Chapter 5

Knowledge transfers between and innovative performances of NTBFs in South Africa: an attempt to explain mixed findings in science park research[9]

Science parks are often established to drive regional economic growth, especially in countries with emerging economies. However, mixed findings regarding the performances of science park firms are found in the literature. This study tries to explain these mixed findings by taking a relational approach and exploring (un)intended knowledge transfers between new technology-based firms (NTBFs) in the emerging South African economy. Moreover, the innovation outcomes of these NTBFs are examined by using a multi-dimensional construct. Results show that science park location plays a significant role in explaining innovative sales, but is insignificant when a different indicator of innovation outcomes is used. Furthermore, only for innovations that are new to the firms, both science park location and intended knowledge transfer via informal business relationships have a positive impact; whereas social relationships have a negative impact.

5.1 Introduction

Science parks are not a new phenomenon. The concept can be traced back to the 1950s when Silicon Valley, with the support of Standford University, transformed from an agricultural valley into the birthplace of the semiconductor and ICT industry. Following the USA experience in the 1960s, the development of Cambridge Science Park (UK) and Sophia Antipolis (France) have set good examples for many European countries. The majority of the science parks currently existing in the world were created during the 1990s and about 18% of these science parks werelaunched in the first two years of the new century. Today

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there are over 400 science parks in the world, primarily concentrated in developed economies, with over 140 founded in North America.

The reason behind this rapid growth of science parks around the world is the belief, mostly by policy makers in industrialised economies, that the establishment of these parks will promote economic growth and competitiveness of cities and regions by creating new business, adding value to companies, and creating new knowledge-based jobs (The International Association of Science Parks). The founding of a science park is often used as a policy intervention to stimulate high-technology start-ups (McAdam and McAdam, 2008). It is where government provides infrastructure, industry provides business skills and funding, and universities provide research knowledge and new technology development; also known as the Triple Helix of university-industry-government relations for innovation (Etzkowitz and Leydesdorff, 2000). An important function of any science park is to contribute to the establishment of a knowledge-based economy by fostering market-orientated technological development. This type of economy depends on three interrelated processes: local knowledge creation, transfer of knowledge from external sources and transformation of that knowledge into productive activities and valued outcomes (Chen and Choi, 2004). Consequently, networking between firms and between firms and universities to transfer knowledge and foster collaboration and innovation are vital processes for science parks.

Despite the benefits that science parks might bring, researchers have been studying the science park phenomenon to analyse to what extent science parks are just "high tech fantasies" (Massey et al., 1992; Bakouros 2002) or not (Yang et al., 2009). To ascertain the "added value" of a science park location, researchers believed comparative studies should be conducted (Westhead, 1997; Lindelöf and Löfstsen 2004). These studies compared behaviour and performance of firms located on a science park with those of firms not located on a science park to explore the potential differences between them. Interestingly, in this literature researchers have reported mixed empirical findings on the performance of science park firms. Some researchers found empirical evidence of the "added value" of science park location (for example, Felsenstein, 1994; Lindelöf and Löfstsen, 2004), whereas others clearly questioned the assumed benefits of the science park model (for example, Westhead, 1997; Malairaja and Zawdie, 2008). The latter group of scholars found that there are no differences between on-park firms and off-park firms in terms of their performance. Further details of these comparative studies will be elucidated in a later section. From the observations of these studies it can be concluded that there are mixed findings regarding the performance of science park firms. The mixed evidence in the empirical literature inspired the following question to be asked: How can one explain these mixed findings? While contemplating this question, it came to mind that two general types of knowledge transfers reach science park firms: intended and unintended. It might be that the interplay of the two could lead to an answer to the question. Perhaps the occurrence of unintended, thus unsolicited, knowledge transfers impact negatively on the level of intended knowledge transfers between firms. Consequently, this interplay leads to lower overall interorganisational knowledge transfers, and probably to lower performance levels. Hence, the research question of this study was put forward:

To what extent do intended/unintended knowledge transfers explain the innovative performance of science park firms?

