Chapter 1

Introduction

1.1 Setting the stage

Building economic strength is given top priority in most developing countries as one of the ways of improving the wealth standards of their citizens. The integration of technology and innovation into the development process plays an important role in creating a sustainable economy and has proven to be a success in many developed countries. Developing countries, in trying to catch up with the developed countries who have gained from their *knowledge-driven* economies by establishing regional or national systems of innovation, have started establishing their own systems of innovation. The establishment of science parks (SPs) is one of the important ways of connecting technological innovation and economic development, which are often integrated with the innovation systems of developed countries, especially in the West. SPs can be regarded as spatially bound infrastructures for facilitating and promoting knowledge flows between knowledge-intensive small and medium-sized technology-based firms. In other words, SPs provide these firms with a supportive environment in order to conduct innovative knowledge-based activities and thus improve their performance. Despite several successful stories about SPs and the benefits that SPs bring to their firms located on site (Felsenstein, 1994; Lindelöf and Löfsten, 2004), some researchers doubt the benefits that SPs claim to have (Westhead, 1997; Malairaja and Zawdie, 2008) to their on-site firms. From previous studies, a picture of mixed findings in terms of science park firm performances emerges. This thesis aims to explain the mixed findings regarding science park firm performances found in the SP literature (more details are reported in Chapter 5). In order to explain these mixed findings, this thesis proposes to study the general view of and the problems of interorganisational knowledge flows which are important aspects of a system of innovation.

In the next section, the concept of national system of innovation (NSI), which forms one of the backbones of this study, is discussed. The science park concept is rooted in the NSI literature. After the discussion of the NSI concept, the concept of SP is elaborated in terms of its definitions and its relation to a regional system of innovation in Section 1.3. Because the data used in this study was collected from firms located in Gauteng, South Africa (SA), a country with an emerging economy, the history and the state of the affairs of NSI implementations, as well as the technology and innovation situation in the SA economy and the Gauteng region in particular, are discussed in Section 1.4. With all the relevant concepts and the South African innovation background study in place, Section 1.5 will develop the main research question of this study and propose a relational approach with a resource-based view (RBV) as its theoretical basis. More details of the RBV and the theoretical relevance of this research are discussed in Section 1.6. The main research question is broken down into several subquestions in Section 1.7. This section will also discuss how each of the following chapters in the thesis relate to each subquestion. In this way, the coherence of this thesis will become clear. In the last section of this chapter, a discussion about the research contribution will be presented to show how this thesis is (together with the theoretical relevance as discussed in Section 1.6) practically and scientifically relevant.

1.2 National system of innovation and knowledge-driven economy

Governments often have used the National System of Innovation (NSI) framework to promote innovations and economic development (Lundvall, 2010). The NSI approach can be traced as far back as 1841, when Friedrich List proposed the concept of "national system of production" where he pointed out the need for a national infrastructure (to transport people and commodities) and institutions (including educational institutions) to promote "mental capital", which, in turn, boosts economic development. Later the concept of NSI was firstly published by Freeman in 1987, when he defined NSI as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies" (Freeman, 1987: 1). Subsequently, in 1992, Lundvall published a book that was, according to Freeman (1995), "highly original and thought-provoking", entitled *National systems of innovation: towards a theory of innovation and interactive learning*. It is proposed in this book that an NSI should consist of elements and relationships that interact in the production, diffusion and use of new, and economically useful, knowledge (Lundvall, 1992: 2). The term *elements* can be regarded as "a set of institutions whose interactions determine the innovative performance of national firms" (Nelson, 1993: 4). On the other hand, *relationships*, as in "relationships between institutions", may be seen as "carriers of knowledge, and interaction as processes where new knowledge is produced and learnt" (Johnson et al., 2003: 5). As opposed to Freeman and Lundvall's broad understanding of NSIs, Mowery and Oxley (1995) narrowed these relationships to only the relationships "between R&D-efforts in firms, S&T-organisations, including universities, and public policy" (Muchie et al., 2003). These relationships closely resemble the Triple Helix concept where the changing relationships between universities, government and business are the focus. The Triple Helix concept is relevant to this study as it is strongly associated with the science park concept (which will be elaborated further in Section 1.3).

According to Godin's literature review, the concept of knowledge economy re-emerged in Lundvall's book on NSI (Godin, 2006: 18), where Lundvall proposes that "the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning" (Lundvall, 1992: 1). He further elaborates on the process of learning and states that "the most important forms of learning may fundamentally be regarded as *interactive learning*" (Lundvall, 1992: 9). Interactive learning is a process where "the interaction with external actors determines a firm's access to a diversity of resources; and the learning enables firms to transform these resources into innovations" (Meeus et al., 2001: 146). In the innovation system, knowledge has tacit elements that are embodied in the minds of people, routines of firms and interactions between people and organisations (Dosi, 1999). For an economy to be knowledge-driven, it is vital that individuals and organisations should take part in an active and interactive learning during the different stages of the innovation processes (Johnson, Edquist and Lundvall, 2003).

Science parks are often used as government initiatives to indirectly facilitate interactive learning and to promote regional systems of innovation (RSI). As a subset of NSIs, RSIs are another geographical demarcation in the system of innovation approach. There are three possible reasons for regional or special boundaries in knowledge production and exchange: (a) "a minimum level of localised learning spill-overs (between organisations), which is often associated with the importance of transfer of tacit knowledge between (individual and) organisations"; (b) "localised mobility of skilled workers as carriers of knowledge, i.e. that the local labour market is important"; and (c) "a minimum proportion of the collaborations between organisations leading to innovations should be with partners within the region"…"i.e. the extent to which learning processes between organisations are interactive within regions" (Edquist, 2001: 14). RSI can be defined as a geographical system "in which firms and other organisations are systematically engaged in *interactive learning* through an institutional milieu characterised by embeddedness" (Cooke, 1998).

More details of the concept of science parks and their inhabitants, namely new technology-based firms, will be provided in the next section.

1.3 Science parks and new technology-based firms

As mentioned earlier, science parks (SPs) are often used by policy makers as initiatives to indirectly facilitate interactive learning and stimulate information and knowledge exchange between regional actors, and, in the long run, regional innovations and economic progress. A region is one of the entities providing firms with the requisite support for innovation because close geographical proximity, as shown in literature, facilitates the exchange of knowledge and interactive learning (Arundel, 2001; Boschma and Kloosterman, 2005; Baptista and Mendonça, 2009). In order to understand the role of SPs in a regional system of innovation, one first needs to know what SPs are all about.

Many definitions of a science park can be found in the literature. In 1986, the United Kingdom Science Park Association (UKSPA) defined a science park as a property-based initiative that:

(i) has formal operational links with a university or other higher educational or research institution;

(ii) is designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site; and

(iii) has a management function that is actively engaged in the transfer of technology and business skills to the organisations on site.

The Association of University-related Research Parks (AURRP) states in its Worldwide Research & Science Park Directory (1998) that the research and science park concept generally includes three components:

• A real estate development.

• An organisational programme of activities for technology transfer.

• A partnership between academic institutions, government and the private sector.

Westhead et al. (2000) define a science park as an area that allows an agglomeration of technological activities, leading to positive externality benefits to individual firms located in the park.

The website of the International Association of Science Parks (IASP) defines a SP as:

> "*A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities'*" (IASP website)

Based on the above definitions, one can see that some important general characteristics of SPs are that knowledge flows between technology-based firms that are spatially bounded, that there are industry-academic links, and that small technology-based firms are formed and supported. Drawing from the common characteristics shown in various definitions, science parks are viewed in this research as physical infrastructures (often initiated by governments) where small or medium innovation- or technology-based firms (see a next section for details) are situated within a spatial boundary. A SP is not another kind "office park", because there is a management team on site that supports the new technology-based firms (NTBFs) by encouraging innovative activities and a flow of knowledge between them.

In many SP studies, SPs are related to cluster theory and regarded as clusters. As Chan and Lau mention in their SP study, "high tech firms of similar characteristics and within the value chain would be attracted to cluster together in the science park and therefore, gradually emerge as a strong allied group complementary to each other" (Chan and Lau, 2005: 1217). However, SPs are not just ordinary clusters, they have a special characteristic, namely that they are adjacent to universities to promote higher education institute (HEI) and industry linkages and to foster knowledge transfer. This industry-academic link is important for transforming scientific knowledge into innovations and thus improving the economic growth in the region.

Moreover, as indicated in Doloreux's study about regional systems of innovation (RSI), the interactions, which can be regarded as flows of knowledge between learning firms in a cluster, "constitute the most important process driving the evolution and reinforcement of an RSI" (Doloreux, 2002: 247). In other words, the knowledge flows between NTBFs in an SP environment or from an SP to its region (knowledge spillovers) form an important element of RSIs. In the next paragraph, more particulars of NTBFs are provided.

New technology-based firms (NTBFs) situated on an SP possess certain characteristics that one needs to investigate to understand their contributions to the process of innovation. NTBFs can be seen as small high-technology firms

(Oakey 1994). Since the early 1970s, governments in advanced economies have recognised these small firms as key economic role-players in generating employment, introducing technological innovations and diffusing new technological knowledge (OECD, 1982; Johnson, 2007). Johnson points out that the small firms have close links with entrepreneurial activities. The term *entrepreneur* refers to the founder or owner of a small firm who is seen as a risk-taker and innovator (Hebert & Link, 2006; Johnson, 2007). This behaviour could possibly account for the radical innovations (which involve high levels of uncertainty) that are observed in small firms (OECD, 1982; Kirby, 2003). Like most small firms, NTBFs have the liability of being new and encounter two main problems: a lack of a large variety of different resources and a lack of external legitimacy (Singh, Tucker and House, 1986). Because the firms are young and new in the market, they have limited external linkages with key players or partners in the market and are thus less recognised. Small technology-based firms, especially those involved in high-tech developments, need *knowledge* resources, which are fundamental to technological innovations. Establishing linkages with partners can be regarded as a strategy to access sufficient knowledge for innovative activities. With the aim to facilitate knowledge circulation, the establishment of science parks provides NTBFs with opportunities to establish such linkages, due to their close geographical proximity with each other, and especially with adjacent universities where the fundamental knowledge resides.

