companies and for other opportunity partners in the Berlin region. In particular, universities of applied sciences, which are characterized by a more demand-led approach, appear to be more suitable partners, for instance, in talent-related cooperation:¹⁶

We have tried to support master theses, but the professors didn't want to, because it is too practical-oriented. (...) Now, we only do it with universities of applied sciences. (...) First, I thought, it's just my impression regarding the willingness for cooperation by HUB. Though, in the meantime there's an increasing indication that professors from HUB do not want to cooperate in general. (Company 22, STP Adlershof)

In terms of the competence and knowledge base, the university at Cartuja appears to match the firms' needs better than in the case of Berlin-Adlershof. The School of Engineering's strong role is based on its alignment towards practical-oriented research and training in engineering, which caters to the large number of engineering companies (e.g. civil and mechanical engineering) and other firms that operate in related fields (e.g. environmental technologies, ICT and aerospace) at the science park Cartuja.¹⁷

¹⁵ 'Usually there aren't any obstacles, when the personal level works. It's important that you know each other. (...) Openness for dialogue is important, especially in case of different objectives.' (Company 19, STP Adlershof)

¹⁶ OECD (2010) finds that universities of applied sciences, which are more application-oriented, are more suitable partners to match the needs of companies in the Berlin region. Typically, research-intensive universities in metropolitan regions such as Berlin focus on their national and international roles and show low interest in cooperation with regional SMEs. Thus, geographical co-location among innovation entities (universities, R&D institutions, companies etc.) in metropolitan regional innovation systems sometimes is not matched with social and institutional proximity (Asheim 2010, Boschma 2005). In addition, it is argued that a high share of SMEs work in more practical-oriented industries, where innovation is more incremental and demand-led than science-based (OECD 2010).

¹⁷ Additionally, nine spin-off companies of the University of Seville participated in the survey.

An example for the demand-led approach at Cartuja is the creation of specific study programmes for engineers. The university's School of Engineering created specific training programmes in aeronautics and aerospace in response to the sector's strong position in the region and the firms' demand for skilled labour and industry-related research.¹⁸ The cognitive dimension of proximity is also strongly interrelated to social proximity, as has been the case for many of the personal relationships established in universities and R&D institutions. Thus, a shared understanding based on a similar educational and professional background facilitates the formation of collaborative ties (Grossetti and Bes 2001). In particular, the strong university ties of the university spin-offs in both science parks illustrate the interrelation of social, cognitive and institutional proximity.

Nevertheless, the generally weak business-to-university ties at the science park Adlershof are largely caused by the lack of 'non-spatial proximity' (Knoben and Oerlemans 2006: 73). First, the university's natural science departments primarily focus on basic research, and consequently, rarely complement the companies' need for demand-led solutions. Secondly, prejudices about the rigid work culture and long bureaucratic decision-making processes remain strong. Thirdly, many companies simply lack the personal relationships with university researchers. Finally, we argue that, in particular, the lack of transparency and openness regarding potential opportunities for collaborative activities is responsible for the university's weak local integration at the science park. One entrepreneur underlines the necessity for a more active approach to show the university's commitment at the science park:

The last thing that I saw was a clean room, where two people work (...). It was completely empty. Now the question is, what are the opportunities for others? Who will organize it, and does the Humboldt-Universität zu Berlin actually want it? (...) It's not clear to me, how the HUB wants to integrate into this SME landscape here. (Company 17, STP Adlershof)

At the science park Cartuja, the School of Engineering appears more successfully integrated. Not only do the university spin-offs maintain strong informal and formal relationships, but multi-faceted interlinkages with other co-located firms have also evolved. Research and training foci better match the companies' needs for market-oriented knowledge and solutions. Despite the important role of the School of Engineering, the University of Seville's Faculty of Communication and other non-university R&D institutions at the science park have not yet shown a great impact on localized interactive innovation processes.

5. Discussion and Conclusion

The goal of this paper was to contribute to the discussion of universities' role in interactive learning and innovation processes in science parks by analysing the significance of proximity in its multi-dimensional character. In the case studies of Berlin and Seville, geographical proximity between universities and business was an integral element of the science park concept. In the comparative analysis, we find that geographical co-location alone is not enough to develop strong interdependencies between universities and businesses. Four particular dimensions of proximity have been more crucial for business-to-university linkages in the two science parks.