This study contributes to the science park literature in three ways. Firstly, the most important contribution of this study is the explanation of the mixed empirical findings that exist in the science park literature. This chapter will explore the link between knowledge transfers and firm innovativeness to explain the mixed findings found in the literature. In this way, two largely separate branches of literature, on interorganisational knowledge transfers and on knowledge spillovers, are combined in one study. Secondly, most science park studies use "patents" and "new products/services" (for example, Westhead, 1997; Siegel et. al., 2003; Akçomak and Taymaz, 2004) as indicators of firms' innovative performance. These indicators only give a partial view of innovative firm performance. In this study, innovative performance is conceptualised as a multidimensional construct and is thus measured with multiple indicators to obtain a more holistic view of innovative performance of science park firms. Thirdly, most science park studies are conducted in developed economies, whereas this study is performed in an emerging economy (South Africa). In developed economies, science parks are often more easily and better connected to the rest of the system of innovation. In many cases, this is not true for emerging economies (Lorentzen, 2009) that often lack a well-developed and connected system of innovation. Consequently, firms located on science parks in emerging economies have to focus more strongly on interaction with partners located on the same science park. Interaction with spatially proximate partners brings certain benefits, but also some potential disadvantages (Knoben and Oerlemans, 2006). By sorting out these benefits and disadvantages, this study adds to the literature on geographical proximity.

This empirical chapter is organised as follows. In the next section, the results of a literature review on the performance of science park firms will be presented. In Section 3, the theoretical framework of this study and relevant hypotheses will be developed. Section 4 describes the research methodology that is applied in this study. Section 5 discusses the results of analyses of data on new South African technology-based firms (NTBFs), focusing on firms' knowledge transfer behaviours and innovative performances in 2007. Section 6 provides concluding remarks and recommendations for policy makers and further studies.

5.2 Science parks and mixed findings: a literature review

What is known in the recent literature about the performance of science park firms? To answer this question, a literature search was conducted using Google Scholar, Science Direct, Swetwise and Proquest as search engines. Key words used were "on-park firms", "off-park firms", "science park performance", "science park evaluation", "benefits of science park" and "added values of science park". The main purpose of this literature review was to get an overview of the empirical results from past studies regarding science park firms. The details of the review are summarised in this study (Appendix 2). Besides the names of the author(s), the following criteria were included:

- Country and period: Where and when was the research conducted? In particular it was important to know in which country a study was conducted, as collaborating cultures differ between countries.

- Research focus: Which research questions do studies try to answer? From this column one can deduce the various foci the researchers used and where gaps might exist.
- Research methodology: Which research methodologies do studies apply to answer their research questions empirically? From these two columns the most commonly used research methodology could be explored. This gives an indication of the maturity of the field. Moreover, one can learn from these approaches in the study.
- Key results: Regarding the aspects studied; do on- and off-park firms differ from one another? From this column, one can see which findings on science park performance are reported in the literature.

The table in Appendix 2 summarises 13 comparative studies. One can see that Westhead, Lindelöf and Löfsten are very active researchers in this field of study. Most of the studies were conducted in the period between 2002 and 2004, using longitudinal data sets (ranging from three years to ten years), which are necessary to examine proxies of firm performance such as the "employment growth" or "survival" of firms over time. The founding of science parks increased from 1973 (IASP website) until 1987, after which a decline occurred, followed by an increase from 1997 onwards. This growth-decline-growth phenomenon in science park creation may be one of the reasons why more researchers use comparative approaches to investigate to what extent science parks have benefits.

The majority of studies were conducted in Western countries (UK, Sweden, and Italy) and only a few stem from emerging economies (Israel, Malaysia, and Taiwan). There seems to be a lack of comparative studies from emerging economies. The collaborative culture differs from country to country. Western cultures (Western Europe, North America, and Australia) are characterised as individualistic, whereas some non-Western cultures (Asian, South American, and Africa) are characterised as collectivistic (Green et al., 2005). Thus, these cultures may have an influence on how firms in a specific country interact with one another.