1.4 The research context: South Africa and the Gauteng region

1.4.1 NSI in South Africa

South Africa is regarded as the most economically and technologically developed country on the African continent. However, it is a fact that a dramatic decrease in research and development (R&D) intensity since 1991 can be noticed (Mani, 2003). It was towards the end of apartheid in 1993 that an IDRC report entitled "Towards Science and Technology Policy for a Democratic South Africa" was commissioned by the soon-to-be new government, the African National Congress (ANC), which came into power in 1994. This report led to a Green Paper on

Science and Technology in 1996 and later a White Paper on Science and Technology, entitled "Preparing for the 21st Century", which constitutes the official science and technology policy of the country. In this document, "knowledge is valued as an important component of national development" and the NSI, as a framework in the national policy on science and technology, is described as a "means through which the country will seek to create, acquire, diffuse and put into practice new technology that will help the country and its people to achieve their individual and collective goals" (DACST, 1996). At that time, South Africa was the first developing country that used the NSI as a framework for promoting innovation in the nation, or as Lorentzen says, "an explicit anchor of its innovative endeavours" (Lorentzen, 2009: 33). However, criticisms were also noticed at the same time. In Kaplan's review study, he stated that the objectives outlined in the NSI policy could not be easily put forward into plans of action (Kaplan, 1999). Moreover, Lorentzen pointed out that the focus of the NSI was "on the policies and initiatives of the government and not on the private sector or any other constituents" (Lorentzen, 2009: 35).

Although a number of new South African government initiatives post-1994 had set a foundation for NSI, the Spatial Development Initiatives (SDI) programme, led by the Department of Trade and Industry (DTI), undoubtedly captured the most public attention because of its explicit spatial focus (Bloch, 2000) and its aim to fast-track private sector investment and stimulate the growth of SMMEs (Crush and Rogerson, 2001). The SDI was devised by the national government and has been implemented since 1996 as a short-term investment strategy aimed at unlocking economic potential in selected areas or zones of South Africa, inter alia, by developing the necessary infrastructure, implementing marketing and investment strategies, reducing bureaucratic red tape, and encouraging skills training and resource building (Rogerson, 1998; Crush and Rogerson, 2001). To support the SDI programme, the Gauteng Provincial Government established an initial R1.7 billion fund for ten mega-projects, named Blue-IQ projects, with the aim to build a platform for business of the future. Gauteng, as the region with the most innovative activities in South Africa (Lorentzen, 2008), will be discussed in the next section to show that it is an appropriate region in South Africa for any innovative policies to take place.

1.4.2 Gauteng and The Innovation Hub

In the 1970s, high-technology developments began in Midrand [1] and the Johannesburg-Pretoria (the two major cities in Gauteng) high-technology belt, which was identified in Hodge's study in 1997, started emerging. In Rogerson's study, the spatial distribution of high-technology industry in South Africa is illustrated by a figure revealing "an intense agglomeration of activity in the Gauteng province" (Rogerson, 1998). A recent study by Lorentzen shows that a regional innovation system possibly exists in Gauteng where it "seems to exploit diversified knowledge industries" (Lorentzen, 2008). The presence of such a system means that the necessary conditions to establish a science park have been met.

The Innovation Hub (TIH) was one of the Blue-IQ projects initiated by the Gauteng Provincial Government to invest in regional economic infrastructure development to create a truly smart province. TIH is South Africa's first internationally accredited science park and a full member of the International Association of Science Parks (IASP). It is regarded as "the catalyst that will spur the development of a new wave of knowledge-intensive, hi-tech industries in South Africa" (Foster, 2003: 13). It was officially opened at its new site in Pretoria in April 2005 as a high-tech cluster for knowledge-intensive companies. Anchor tenant company, SAPPI, moved into its building in January 2005. The Innovation Hub is located in Gauteng, between the Council for Scientific and Industrial Research (CSIR) and the Hatfield campus of the University of Pretoria. The 60 ha site, which is placed around 30 km from the OR Tambo International Airport, offers state-of-the-art ICT technology. Its focus sectors are advanced engineering (value-added materials and manufacturing and defence technology spin-offs), biotechnology and ICT. These focus areas are aligned with the recommendations of the previous technology foresight project conducted by the SA government. The Innovation Hub focuses on clustering high-tech businesses to foster innovation and drive the development of

[1] Midrand lies in between two urban cities, Johannesburg and Pretoria, in Gauteng. Midrand was considered to have a "'disproportionately large share of South Africa's private and public demand, as well as factor inputs for high-technology sectors" (Hodge, 1998: 851). Moreover, the dynamic information technology and high technology manufacturing activities have brought Midrand vibrant economic growth (Rogerson 1998). Now, Midrand is no longer a separate entity, but is incorporated into Greater Johannesburg.

new intellectual property, which will add significant value to Gauteng as the country's "smart" province and to South Africa as a competitive economy in the high-tech sector.

1.5 Research goal and main research question

Despite the rapid growth in the number of science parks, researchers have often asked the question: Do science parks really perform as promised? With this question in mind, researchers in the past have done comparative studies (between on- and off-park firms) at firm level and analysed firm characteristics and their innovative performances as the main foci. This research reviews the SP literature and reports that there are mixed findings in the studies regarding the performances of science park firms (details in Chapter 4 of the thesis). The question that forms the main research question in this study is further raised:

How can the mixed findings found in previous research studies regarding the innovative performance of science park firms be explained?

With this main research question in mind, the research goal is to find alternative theoretical and empirical ways to examine technology-based firms and their innovative outcomes. Discussions about the concepts of NSI, RSI, knowledge-based economy and science parks all focus on *knowledge* and *relationships* between elements, institutions and firms. This guided the research to adopt a theoretical perspective emphasising a relational approach to answer the research question. The relational approach here is regarded as the interorganisational relations that exist in *knowledge* networks of social relations. Both relational (characteristics of relationships) and structural (characteristics of the relational structure) aspects of these networks will provide insights into how firms exchange knowledge with one another and which effects will emerge. As Gulati mentions, relational aspects of a network "stress the role of direct cohesive ties as a mechanism for gaining fine-grained information", typically with actors who are "strongly tied to each other and likely to develop a shared understanding of the utility of certain behaviour as a result of discussing opinions in strong, socializing relations" (Gulati, 1998: 296). On the other hand, the structural aspects of a network allow one to observe the degree (for example, the number of relationships with others) to which an actor does have access to resources. Resources in this study refer to *knowledge,* which is a very important resource for any innovative firm. In the literature, the resource-based view (RBV) is often been used to explain the differences between firms' performances, which causes this theoretical perspective to be important when studying the performance differences of science park firms. Lavie (2006) has *extended* the RBV by including the "relational approach" in his *extended* version of the RBV. This research project will take the extended RBV as its theoretical backbone, which will be elaborated further in the next section.

1.6 Theoretical background: the resource-based view of the firm

Until the 1980s, the resources of a firm were regarded as the tangible (for example, machinery and personnel) and intangible (for example, knowledge and brand names) assets a firm possesses (Caves, 1980). The resource-based view (RBV) model is often used to explain the differences in performances between firms: "performance differentials are viewed as derived from rent differentials, attributable to resources having intrinsically different levels of efficiency [...] in the sense that they enable the firms [...] to deliver greater benefits to their customers for a given cost (or can deliver the same benefit levels for a lower cost)" (Peteraf and Barney, 2003: 311). In this statement, *rents* refer to earnings in excess of breakeven if their existence does not induce new competition (Peteraf, 1993). Resources in RBV are regarded to be heterogeneous (unique) and imperfectly mobile (nontradable), and firms often design *resource-position barriers* such as patents (Wernerfelt, 1984). These characteristics enable firms to protect their internal resources to some extent against imitation by competitors (Reed and DeFillippi, 1990; Lavie, 2006). The fundamental principle in RBV is that if a firm has the ownership and control of its *internal resources*, it has a competitive advantage (Lavie, 2006). In most of the RBV studies, there is a strong association between a firm's internal resource and its performance. For example, in

Bharadwaj's empirical study, there is a positive and significant relationship between firms' IT capabilities as their internal resources, and their performances (Bharadwaj, 2000).

The conventional RBV introduced above does not take into account the "superior resources of alliance partners" when a focal firm is involved in inter-firm interactions. These resources are referred to as *network* or *external resources*, which are also of importance in this study, as the focus is on the impacts of relationships and knowledge flows between organisations located in science parks.

In Lavie's study (2006), a theoretical framework is developed with the aim of extending the RBV by taking into account the *inter-firm relationships* aspects. As opposed to the conventional RBV, where resources are imperfectly mobile, Lavie points out that resources can be directly shared between independent actors and that the benefits associated with these resources can be indirectly transferred between firms. In his so-called extended RBV model, where a firm shares resources with its partner, it can gain additional two types of rents (besides its own internal rent from its internal resources): *appropriated relational rent* from the shared resources and *inbound spillover rent* from both the shared and the non-shared resources. Appropriate relational rent is a common benefit from the idiosyncratic resources which are created by combining the respective resources of the partner firms or developed during the life of their alliance. These idiosyncratic resources are "more valuable, rare, and difficult to imitate than they have been before they were combined" (Dyer and Singh, 1998: 667). Idiosyncratic resources can both be tangible, for example, a joint manufacturing facility, or intangible, such as a more efficient process when two partners work together (Hunt, 2000). Inbound spillover rent is the "unintended gains" (in the condition when one acts "opportunistically") due to both the shared and non-shared resources of the alliance partners. Later in the thesis, this is identified as the "unintended knowledge flows" between organisations. These two resources are the "superior resources" (and additional resources) when a firm is involved in an alliance with its partners. RBV believes that the more (unique) resources a firm possesses, the more successfully it will perform.