First, personal relationships between entrepreneurs and scientists are fundamental (social proximity). Secondly, research and training at the universities must correspond to the businesses' activities (cognitive proximity). Thirdly, the universities have to embody their role as 'entrepreneurial universities' (Bercovitz and Feldman 2006: 175; Etzkowitz and Leydesdorff 1997: 141) by adapting to the private sector's work culture (institutional proximity). Finally, support schemes and intermediaries also spur the inter-organizational knowledge transfer (organizational proximity).

¹⁸ Helice Foundation - Andalusian Aerospace Cluster (Meeting within Know-Man project, 8 February 2012).

The impact of the University of Seville on localized inter-organizational innovation activities at the science park Cartuja stands out in particular due to the multi-faceted interconnectedness of the University's School of Engineering. In particular, the strong personal contacts between entrepreneurs and researchers as well as a demand-led approach in research and training are identified as responsible ingredients for strong integration in the science park. Intermediaries that facilitate business-to-university cooperation and specific support schemes enhancing the development of a 'spin-off culture' (e.g. the CAMPUS programme of the Andalusian regional government) in the region are additional success factors.

At Berlin-Adlershof, a particular lack of convergence of university research and companies' needs is observed ('unrelated variety', OECD 2010: 77). The OECD (2010) concludes that the science-led economic development strategy in Berlin has only been successful in distinct industries such as the life science sector, in which innovations are more science-based (for example, in the case of the Berlin-Buch science park). More practical-oriented industries represented by the key cluster in the Adlershof science park, which are dominated by SMEs, show weaker results. For a stronger role of universities in existing science parks and future science park development projects, we want to outline several policy recommendations. First, a convergence of university research and industry clusters has to be ensured. Secondly, universities have to adapt their work culture as well as research and training to their designated entrepreneurial role. Thirdly, they have to communicate how they plan to contribute to the science park's objectives and the co-located entities of the private and research sector. Here, proactive marketing of the accessible university competencies and assets (e.g. knowledge, infrastructure and talent) is required. The university staff's activities and motivation also have to be aligned to the overall strategy and vision that define the university's third role (Etzkowitz and Leydesdorff 1997; Goddard et al. 2011). Finally, informal and low-barrier forms of business-to-science cooperation, such as student placements and use of university equipment, may serve as 'ice-breakers' for the development of continuous, multi-faceted inter-organizational relationships. Additionally, mixed teams of researchers and company staff as well as shared co-working spaces can contribute to enhanced inter-personal work experiences and, consequently, in the building of personal trust.

In addition, we emphasize that superior factors, particularly time, are critical for developing social capital and for fostering interactive relationships in territorial innovation systems (Hewitt-Dundas 2011). In comparison to the step-by-step re-location of the various departments of the Humboldt-Universität zu Berlin between 1998 and 2003, the School of Engineering became part of the Cartuja science park in July 1997 (see Figure 5). Other case studies of science parks, e.g. Sophia Antipolis in France, have also shown that the passage of time is a key factor for the formation of localized interactive innovation processes (Longhi 1999).

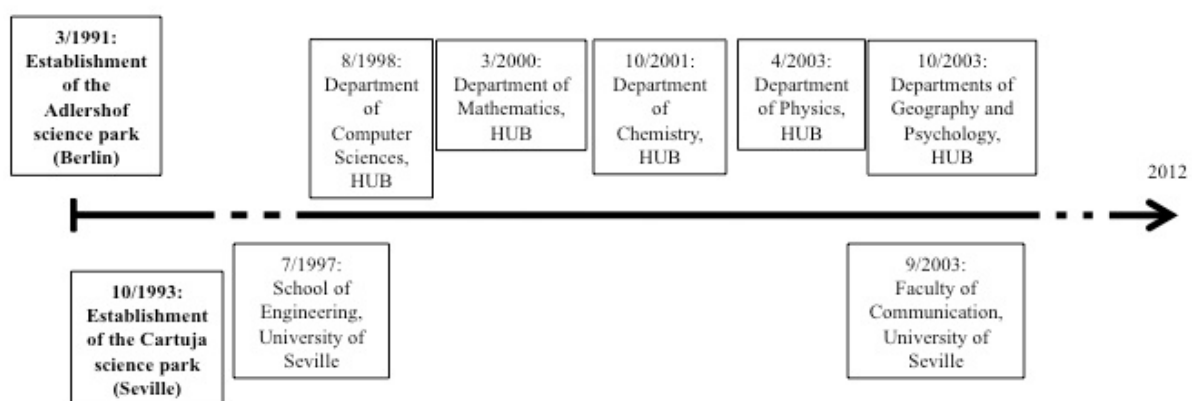


Figure 5. Time frame of university re-location at the two science parks

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