Studies tend to focus on three areas: (1) Employment growth (Westhead and Cowling, 1995; Colombo and Delmastro 2002; Ferguson and Olofsson, 2004;

Akçomak and Taymaz, 2004); (2) Industry-academic links (Felsenstein, 1994; Löfsten and Lindelöf, 2002; Lindelöf and Löfsten, 2004; Akçomak and Taymaz, 2004; Dettwiler et. al., 2006); and (3) Innovativeness as indicated by R&D inputs, outputs and productivity (Westhead 1997; Colombo and Delmastro 2002; Siegel et al., 2003; Akçomak and Taymaz, 2004; Yang et al., 2009).

As far as knowledge transfers are concerned, the focus is mainly on the knowledge links with local universities. Other linkages such as with business partners (for example, buyers or suppliers) or with other science park firms are often not taken into account. Moreover, researchers seem to focus on intended knowledge transfers, paying little attention to unintended knowledge transfers (knowledge spillover).

From a methodological perspective, it can be noted that most studies used a matched-sampling approach to select comparable off-park firms in line with the properties of on-park firms. The two sample sizes are more or less equal, ranging from 40 to 139 for each paired sample. This finding shows a commonly accepted way of sampling. All studies used questionnaires and surveys to collect firm-level data. One exception is Yang's study where panel data from a financial databank was used. This shows a trend in firm-level analysis to explore the performance of science parks. Most studies used the independent sample t-test for continuous and discrete variables and the Chi-squared test for dummy variables. These two statistical analysis tests are commonly used when one needs to compare variables from two independent samples and explore any significant differences between the groups of firms to show the added-value of science parks. Moreover, from this literature review it can be concluded that there is a lack of use of multivariate analysis to explore more fine-grained and complex relationships between firm characteristics and performance (for example, using multivariate regression analysis).

A comparison of the research findings in the studies in the review reveals that there are mixed findings regarding the added value to firms of science park location:

- Employment growth: Some find no significant difference between on- and off-park firms (Westhead and Cowling, 1995; Akçomak and Taymaz, 2004; Ferguson and Olofsson, 2004), whereas others report that on-park firms have a higher employment growth (Löfsten and Lindelöf, 2002; Colombo and Delmastro, 2002).
- Interactions with universities: Some report no significant difference between on- and off-park firms (Malairaja and Zawdie, 2008) and others find that on-park firms have higher levels of interaction with (local) universities (Felsenstein, 1994; Lindelöf and Löfsten, 2004).
- R&D outputs and productivity: Some find no significant difference between on- and off-park firms (Westhead, 1997; Colombo and Delmastro, 2002; Lindelöf and Löfsten, 2003 and 2004, whereas others report that on-park firms have higher R&D outputs and productivity (Siegel et al., 2003; Yang et. al., 2009).

On specific indicators studies report similar findings, but these do not support the "promises" that science parks often make:

- There are no differences between on- and off-park firms in sales/profitability (Löfsten and Lindelöf, 2002; Ferguson and Olofsson, 2004).
- There are no differences between on- and off-park firms regarding R&D inputs (Westhead, 1997; Colombo and Delmastro, 2002).

From the mixed findings observed, one can clearly see that studies show that not all science parks deliver their promises of bringing added value to their firms and connected regions. Wondering about these mixed findings, this study asks the question: How can these mixed findings be explained? In other words, why do some on-park firms outperform the off-park firms and some do not? In the next section, a framework is presented to explain these mixed findings from a theoretical point of view.