If one wishes to apply Lavie's model in a SP context (where firms are geographically concentrated in a limited space), the geographical dimension is missing in the model. The theoretical relevance of this study is to add *geographical dimension* to Lavie's model, "extension of the RBV". Geographical proximity is required as an additional dimension because the establishment of science parks around the world is built on the assumption of the importance of geographical boundaries where they play a role in the relationship between SP firms and knowledge transfer among firms. For example, close geographical distance between two partnering firms may enhance the *appropriated relational rent* from the shared resources that these firms control. This may be due to the fact that when two R&D researchers are located next door to each other, they are able to spend more time (due to lower travelling cost) on face-to-face interaction where tacit knowledge can be gained via interactive learning and as a result bring benefits for both companies' innovative activities. In Chapter 2, in particular, the relationship between innovation and geography is discussed in more depth.

1.7 Research subquestions and layout of the thesis

The focus of this thesis is on explaining the mixed findings found in the science park literature by following a relational approach to investigate inter-firm knowledge networks. With the relational approach in mind, the main research question is broken down into several subquestions. The chapters that follow are targeted to answer these subquestions. Chapter 2 is a theoretical study that positions the whole research by giving a theoretical overview of the factors that influence firms' innovative outcomes, using a knowledge flow perspective. The main argument developed is that the mixed findings may be due to the combined effects of intended and unintended knowledge flows. Therefore, this chapter answers the theoretical subquestion:

Which theoretical explanation can be given for the mixed findings regarding the performance of science park firms?

Using the theoretical framework developed in Chapter 2, chapters 3 to 5 empirically examine some models and answer three empirical subquestions. Chapter 3 is a descriptive and empirical study that aims to answer the empirical question:

Which knowledge exchange behaviours do science park firms show?

In order to answer this question, Chapter 3 investigates how science park firms behave with respect to each of the factors identified in the theoretical framework in Chapter 2. Therefore, this part of the study focuses on a diagnosis of knowledge flows between a specific group of firms, namely firms located in a science park (The Innovation Hub in South Africa). The results of this chapter show that firms behave differently with regard to knowledge exchange. Taking the results found in Chapter 3 into account, the next empirical subquestion is raised:

If science park firms behave differently with regard to knowledge exchange, do these differences matter for firm performance?

The above question is answered empirically in Chapter 4 by taking a sample of firms located in the South African Gauteng region and it is investigated to what extent certain behaviours affect certain innovation outcomes of firms. This chapter focuses on the *usefulness of knowledge received* as the variable to be explained. The findings in this chapter show that there are different factors that impact on this dependent variable:

- Organisational similarity is negatively related to usefulness of knowledge received.
- Technological similarity is positively related to usefulness of knowledge received.
- Frequency of knowledge transfer is positively related to usefulness of knowledge received.

Chapter 4 shows that differences in firm behaviours when they exchange knowledge do matter for firms' outcomes or performances. This finding inspired the following empirical subquestion:

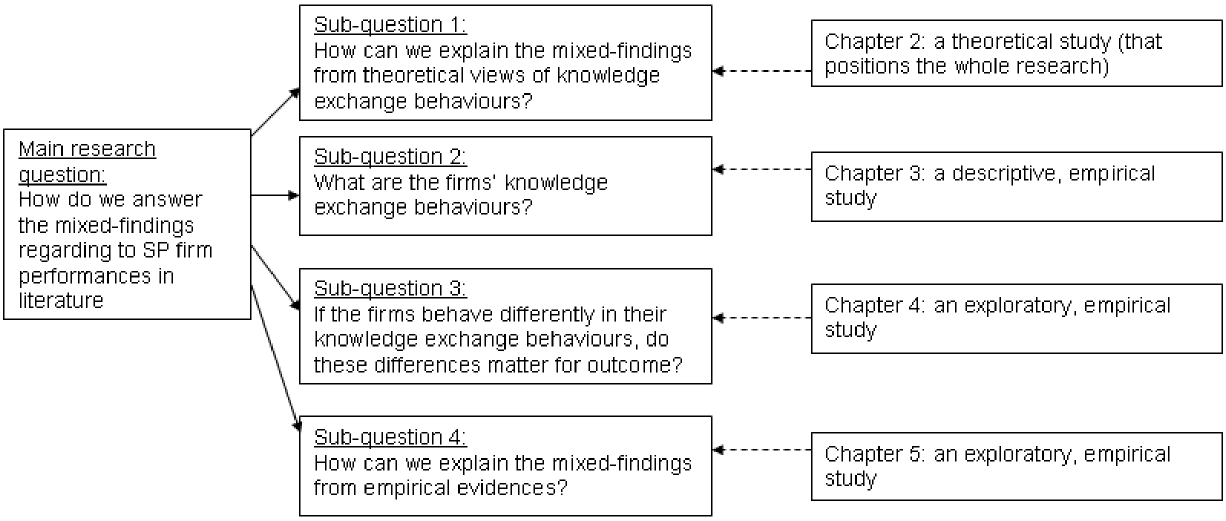
How can the mixed findings be explained from an empirical point of view?

Chapter 5 is an empirical study that takes the same sample of firms again and tries to explain the mixed findings. The findings of this study show that various types of knowledge inflows impact differently on various innovative outcomes:

- Intended knowledge inflows via formal interorganisational relationships have a positive impact on firms’ relative innovations.
- Intended knowledge inflows via informal interorganisational relationships have a positive impact on firms’ new innovations.
- Intended knowledge inflows via social network relationships have a negative impact on firms’ new innovations.
- Unintended knowledge inflows (when a firm is involved in informal and/or social networks) have a positive impact on firms’ new innovations.

Figure 1 shows the coherence of this study with the main research question as the guiding principle. In addition, Appendix 1 shows the variables identified in Chapter 2 and how these variables will be empirically examined in chapters 3 to 5 (which are published or submitted journal papers). This appendix will help to guide the readers to the overview of the research while reading each chapter.

Figure 1: Coherence of the study: research questions and related chapters



The last chapter, Chapter 6, is a concluding chapter that will summarise the findings in chapters 2 to 5 and propose an answer to the main research question. The implications of the findings, the limitations of this study, and recommendations for future research will be addressed in this concluding chapter.

1.8 Research contributions

At the end of each individual chapter, there is a description of how that specific chapter contributes to the research. However, the overall practical relevance of this study is that it enables South African policy makers to better understand the implication of science parks in its NSI. Recommendations for policy makers are discussed at the end of the empirical studies (chapters 3 to 5) so that they can assist the design or support initiatives regarding science park establishments. As for the scientific relevance, this research explores the SP performances in the literature and finds mixed findings with regard to SP firm performances (details in Chapter 5). The main contribution of this study is to explain these mixed findings theoretically and empirically. Moreover, this study increases insight in the performance of SP firms in the emerging economy of South Africa.

References

Arundel, A. and Geuna A., 2001. Does proximity matter for knowledge transfer from public institutes and universities to firms?. SPRU, Electronic Working Paper Series, Paper # 73.

Baptista, R. and Mendonça. J., 2009. Proximity to knowledge sources and the location of knowledge-based start-ups. *The Annals of Regional Science*, Special Issue, published online.

Bharadwaj, A.S., 2000. A resource-based perspective on information technology capability and firm performance: an empirical investigation, *MIS Quarterly*, 24(1), 169-196.

Bloch, R., 2000. Subnational economic development in present-day South Africa. *Urban Forum*, 11, 227-271.

Boschma, R.A. and Kloosterman, R.C., 2005. *Learning from clusters. A critical assessment from an economic-geographical perspective*, Dordrecht: Springer.

Caves, R.E., 1980. Industrial organisation, corporate strategy and structure. *Journal of Economic Literature*, 58, 64-92.

Chan, K.F. and Lau, T., 2005. Assessing technology incubator programs in the science park: the good, the bad and the ugly, *Technovation*, 25, 1215-1288.

Cooke, P., Uranga, M.G. and Etxebarria, G., 1998. Regional systems of innovation: an evolutionary perspective. *Environment and Planning,* 30, 1563-1584.

Crush, J. and Rogerson, C., 2001. New industrial spaces: evaluating South Africa's spatial development initiatives (SDI) programme. *The South African Geographical Journal,* 83, 85-92.

DACST (Department of Arts, Culture, Science and Technology), 1996. *White Paper on Science and Technology: Preparing for the 21st Century.* Pretoria: Department of Arts, Culture, Science and Technology.

Doloreux, D., 2002. What we should know about regional systems of innovation. *Technology in Society*, 24, 243-263.

Dosi, G.,1999. Some notes on the national systems of innovation and production, and their implications for economic analysis. In: D. Archibugi, J. Howells and J. Michie, eds. *Innovation policy in a global economy*. Cambridge: Cambridge University Press, 35-48.

DST (Department of Science and Technology), 2007. *Innovation towards a Knowledge-based Economy: Ten-year Plan for South Africa (2008–2018).* Draft Document for Discussion, 10 July. Pretoria: DST

Dyer. J.H. and Singh, H., 1998. The relational view: Cooperative strategy and sources of interorganisational competitive advantage. *Academy of Management Review*, 23(4), 660-679.

Edquist, C., 2001. The system of innovation approach and innovation policy: an account of the state of the art, *DRUID conference*, June 12-15 Aalborg.

European Commission. Green Paper. Luxembourg, 1995.

Felsenstein, D., 1994. University-related science parks – 'seedbeds' or 'enclaves' of innovation?. *Technovation*, 14, 93-110.

Foster, N., 2004. The opportunities for entrepreneurship, innovation and knowledge-building at Blue IQ in Gauteng and Dube Tradeport in KwaZulu-Natal, DRUID conference, January 22-24 Aalborg.

Freeman, C., 1987. *Technology policy and economic performance: lessons from Japan*, London: Frances Printer.

Freeman, C., 1995. The 'National System of Innovation' in historical perspective. *Cambridge Journal of Economics*, 19, 5-24.

Godin, B., 2006. The knowledge-based economy: Conceptual framework of buzzword. *Journal of Technology Transfer*, 31, 17-30.

Gulati, R., 1998. Alliances and Networks. *Strategic Management Journal,* 19, 293-317.

Hébert, R.F. and Link, A.N., 2006. The entrepreneur as innovator. *The Journal of Technology Transfer*, 31(5), 589-597.

Hodge, J., 1997. *The Johannesburg-Pretoria N1 Corridor: a high technology belt*. Unpublished report prepared for the International Development Research Centre. Cape Town: University of Cape Town.

Hunt, S.D., 2000. *A General Theory of Competition.* CA: Sage.

IASP, Website. About Science and Technology Parks. http://www.iasp.ws, accessed 9 April 2010.

Johnson, B., Edquist, C. and Lundvall, B., 2003. Economic development and the national system of innovation approach. *First Globelics Conference*, Nov. 3-6 Rio de Janerio.

Johnson, P., 2007. *The economics of small firms: an introduction*. London: Routledge.

Kaplan, D.E., 1999. On the literature of the economics of technological change – science and technology policy in South Africa. *The South African Journal of Economics*, 67(4), 473-490.

Kirby, D.A., 2003. *Entrepreneurship*. Maidenhead: McGraw-Hill.

Lavie, D., 2006. The competitive advantage of interconnected firms: an extension of the resource-based view. *Academy of Management Review*, 31, 638-658.

Lindelöf, P. and Löfsten, H., 2004. Proximity as a resource base for competitive advantage: university-industry links for technology transfer. *Journal of Technology Transfer*, 29, 311-326.

Lorentzen, J., 2008. Provinces, city-regions, and innovations in South Africa. *VI Globelics Conference*. September 22-24, Mexico City.

Lorentzen, J., 2009. Learning by firms: the black box of South Africa's innovation system. *Science and Public Policy*, 36, 33-45.

Lundvall, B.-Å., 1992. *National systems of innovation: towards a theory of innovation and interactive learning*. London: Pinter.

Lundvall B.-Å., 2010. *National systems of innovation: towards a theory of innovation and interactive learning.* London: Anthem Press.

Malairaja, C., and Zawdie, G., 2008. Science parks and university-industry collaboration in Malaysia. *Technology Analysis and Strategic Management*, 20, 727-739.

Mani, S., 2003. The role of government in shaping the national system of innovation: The case of South Africa since 1994. In: M. Muchie, P. Gammeltoft and B.-Å., Lundvall, eds. *Putting Africa first – the making of African innovation systems*. Aalborg: Aalborg University Press.

Meeus, M.T.H., Oerlemans, L.A.G. and Hage, J., 2001. Patterns of interactive learning in a high-tech region, *Organisation Studies*, 22, 145-172.

Mowery, D.C. and Oxley, J.E., 1995. Inward technology transfer and competitiveness: the role of national innovation systems, *Cambridge Journal of Economics*, 19(1), 67-93.

Muchie M., Gammeltoft, P. and Lundvall, B.-Å., 2003. *Putting Africa first – the making of African innovation systems*. Aalborg: Aalborg University Press.

Nelson, R., 1993. *National innovation systems: a comparative analysis.* Oxford: Oxford University Press.

Oakey, R.P., 1994, *New technology-based firms in the 1990s.* London: Paul Chapman Publishing Ltd.

OECD, *Innovation in small and medium firms*, France: OECD.

Peteraf, M.A., 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*, 14, 179-191.

Peteraf, M. and Barney, J., 2003. Unravelling the resource-based tangle. *Managerial and Decision Economics*, 24, 309-323.

Reed, R. and Defillippi, R., 1990. Causal ambiguity, barriers to imitation, and sustainable competitive advantage. *Academy of Management Review*, 15(1), 88-102.

Rogerson, C.M., 1998. High-technology clusters and infrastructure development: International and South African experiences. *Development Southern Africa*, 15, 875-905.

Singh, J.V., Tucker, D.J. and House, R.J., 1986. Organisational legitimacy and the liability of newness. *Administrative Science Quarterly,* 31(2), 171-193.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5, 171-180.

Westhead, P., 1997. R&D 'inputs' and 'outputs' of technology-based firms located on and off science parks. *R&D Management,* 27(1), 45-62.

Westhead, P., Batstone, S. and Martin, F., 2000. Technology-based firms located on science parks: the applicability of Bullock's Soft-Hard Model. *Enterprise and Innovation Management Studies*, 1, 107-139.

Chapter 2

Explaining mixed results on science parks' performance: bright and dark sides of the effects of interorganisational knowledge transfer relationships[2]

In the recent past, several researchers have explored the added values of science parks. On the basis of empirical research, some questioned the assumed benefits of the science park model, whereas others reported positive outcomes. As a result, mixed findings regarding the benefits of science parks for firms can be observed. These mixed empirical findings ask for a theoretical explanation. This study argues that different levels and types of knowledge exchange behaviour of science park firms could be one of the theoretical explanations for these mixed findings. The literature on networks mainly stresses the benefits of networking in general, and networking between firms located on science parks in particular. This study proposes that networks can have both positive (knowledge sharing) and negative effects (opportunistic behavior and knowledge spillovers) for firms located on science parks. When the latter occurs, location on a science park might produce negative effects. A conceptual model is developed that summarises the theoretical arguments.

2.1 Introduction

The majority of the currently existing science parks in the world were created during the 1990s and about 18% of the existing science parks were launched in the first two years of the new century. This rapid growth of science parks attracted the interest of many researchers to undertake studies of science parks (for example, Bigliardi et al, 2006; Goldstein and Luger, 1990 & 1991; Löfsten and

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Lindelöf, 2003; Westhead and Batstone, 1999). In the recent past, several researchers explored the added values of science parks (for example, Löfsten and Lindelöf, 2003; Ferguson and Olofsson, 2004; Fukugawa, 2006) by exploring the characteristics and performance of firms located on and outside science parks. These researchers showed that science parks provide an important resource network for on-park new technology-based firms (NTBFs) and that on-park NTBFs are likely to establish knowledge linkages.

However, other researchers questioned the assumed benefits of the science park model (for example, Chan and Lau, 2005; Quintas and Massey, 1992; Westhead, 1997) and found in their studies that firms do not gain any benefits from networking and clustering or from the linkages between academic research and industrial activity. How can these different empirical findings be explained from a theoretical point of view? This study tries to answer this main research question and proposes that knowledge flows in networks can have both positive and negative effects for firms located on them. It distinguishes knowledge flows between organisations as "intended" and "unintended". The effects of both types of knowledge flows are combined with geographical and technological proximity. From the literature, two contrasting views can be derived of the effects of this specific combination. Alcacer and Zhao found that firms try to prevent the risk of unintended knowledge outflow by locating themselves further away from their competitors with similar technological backgrounds and in similar industries (Alcacer and Zhao, 2007). This implies that by clustering firms together (as on a science park) the probability of unintended knowledge flow is higher and thus the firms with leading technologies will, if possible, move further away from their competitors to prevent their technology being spillovered to them. On the other hand, the main purpose of science park location is to aggregate firms in related industries and supporting organisations (that is, to create high geographical proximity) so that they are able to collaborate in research, thereby facilitating intended knowledge exchanges. These contrasting views create a gap in the literature and lead to the main hypothesis of this study: “The positive relationship between intended knowledge flows and innovative performance of firms will be negatively moderated by higher levels of unintended knowledge flows. This moderating effect is stronger for on-park firms than for off-park firms”. To formulate an answer to the main research question, the following research subquestions are formulated:

1. What are the effects of intended interorganisational knowledge transfer on the innovative performance of firms located on and off science parks?
2. What is the effect of unintended interorganisational knowledge flow (knowledge spillover) on the innovative performance of firms located on and off science parks?

The aim of this study is to theoretically reconcile the mixed results found in empirical research on science park performance. Moreover, it proposes a research model with which the propositions developed in this study can be tested empirically. The remainder of this study is structured as follows. Section two gives a brief background of the development of science parks around the world and their characteristics that form the focus of this study. Section three unfolds the literature of networks and knowledge flows with respect to innovations. Several propositions are formed to build the theoretical model of this study. The final section will conclude this study.

2.2 Science parks: history of development, definition and characteristics

2.2.1 History of development of science parks

Science parks are not a new phenomenon. The first science-based park, Standford Industrial Park (later resulting in the development of Silicon Valley), was established in 1951 in the USA. In 1972, Cambridge Science Park was established in the UK. The majority of the currently existing science and technology parks in the world were created during the 1990s and 18% of the existing science parks have been launched in the first two years of the new century (IASP website). The Association of University Research Parks (AURP) reports that there are 123 university-based science parks in the United States (Link & Link, 2003). The UK Science Park Association (UKSPA) reported that there were 32 science parks in the UK in 1989 and 46 in 1999. In Asia, there are more than 200 science parks, with Japan topping the list with 111 initiatives. Currently, there are over 400 science parks in the world and the number continues to grow rapidly due to regionally targeted initiatives introduced by governments and other organisations to provide an appropriate physical infrastructure for a successful local economy and social environment (Löfsten and Lindelöf, 2002).

2.2.2 Definitions of science parks

As early as 1986, the UKSPA defined a science park as a property-based initiative that:

(i) *has formal operational links with a university or other higher educational or research institution;*
(ii) *is designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site; and*
(iii) *has a management function that is actively engaged in the transfer of technology and business skills to the organisations on site.*

Later, another science park association, the Association of University Related Research Parks (AURRP), stated in its Worldwide Research & Science Park Directory in 1998:

"The definition of a research or science park differs almost as widely as the individual parks themselves. However, the research and science park concept generally includes three components:

(i) *A real estate development.*
(ii) *An organisational program of activities for technology transfer.*
(iii) *A partnership between academic institutions, government and the private sector."*

A more recent visit to the website of the International Association of Science Parks (IASP) reveals that its official definition of a science park is as follows:

> *"A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities."* (IASP website)

Even though there are several definitions and an absence of a generally accepted definition for the term *science park*, these definitions outline the important aspects of a science park such as links with universities, a management function in a science park, a knowledge-sharing environment to encourage innovations and the creation of spin-off companies. In this study, science parks are defined using the IASP's definition, as it includes most of the aspects of a science park.