5.3 Theoretical framework

5.3.1 Key concepts defined

Knowledge is identified as a key resource for a technology-based firm's competitive advantage because it is difficult to replicate and is critical to the process of innovation (Murmann, 2003; Thornhill, 2006; Ichijo and Nonaka, 2007). In this age of increasing globalisation and complexity of technological innovation, the use of internal generated knowledge resources (for example, from in-house R&D) is no longer sufficient for technological innovation. Firms often acquire and use knowledge from external actors to complement their internal knowledge bases for innovative product or service development. Researchers have distinguished two categories of knowledge transfers: intended and unintended knowledge transfers (Fallah and Ibrahim 2004; Oerlemans and Meeus, 2005). An intended knowledge transfer is a conscious and deliberate transfer of knowledge between two or more organisations. On the other hand, unintended knowledge transfer refers to any knowledge that is transferred unwillingly by the sending firms.

In this study, the definition of innovative performance is based on one proposed by Ernst (2001): an achievement in the trajectory from the conception of an idea up to the introduction of an invention into the market. Many studies use one-dimensional conceptualisations only and thus single measurements of innovative performance such as patents (for example, Bottazzi and Peri, 2003) or the number of new products introduced (for example, Stock et al., 2002). From Ernst's definition, one should look at innovation from a holistic perspective, that is, looking at the whole innovation cycle (from ideas to commercialisation). Thus, in this study, innovative performance is measured with multiple dimensions (e.g. total innovative sales and relative innovative performance).

5.3.2 Intended knowledge transfers and innovative performance

Firms establish linkages with other organisations with the intended purpose of accessing and acquiring different knowledge assets from external actors to develop technological innovations. A firm can interact with its partners on a formal basis. One of the common strategies is through formal collaborations such as joint R&D as effective ways to employ outside knowledge resources and increase the effectiveness of innovations (Du and Ai, 2008). The governance of collaborations of this type is commonly through mutually accepted contracts to control the relationship between the parties with the aim of increasing the level of success in the knowledge transfer process (Mentzas et al., 2006). Knowledge also can be transferred between organisations on a non-contractual basis through so-called informal networking activities that are conducted without any formal agreements between two parties. Informal networking can happen at two levels: interorganisational informal networking (labelled as "informal networking" in this study) or inter-personal informal networking (labelled as "social networking"). Informal networks can be created by informal functions arranged between two organisations, such as breakfast/lunch meetings, golf events, etc. On the other hand, social networks consist of informal/social ties of employees with employees of other firms (they may be friends or previous colleagues) and through these social ties the knowledge of how new products are created or innovative ideas can be shared during these social conversations.

Studies have shown the positive relationship between intended formal and informal interorganisational network activity and innovative performance. For example, a study by Jensen, Johnson, Lorenz and Lundvall (2007) shows that firms that applied a so-called doing, using and interacting mode (informal processes of learning) in combination with a mode of accessing and using codified knowledge, outperform firms relying predominantly on one of the two modes. Moreover, Boschma and Ter Walt (2007) report that a strong local network position (high number of formal interorganisational relationships) of a firm tends to increase its innovative performance in an industrial district. It is through these intended interactions (that is, ties in networks) that external knowledge is able to transfer to an innovating firm. Intended knowledge transfers fuel innovations.

Firms involved in interorganisational networks are able to gather more knowledge resources to perform their innovative activities. Partners who have formalised relationships (for example, through contracts) with a focal firm or who are involved in informal relationships are more willing to share (and less likely to hold back) knowledge due to the trust present in these relationships, and as a result the receiver firm is able to access better or more knowledge resources for successful innovations. Networks also provide opportunities for firms to compare and integrate intended knowledge flows from various sources so that new knowledge can emerge for technology development. Based on the above theoretical arguments Hypothesis 1 is proposed:

The higher the number of intended knowledge transfer relationships, the higher the firm's innovation outcomes