2.2.3 Characteristics of science parks

The subject of science parks has generated a vast amount of literature and various aspects of science parks' characteristics have been researched. These characteristics include:

2.2.3.1 Clustering

High-tech firms with similar characteristics (sharing a common market for their end products, using a similar technology or labour force skills, requiring similar natural resources, etc.) and/or within the same value chain (linked by buyer-seller relationships) would be attracted to cluster together as a strong allied group to complement each other (Chan and Lau, 2005). This phenomenon can be seen on science parks, which are supposed to be a geographically concentrated cluster of independent firms that are technology-related and knowledge-based and supported by other organisations. Through this clustering, firms have a degree of geographical proximity, which facilitates knowledge flows. Studies have shown that maximum flow of information and ideas exists among geographically proximate firms (Gordon and McCann, 2000) because this type of proximity supports the learning process through networking and thus positively influences the innovative outputs of firms (Romijn and Albu, 2002).

2.2.3.2 Academic-industry link

The transformation of scientific knowledge into technological innovation lies within the core of science parks (Quintas and Massey, 1992; Phillimore, 1999), thus a host academic institution (mainly HEIs) is often formally associated with a park. This academic-industry link can take many forms (Quintas and Massey, 1992; Monck et al., 1988):

- The transfer of people, including founder-members of firms, key personnel and staff, to employment in firms.
- The transfer of knowledge through collaborations with researchers and students of HEIs.
- Contract development, design, analysis, testing, evaluation, etc.
- Access to university facilities.
- The establishment of "academic spin-off firms", formed by academic staff taking research out of the laboratory and into the science park, starting their own commercial enterprises.

The presence of HEIs often improves the prestige or image of science parks and is often a major factor in a firm’s choice to locate in a science park (Monck et al., 1988; Westhead and Batstone, 1998). The contribution by HEIs has set the science park apart from other property initiatives and also helps to raise rental values.

2.2.3.3 Management function

From the UKSPA's definition of a science park it follows that it has a management function that is actively engaged in facilitating the transfer of technology and business skills to the organisations on site. Johannisson (1994) further explains a science park's management function as a formal administrative structure to manage the property on the park and/or to manage the delivery of auxiliary activities and professional services required by firms located on science parks, with a focus on channelling information and resources to the on-park firms (Westhead and Batstone, 1999) by providing internal networking services between on-park firms and HEIs and external networking services with customers, collaborators and potential investors (Von Zedtwitz and Grimaldi, 2006). A managed science park is considered to have a general full-time manager or management company on site whose principal task is to manage the park. As a concluding statement, Westhead and Batstone point out that science parks generally need to strengthen their managerial functions with an emphasis on developing an effective way of linking tenant firms to the facilities and resources provided by a local HEI (Westhead and Batstone, 1999).

2.2.3.4 Knowledge flows

Firms located on science parks are bound in space and therefore more geographical proximate than rival firms located elsewhere. This spatial agglomeration promotes the transmission of knowledge, due to lower costs of communication in a dense environment. Researchers have distinguished two categories of knowledge transmission: intended and unintended knowledge flows (Fallah and Ibrahim, 2004; Oerlemans and Meeus, 2005). If knowledge is exchanged with the intended people or organisations, it is "knowledge transfer", while any knowledge that is exchanged unwillingly and outside the intended boundary is "knowledge spillover". When firms form networks (formal as via collaboration or informal as via social networking) on science parks, knowledge exchange occurs via these direct connections (Cross and Cummings, 2004; Mowery et al., 1996). Economists have been studying "knowledge spillovers", as firms investing in research and development end up facilitating other firms' innovations by revealing their knowledge unintentionally (Arrow, 1962; Nelson, 1959). A firm can access unintended knowledge in various ways, such as knowledge from reverse engineering on rivals' innovative products or knowledge from patent information.

These science park characteristics enable the construction of the theoretical framework that is presented in the following section.

2.3 Theoretical framework and conceptual model

2.3.1 Knowledge transfer networks

In the literature, there is a common emphasis on the importance of interorganisational networks and networking for innovation through the external acquisition of knowledge and information (Cowan and Jonard, 2004; Kingsley and Malecki, 2004; Pittaway et al., 2004). Many aspects of networks have been studied, but for the purpose of this study, the emphasis is on pursuing networking for profiting from intended knowledge flows. Two levels of analysis can be seen in network studies: whole networks and egocentric networks. At the whole network level, the entire set of present and absent linkages between firms needs to be examined. For this study, it is assumed that the boundary of the network of science park firms is difficult to determine because on-park firms can also have many links with firms off-park and the network structure of this latter group of firms is hard to determine. Therefore, the so-called egocentric network level is chosen for this study because this approach considers only the direct linkages ("alters") of a given (science park) firm ("ego"), and, operationally, this usually relies entirely on ego's self-reports about its network. To build the argument, three concepts are used: degree centrality, tie characteristics (trust, proximities and knowledge quality) and diversity of actors, and relate these to knowledge transfer and innovation.

2.3.1.1 Number of interorganisational knowledge transfer relationships and innovation

During the 1990s, innovation became faster and increasingly involved interorganisational networking (Rothwell, 1992). Through networking, firms are able to access knowledge externally from other actors and develop their own innovations. When firms interact formally (by explicit agreement) or informally (on a social basis), knowledge sharing often occurs and the resultant knowledge is available to partners. Evidence from the literature illustrates that "those firms which do not co-operate and which do not formally or informally exchange knowledge, limit their knowledge base over the long term and ultimately reduce their ability to enter into exchange relationships" (Pittaway et al., 2004). Network position, such as centrality, is an important aspect of the network structure because it determines the degree to which an actor has access to resources throughout the network. Centrality as a type of network position indicates the involvement of an actor in the network; the more a firm is involved in its network, the more it can compare information across multiple information sources and discover new information. More central firms are less likely to miss any vital information and are able to combine information in novel ways to generate innovations (Van de Ven, 1986). Various studies have shown that centrality is highly associated with innovation and enhances firm performance (Bell, 2005; Powell et al., 1999; Zaheer and Bell, 2005). This leads to the first proposition.

<u>Proposition 1:</u> The more direct ties a firm maintains, the higher the firm's innovative performance.

While most researchers pay attention to network structures (for example, Ahuja, 2000; Chang, 2003; Cheuk, 2007; Sparrowe et al., 2001), some researchers argued that the characteristics of ties within networks cannot be neglected, as they also influence the performance of actors (for example, Cross and Cummings, 2004; Granovetter, 1983; Newell and Swan, 2000). Ties are connections between nodes. In this case, the nodes are organisations and the connection is the interactions between them that make knowledge transfer possible. As mentioned earlier, some researchers have focused more on the dynamics of ties/relations than on their structural configuration. Various aspects of ties dynamics can be considered, such as purpose, direction, content and strength (Lin, 2002). This study focuses on knowledge as the tie content and therefore the purpose of a tie is aimed at knowledge sharing for innovations. The other two dynamics of ties, strength (associated with trust and proximity) and contents (quality of knowledge flowing in the tie), need to be explored as well to fully understand the characteristics of a tie.

2.3.1.2 Trust, interorganisational knowledge transfer and innovation

The willingness of organisations to exchange knowledge and information is often associated with tie strength (Cross and Sproull, 2004; Hansen, 1999) and studies have identified trust between partners in interorganisational relationships as an important relational asset (Storper, 1997) that promotes the willing exchange of knowledge. Trust can be defined as "the judgment one makes on the basis of one's past interactions with others that they will seek to act in ways that favour one's interests, rather than harm them" (Lorenz, 1999). From this definition it can be concluded that having trust can minimise the risks that stem from exposure to opportunistic behaviour by partners. Through past interactions, organisational members are more involved emotionally with each other and eventually trust is built between them. This form of trust is often called the "intentions" form of trust (Lazaric and Lorenz, 1998) because it refers to the belief that partners intend to uphold the commitments they make. Another form of trust is "competence-based trust", which refers to the belief the partners have in their capabilities to meet joint commitments. In this study, trust refers to the belief that a partner is capable (competence form of trust) of providing the knowledge a firm needs for innovations as well as the belief that a partner is willing to share such knowledge for the mutual benefit of all parties (intentions for trust). Therefore, the higher these trust levels, the more willing actors are to exchange knowledge and information. As a result of this exchange, actors can increase their innovative performance. Based on the above discussions, the following hypothesis is developed:

Proposition 2: The higher the level of trust a firm has with its actors, the better the firm's innovative performance.

2.3.1.3 Proximities, interorganisational knowledge transfer and innovation

Gertler states that "recent work on innovation and technology implementation suggests the importance of closeness between collaborating parties for the successful development and adoption of new technologies" (Gertler, 1995). In the literature this closeness between organisational actors is also known as the "proximity" concept, which refers to "being close to something measured on a certain dimension"" (Knoben and Oerlemans, 2008). Scholars distinguish various dimensions of proximity and most of the time their definitions overlap. Following Knoben and Oerlemans' literature review, this study uses three dimensions of proximity and relates these with knowledge transfer and innovation.

In the study of innovation and knowledge transfer, there is an emphasis on the importance of geographical proximity for the transfer of (tacit) knowledge. The concept is often defined as geographical distance expressed as a specified radius of each firm (Orlando, 2000) or travel times/perception of this distance (Boschma, 2005). A short distance between two actors facilitates knowledge sharing and the transfer of tacit knowledge, in particular. Tacit knowledge transfer is enhanced through face-to-face contact and therefore the spatial dimension is essential.

Proposition 3(a): The greater the geographical proximity of innovative firms in relation to their partners, the higher the innovative performance will be.

The concept of proximity goes beyond geographical distance. Researchers, for example, Freel (2003), Boschma (2005), and Knoben and Oerlemans (2006), maintain that the concept of proximity is not only a spatial phenomenon. Geographical proximity is often combined with some level of cognitive proximity for interactive learning to take place. Cognitive or technological proximity can be understood in terms of a shared knowledge base in order for two networking firms to communicate, understand, absorb and process new information (Boschma, 2005). Two firms may be located next to each other, but if their knowledge bases are too distant, so that people cannot understand each other, geographical proximity does not matter for effective knowledge transfer. This suggests that cognitive proximity may be a condition that makes geographical proximity less important. In addition, geographical proximity is influenced by the nature of innovation. Innovations that need very special or scarce knowledge may force firms to collaborate with international partners because such knowledge cannot be found locally (Arndt and Sternberg, 2000). In this case, where two firms are located in two different countries, other dimensions of proximity play a more important role than geographical proximity.

Technological proximity refers to the similarities between actors' technological knowledge, in other words, how similar the knowledge bases are between them. The transfer of unrelated knowledge can cause difficulties in the assimilation and application of the knowledge (Cassiman et al., 2005) because the firm that receives the knowledge is not capable of identifying, assimilating and exploiting knowledge coming from external sources (relative absorptive capacity, as defined by Lane and Lubatkin, 1998). On the other hand, the novelty of sources triggers new ideas and creativity (Cohendet and Llernea, 1997). Nooteboom et al. (2007) state that the interaction between people with different knowledge bases allow them to stretch their knowledge. Moreover, when two firms have identical knowledge bases, they may face the risk of lock-in, where their view of technology may be obscured and is less open to the outside world (Boschma, 2005). With this notion, Proposition 3(b) now reads as follows:

Proposition 3(b): There is an inverted U-shaped relationship between technological proximity and firm innovative performances.

The third dimension of proximity refers to "organisational proximity". In Knoben and Oerlemans' paper (based on Rallet and Torre, 1999), organisational proximity is defined as *"the set of routines – explicit or implicit – which allows coordination* *without having to define beforehand how to do so. The set of routines incorporates organisational structure, organisational culture, performance measurements systems, language and so on"*. Collaborating firms that have low organisational proximity have different sets of routines and thus, instead of creating innovations together, they create problems due to these non-overlapping routines. As a worst-case scenario, an unsuccessful collaboration leads to no innovative outputs. Based on the discussion above, geographical, technological, and organisational proximity between firms enhances the ease with which firms collaborate in general, and exchange knowledge in particular. Consequently, firms can increase their innovation outcomes and consequently the next proposition is formulated.

<u>Proposition 3(c):</u> The greater the organisational proximity of innovative firms in relation to their partners, the higher the innovative performance will be.

2.3.1.4 Qualities of knowledge exchanged and innovation

Soo and Devinney's paper found a positive relationship between knowledge quality and innovative performance (Soo and Devinney, 2004). The quality of knowledge exchanged comprises two factors: usefulness of the knowledge that a firm receives for its innovations and how frequently it receives the knowledge. The context of the knowledge a firm receives directly influences the success of the innovative outcomes if the firm can actually use such knowledge. The knowledge can be new to the receiving firm, but if it cannot be used and contribute to the firm's development of new innovations, then such knowledge has a low knowledge quality for the firm. The frequency of receiving knowledge (knowledge transfer) is also a dimension of the quality of the knowledge because more frequent communication can lead to more effective communication (Reagans and McEvily, 2003). With frequent communication, the receiving firm can better understand the knowledge it receives and the chances are increased that the knowledge is useful for the firm's innovations. Audretsch and Feldman (2004) mention in their study that the marginal cost of transmitting knowledge, especially tacit knowledge, is lowest with frequent social interaction, observation and communication. This leads to the fourth proposition, namely the following:

Proposition 4: The higher the usability of the acquired knowledge and the higher the communication frequency, the better the innovative performance of firms.

2.3.1.5 Diversity of network actors

Many innovators derive their ideas from a diverse set of actors because these provide diverse and non-redundant ideas which are a source of novelty that can trigger new ideas and creativity in the knowledge-acquiring firm. Actors who interact with partners from diverse communities of practice will be able to convey more complex ideas than those individuals who are limited to interactions with a single body of knowledge (Reagans and McEvily, 2003). A diversity of actors in a network is important for innovation because it is not only the size of the network that maximises information, but also those actors found in networks composed of firms with different, but complementary knowledge (Gulati and Gargiulo, 1999; Staber, 2001; Uzzi, 1999). Knowledge building and innovation often require dissimilar, complementary bodies of knowledge from diverse actors (Cohendet and Llerena, 1997). Diversity is defined here as "multiple sources of knowledge such as competitors, customers, suppliers, HEI, etc. that a firm has"[3]. The relationship between diversity and innovation is formulated as follows:

Proposition 5: The higher the diversity of actors that a firm has in its ego network, the better its innovative performance.

The propositions developed so far basically stress the positive sides of interorganisational knowledge exchange relationships and networks for innovating firms in general, and for firms located on science parks in particular. Interorganisational networks enable innovating firms to mobilise, coordinate and combine knowledge resources. Provided that firms have the ability to process the acquired knowledge (see the section below on absorptive capacity),

[3] In this study, the measurement of technological proximity refers to the dyadic level (the distance between two actors), where diversity refers to the portfolio of ties with actors a firm has. In other words, technological proximity refers to a characteristic of one tie, whereas diversity refers to the characteristics of a set of ties.

(geographically clustered) networks are argued to be beneficial to innovating firms. Moreover, it is assumed that the transfer of knowledge is intentional.

Following the above arguments, lower levels of success of science parks and of the firms located there can be explained by, for example, the absence of direct ties, or levels of trust or levels of diversity that are too low. It is argued that such explanations are too simple and that other mechanisms are at work. These mechanisms imply the combined effects of high levels of technological and geographical proximity, as is often the case with firms located on science parks, the fact that knowledge transfer can be unintentional, and the characteristics of knowledge. To start with the latter, one can argue that knowledge has two basic characteristics that make this "commodity" look, to a certain extent, like a public good: rivalry and appropriability. Rivalry refers to the fact the use of a good by an actor does not affect the utility of other actors using the same good. Appropriability refers to the extent to which it is possible to exclude actors from using a good. A purely private good has high levels of rivalry and appropriability, whereas the opposite is true for so-called public goods. It is often argued that knowledge is a pure public good, but this point of view cannot be maintained. After all, the more actors use knowledge generated by another actor, the higher the probability that its economic value decreases over time as more actors have that knowledge. As a result, the competitive advantage firms can derive from this knowledge diminishes. In other words, rivalry is not complete. The same is true for appropriability; depending on the type of knowledge, some actors can be excluded. This is especially true for the more tacit types of knowledge.

It was stated above that many studies on interorganisational networks and science parks assume that knowledge sharing is intentional: a sender deliberately and consciously transmits knowledge to one or more recipients. However, knowledge can also be transferred unintentionally or unintended, which can take place through direct communication (for example, observation of the actions of another actor) or through indirect communication (for example, through (illegal) use of media on which knowledge or information is stored).

A third element in the theoretical argument is access conditions, which are the conditions under which exclusion cannot be accomplished. It is maintained that locations such as science parks create beneficial access conditions for the unintended flow of knowledge. The geographical co-location on a science park makes it easier to observe the activities of other science park firms. Moreover, on average these research-intensive firms are more technologically close to each other, which further eases unintended flows of knowledge.

Combined, the arguments lead to the conclusion that science parks can "facilitate" unintended knowledge flows. As is explained in the next section, this can have both positive and negative effects for science park firms and the networking function of science parks.

2.3.2 Unintended knowledge flows (knowledge spillover)

Some researchers (Fallah and Ibrahim, 2004; Oerlemans and Meeus, 2005; Howells, 2002; Ulrich, 2000) relate unintended knowledge flows to the knowledge spillover literature. They define unintended knowledge flow as the knowledge transmission to other actors on an involuntary and unintended basis, or in other words, unintentional transmission of knowledge to others beyond the intended boundary. This type of knowledge flow can be acquired without the acknowledgement of the sending firms. In various knowledge spillover studies, researchers attribute positive innovation effects to knowledge spillovers (Fallah and Ibrahim, 2004; Oerlemans and Meeus, 2005; Jaffe et al., 1993). Therefore, Proposition 6 is put forward.

<u>Proposition 6:</u> Higher levels of unintended knowledge flows will result in better innovative performance by firms.

Moreover, it is proposed that the relationship between intended knowledge flows (intentional knowledge transfer) and innovative outcomes of science park firms will be negatively influenced by higher levels of unintended knowledge flows because the moment the sender firm realises that its knowledge is "used" without its approval by the receiving firms, this will lower its willingness to share knowledge in the official collaborations and/or informal networking activities. The proposed argument is not for *any* exchange between firms, but the interorganisational ties in the collaboration between firms. This leads the next proposition.

Proposition 7: The relationship between intended knowledge flows and innovative performance of firms will be negatively moderated by higher levels of unintended knowledge flows/spillovers.

In other words, if the unintentional use of knowledge is observed by the knowledge-producing science park firm, it will damage trust and, consequently, lower the (willingness to) exchange knowledge. Again, technological and geographical proximity play a role, because this makes it easier to observe a misuse, while the network ties between firms on a science park make it easier to communicate the "misbehaviour" of an organisation. The more firms behave in this opportunistic way, the higher the probability that the network processes on a science park can be inhibited. In fact, the poor performance of some science parks that is reported in the literature could be explained by the accumulated negative effects of the use of unintended knowledge transfer. This study takes on a nuanced approach with regard to unintended knowledge flows by proposing a positive main effect in Proposition 6 and a negative moderating effect in Proposition 7.

2.3.3 Absorptive capacity

Resulting from Cohen and Levinthal's study in 1990, firms' fundamental learning processes, that is, their ability to identify, assimilate and exploit knowledge from the environment, is labelled "absorptive capacity" (Cohen and Levinthal, 1990). Zahra and George later proposed additional definitions that separate Cohen and Levinthal's definition of absorptive capacity into two main dimensions: potential absorptive capacity (the capability to acquire and assimilate knowledge) and realised absorptive capacity (the exploitation or use of the knowledge that has been absorbed) (Zahra and George, 2002). Many empirical studies have shown that there is a positive relationship between absorptive capacity and innovation. Pennings and Harianto's study shows that prior accumulated experience in a certain technological area increases the likelihood of innovation adoption (Pennings and Harianto, 1992). Becker and Peters (2000) and Nelson and Wolff (1997) argue that firms need higher absorptive capacities for scientific knowledge than for other types of knowledge. This shows that absorptive capacity is essential for the use of scientific knowledge, which, in turn, is the base of radical innovation. Hence the next proposition.

Proposition 8: Higher levels of absorptive capacity will result in better innovative performance by firms.

Networking encourages the sharing of tacit and explicit knowledge between actors, but only firms with higher absorptive capacity levels are able to fully assimilate and exploit the absorbed knowledge for their innovations. Similarly, even if a firm is able to access unintended knowledge by monitoring other firms' innovative activities or using their patents, the firm still needs a strong absorptive capacity to understand such knowledge for its own innovations and thus enhance its innovative performance. Therefore, absorptive capacity is included as a moderator in propositions 9 and 10.

Proposition 9: The relationship between intended knowledge flows and innovative performance of firms is moderated positively by higher levels of absorptive capacity.

Proposition 10: The relationship between unintended knowledge flows and the innovative performance of firms is moderated positively by higher levels of absorptive capacity.

The proposition can be summarised in a theoretical model that illustrates the main effects (see Figure 2) and moderating effects (see Figure 3).

Figure 2: The theoretical model showing the main effects

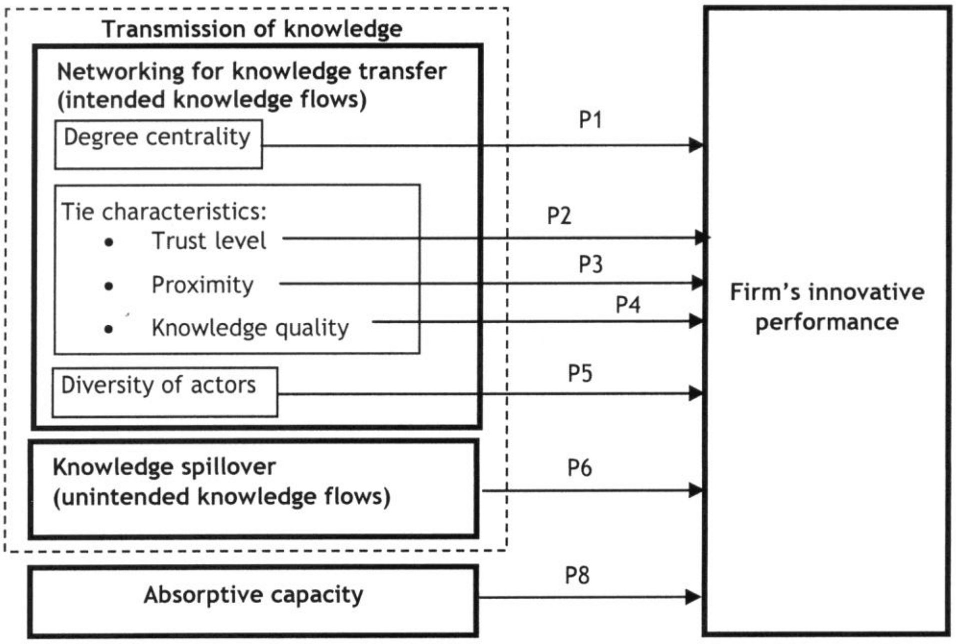
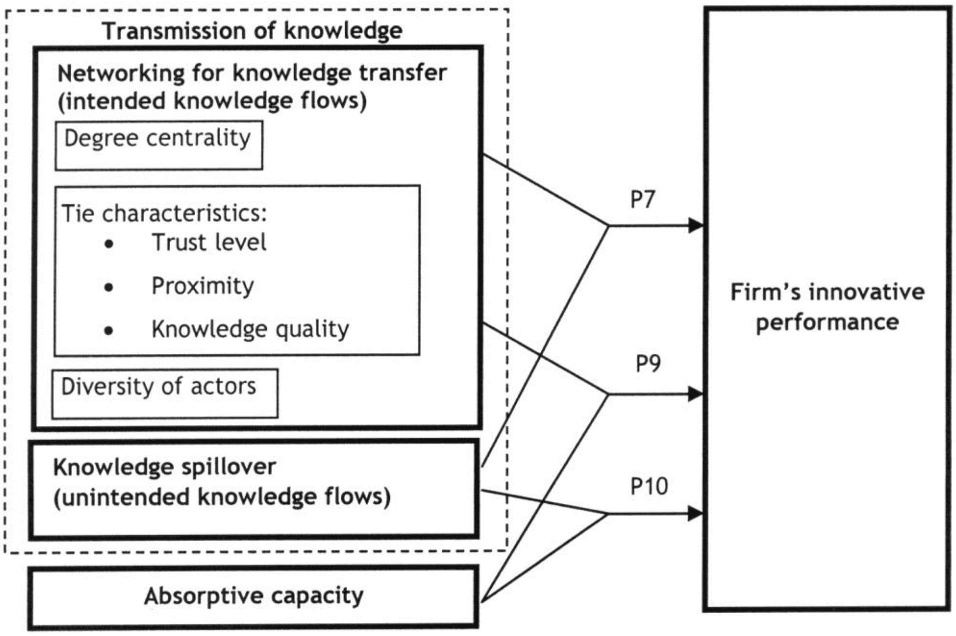


Figure 3: The theoretical model showing the interaction effects



2.4 Conclusions and future research

This study started with the observation that scholars find mixed empirical results on the performance of science park firms and of science parks. It was the aim of this study to develop a theoretical argument to explain why these mixed results are found.

By using a deductive approach in which insights from interorganisational network theory and the economics of innovation are combined, this study proposes that interorganisational networks can have both positive and negative effects for firms located on science parks. One way to deal with the negative effects of unintended knowledge transfer is to (re)locate a firm further away from its partners with similar technological backgrounds or which are in similar industries (Alcacer and Zhao, 2007). However, firms located on science parks do not have a relocation option in the short run. Starting from this assumption, it is argued that the location of firms in related industries on science parks, thus creating high geographical and technological proximity, can both foster and inhibit on-park knowledge flows and collaborations. The reason is that close geographical proximity enables on-park firms to monitor co-located firms' innovation activities, which increases the opportunity for imitation. Sender firms can identify relatively easily which on-park firms imitate their innovations, and, as a result ,this will lower their willingness to share knowledge in formal collaborations and/or informal networking activities with on-park firms. As a result, the innovative performance of firms might suffer, that is, lower innovative performance as a whole might be found on science parks.

The mixed empirical results found in the literature can be explained theoretically by pointing out that the very reason why science parks are established, namely to create a situation in which geographically co-located and technology-related firms can intentionally exchange knowledge through interorganisational relationships and networks, simultaneously creates ideal conditions for unintentional knowledge transfer. If the latter occurs, interorganisational knowledge transfer between science park firms is severely inhibited, resulting in poor(er) science park performance.

From a managerial point of view, one could recommend that science park firms should refrain from acting opportunistically. But that is stating the obvious. It is the researcher's view that there is an important task here for the management of the science park. By creating a positive collaboration culture, for example by stimulating social networking between entrepreneurs, by monitoring the behavior of tenants or by training organisations in intellectual property protection, the propensity of firms to misuse others could be lowered.

So far, the proposed model has not been empirically validated. Results of future studies, coupled with previous findings and the model proposed here, will enhance an understanding of the interrelationships between interorganisational knowledge transfer, absorptive capacity, science park location and the innovative performance of firms.

References

Ahuja, G., 2000. Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3), 425-455.

Alcacer, J. and Zhao, M., 2007. Global competitors as next-door neighbours: Competition and geographic concentration in the semiconductor industry. *Ross School of Business Paper*, No 1091.

Arndt, O. and Sternberg, R., 2000. Do manufacturing firms profit from intraregional innovation links? An empirical based answer. *European Planning Studies*, 8 (4), 465-485.

Arrow, K.,1962. Economic welfare and the allocation of resources for inventions. In: R. Nelson, ed. *The rate and direction of innovative activity.* Princeton: Princeton University Press.

Audretsch, D.B. and Feldman, M.P., 2004. Knowledge spillovers and the geography of innovation. In: J.V. Henderson and J.F. Thisse, eds. *Handbook of urban and regional economics.* Amsterdam: North Holland Publishing, 80-110.

Becker, W. and Peters, J., 2000. *Technological opportunities, absorptive capacities, and innovation.* Volkswirtschaftliche Diskussionsreihe.

Bell, G.G., 2005. Clusters, networks, and firm innovativeness. *Strategic Management Journal*, 26(3), 287-295.

Bigliardi, B., Dormio, A. I., Nosella, A. and Petroni, G., 2006. Assessing science parks' performances: Directions from selected Italian case studies. *Technovation,* 26(4), 489-505.

Boschma, R., 2005. Proximity and innovation: a critical assessment. Regional Studies, 39(1), 61-74.

Cassiman, B., Colombo, M. G., Garrone, P. and de Veugelers, R., 2005. The impact of M&A on the R&D process: An empirical analysis of the role of technological- and market-relatedness. *Research Policy,* 34(2), 195-220.

Chan, K.F. and Lau, T., 2005. Assessing technology incubator programs in the science park: the good, the bad and the ugly. *Technovation*, 25(10), 1215-1228.

Chang, Y.C., 2003. Benefits of co-operation on innovative performance: evidence from integrated circuits and biotechnology firms in the UK and Taiwan. *R&D Management,* 33(4), 425-437.

Cheuk, B., 2007. Social networking analysis: Its application to facilitate knowledge transfer. *Business Information Review*, 24(3), 170-176.

Cohen, W. and Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152.

Cohendet, P. and Llerena, P., 1997. Learning, technical change and public policy: how to create and exploit diversity. In: C. Edquist, ed. *Systems of innovation: technologies, institutions and organisations.* Oxon: Routledge, 223-234.

Cowan, R. and Jonard, N., 2004. Network structure and the diffusion of knowledge. *Journal of Economic Dynamics and Control*, 28(8), 1557-1575.

Cross, R. and Cummings, J.N., 2004. Ties and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal*, 47(6), 928-937.

Cross, R. and Sproull, L., 2004. More than an answer: information relationships for actionable knowledge. *Organisation Science,* 15(4), 446-462

Fallah, M.H. and Ibrahim, S., 2004. Knowledge spillover and innovation in technological clusters. 13th International Conference on Management of Technology. April 2004, Washington.

Ferguson, R. and Olofsson, C., 2004. Science Parks and the development of NTBFs – location, survival and growth. *Journal of Technology Transfer*, 29(1), 5-17.

Freel, M.S., 2003. Sectoral patterns of small firm innovation, networking and proximity. *Research Policy*, 32, 751-770.

Fukugawa, N. 2006., Science Parks in Japan and their value-added contributions to new technology-based firms. *International Journal of Industrial Organisation*, 24(2), 381-400.

Gertler, M.S., 1995. Being there: proximity, organisation, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography*, 71(1), 1-26.

Goldstein, H.A. and Luger, M.I., 1990. Science/technology parks and regional development theory. *Economic Development Quarterly*, 4(1), 64-78.

Goldstein, H.A. and Luger, M.I., 1991. *Technology in the garden: research parks and regional economic development*. University of North Carolina Press.

Gordon, I.R. and McCann, P., 2000. Industrial clusters: complexes, agglomeration and/or social networks?. *Urban Studies*, 37(3), 513-532.

Granovetter, M., 1983. The strength of weak ties: a network theory revisited. *Sociological Theory*, 1, 201-233.

Gulati, R. and Gargiulo, M., 1999. Where do interorganisational networks come from?. *American Journal of Sociology*, 104(4), 1439-1493.

Hansen, M.T., 1999. The search-transfer problem: the role of weak ties in sharing knowledge across organisation subunits. *Administrative Science Quarterly*, 44(1), 82-111.

Howells, J.R.L., 2002. Tacit knowledge, innovation and economic geography. *Urban Studies*, 39(5), 871- 884.

IASP, Website. About science and technology parks. Definitions. http://www.iasp.ws, accessed 17 February 2009.

Jaffe, A.B., Henderson, R. and Trajtenberg, M., 1993. Geographic localisation of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 108(3), 577-598.

Johannisson, B., Alexanderson, O., Nowicki K. and Senneseth, K., 1994. Beyond anarchy and organisation: entrepreneurs in contextual networks. *Entrepreneurship and Regional Development*, 6(4), 329-356.

Kingsley, G. and Malecki, E.J., 2004. Networking for competitiveness. *Small Business Economics,* 23(1), 71-84.

Knoben, J. and Oerlemans, L.A.G., 2006. Proximity and inter-organizational collaboration: a literature review. *International Journal of Management Reviews*, 8, 71-89.

Knoben, J. and Oerlemans, L.A.G., 2008. Ties that spatially bind? A relational account of the causes of spatial firm mobility. *Regional Studies*, 42(3), 385-400.

Lane, P.J. and Lubatkin, M.H., 1998. Relative absorptive capacity and interorganisational learning. *Strategic Management Journal*, 19(5), 461-477.

Lazaric, N. and Lorenz, E., 1998. The learning dynamics of trust, reputation and confidence. In: N. Lazaric and E. Lorenz, eds. *Trust and economic learning*, London: Edward Elgar, 1-20.

Lin, Z., 2002. The dynamics of interorganisational ties during crises: empirical evidence and computational analysis. *Simulation Modelling Practice and Theory,* 10(5-7), 387-415.

Link, A.N. and Link, K.R., 2003. On the growth of U.S. science parks. *Journal of Technology Transfer*, 28(1), 81-85.

Löfsten, H. and Lindelöf, P., 2002. Growth, management and financing of new technology-based firms assessing value-added contributions of firms located on and off Science Parks. *Omega*, 30(3), 143-154.

Löfsten, H. and Lindelöf, P., 2003. Determinants for an entrepreneurial milieu: Science Parks and business policy in growing firms. *Technovation,* 23(1), 51-4.

Lorenz, E., 1999. Trust, contract and economic competition. *Cambridge Journal of Economics*, 23(3), 301-315.

Monck, C.S.P., Porter, R.B., Quintas, P., Storey, D.J. and Wynartczyk, P., 1988. *Science Parks and the growth of high technology firms.* London: Croom Helm.

Mowery, D.C., Oxley, J.E. and Silverman, B.S., 1996. Strategic alliance and interfirm knowledge transfer. *Strategic Management Journal,* 17 (Winter Special Issue), 77-91.

Nelson, R., 1959. The simple economics of basic scientific research. *Journal of Political Economy*, 67(3), 297-306.

Nelson, R. and Wolff, E.N., 1997. Factors behind cross-industry differences in technological progress. *Structural Change and Economic Dynamics,* 8(2), 205-220.

Newell, S. and Swan, J. 2000. Trust and interorganisational networking. *Human Relations*, 53(10), 127-1328.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V. and Van Den Oord, A., 2007. Optimal cognitive distance and absorptive capacity. *Research Policy*, 36, 1016-1034.

Oerlemans, L.A.G. and Meeus, M.T.H., 2005. Do organisational and spatial proximity impact on firm performance?. *Regional Studies*, 39(1), 89-104.

Orlando, M.J., 2000. *On the importance of geographic and technological proximity for R&D spillovers: An empirical investigation*, Federal Reserve Bank of Kansas City Research, Working Paper No 00-02.

Pennings, J.M. and Harianto, F., 1992. The diffusion of technological innovation in the commercial banking industry. *Strategic Management Journal,* 13(1), 29-46.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A., 2004. Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews*, 5-6(3-4), 137-168.

Phillimore J., 1999. Beyond the linear view of innovation in science park evaluation: An analysis of Western Australian Technology Park. *Technovation,* 19(11), 673-80.

Powell, W.W., Koput, K.W., Smith-Doerr, L. and Owen-Smith, J., 1999. Network position and firm performance. In: S. Andrews and D. Knoke, eds. *Networks in and around organisations*, Greenwich: JAI Press.

Quintas, P.D.W. and Massey, D., 1992. Academic-industry links and innovation: questioning the Science Park model. *Technovation*, 12(3), 161-175.

Rallet, A. and Torre, A., 1999. Is geographical proximity necessary in the innovation networks in the era of global economy?. *GeoJournal*, 49(4), 373-380.

Reagans, R. and McEvily, B., 2003. Network structure and knowledge transfer: the effects of cohesion and range. *Administrative Science Quarterly*, 48(2), 240-267.

Romijn, H. and Albu, M., 2002. Innovation, networking and proximity: Lessons from small high technology firms in the UK. *Regional Studies*, 36(1), 81-86.

Rothwell, R., 1992. Successful industrial innovation: critical factors for the 1990s. *R&D Management*, 22(3), 221-240.

Soo, C.W. and Devinney, T.M., 2004. The role of knowledge quality in firm performance. In: H. Tsoukas and N. Mylonopoulos, eds. *Organisations as knowledge systems: knowledge, learning and dynamic capabilities,* New York: Palgrave Macmillan, 252-275.

Sparrowe, R.T., Liden, R.C., Wayne, S.J. & Kraimer, M.L., 2001. Social networks and the performance of individuals and groups. *Academy of Management Journal*, 44(2), 316-326.

Staber, U., 2001. The structure of networks in industrial districts. *International Journal of Urban and Regional Research*, 25(3), 538-552.

Storper, M., 1997. *The regional world: territorial development in a global economy*, London: Guilford Press.

Ulrich, K., 2000. Measuring knowledge spillovers in manufacturing and services: an empirical assessment of alternative approaches. *Research Policy*, 31(1), 125-144.

Uzzi, B., 1999. *Embeddedness in the making of financial capital: how social relations and networks benefit firms seeking financing*, American Sociological Review, 64(4), 481-505.

Van de Ven, A.H., 1986. Central problems in the management of innovation. *Management Science,* 32(5), 590-607.

Von Zedtwitz, M. and Grimaldi, R., 2006. Are service profiles incubator-specific? Results from an empirical investigation in Italy. *The Journal of Technology Transfer,* 31(4), 459-468.

Westhead, P. 1997. R&D 'inputs' and 'outputs' of technology-based firms located on and off Science Parks. *R&D Management*, 27(1), 45-62.

Westhead, P. and Batstone, S., 1998. Independent technology-based firms: the perceived benefits of a science park location. *Urban Studies*, 35(12), 2197-2219.

Westhead, P. and Batstone, S., 1999. Perceived benefits of a managed science park location. *Entrepreneurship and Regional Development,* 11(2), 129-154.

Zaheer A. and Bell, G.G., 2005. Benefiting from network position: firm capabilities, structural holes, and performance. *Strategic Management Journal*, 26(9), 809-825.

Zahra, S.A. and George, G. 2002. Absorptive capacity: a review, reconceptualisation, and extension. *Academy of Management Review,* 27(2), 185-203.