5.3.3 Unintended knowledge transfers and innovative performance

Unintended knowledge transfers are often referred to as knowledge spillovers (Fallah and Ibrahim, 2004; Oerlemans and Meeus, 2005; Erbas et al., 2008) and can be defined as "knowledge received without the permission of the sending firms". Firms that do not have the proper resources to develop a competitive advantage can engage in activities to reduce their resource deficits, such as "hiring away well placed knowledgeable managers in a firm with a competitive advantage or by engaging in a careful systematic study of the other firm's success" (Barney, 2000: 214), by imitating other firm's technologies, or by monitoring other firms' innovative activities. Thus, knowledge spillovers (unintended knowledge transfers) "denote the benefit of knowledge to firms not responsible for the original investment of the creation of this knowledge" (Almeida and Kogut, 1999: 905). In the past, researchers have attributed positive innovation effects to knowledge spillovers or unintended knowledge transfers (Jaffe et al., 2000; Fallah and Ibrahim 2004; Oerlemans and Meeus, 2005; Mukoyama 2003) at different levels (the receiving firm; the region; the industry; the nation). Learning from knowledge spillovers has similar benefits as intended knowledge transfers, namely more knowledge resources to perform innovative activities (Alcácer and

Chung, 2007). In the past, researchers like Nelson (1959) and Arrow (1962) maintained that information and knowledge are almost completely costless to acquire and use. From their point of view, it follows that the benefit of accessing and using knowledge spillover is that it is almost free of costs. However, more recent literature such as Cohen and Levinthal (1989) and Griffith et al. (2000) defend the opposite position. They argued that a firm needs to invest in its own R&D to access and successfully use ("absorb") other firms' R&D outcomes. In this sense, accessing either intended or unintended knowledge flows requires a firm to invest in costly R&D for external knowledge absorption. The benefit of accessing unintended knowledge is the absence of establishing and maintaining relationships with other firms which may be costly. Hence, Hypothesis 2 reads:

The higher the unintended knowledge transfers, the higher a firm's innovation outcomes.

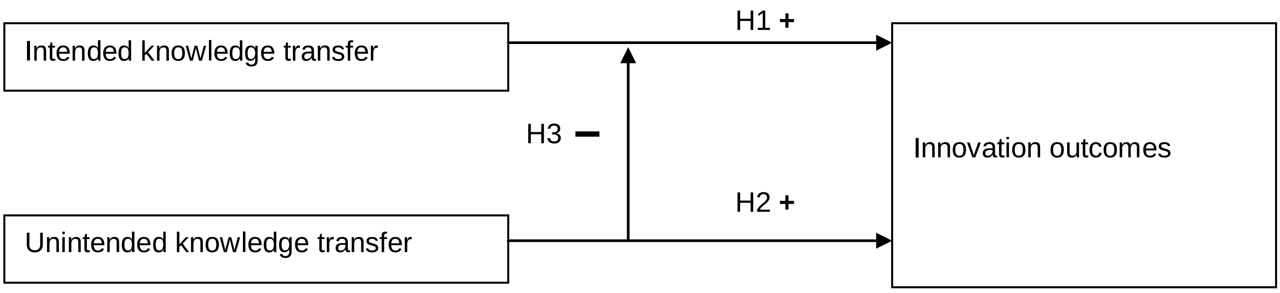
5.3.4 Moderating effect of unintended knowledge transfers

In a previous section, a literature review showed that there is mixed empirical evidence as to the (innovative) performance of firms located on science parks. In this study, it is proposed that the innovative performance of science park firms is lower in instances where unintended knowledge transfers occur. In other words, the mixed findings are due to the moderating effect of unintended knowledge transfers. Therefore, the relationship between intended knowledge transfers and the innovative performance of firms will be negatively influenced by higher levels of unintended knowledge transfers because the moment the sender firm realises that its knowledge is used without its approval, this will dramatically lower its willingness to share knowledge in formal collaborations and/or informal networking activities, as the unintended transfer may lead to an erosion of its competitive advantage (Easterby-Smith et al., 2008). In other words, if the unintentional use of knowledge is observed by the knowledge-producing firm, it will damage trust and, consequently, lower the willingness to transfer knowledge in a formalised or informal knowledge-transfer relationship. From the above argument, Hypothesis 3 can be derived:

The relationship between the number of intended knowledge transfer relationships and innovation outcomes of firms will be negatively moderated by higher levels of unintended knowledge transfers.

The above three hypotheses form the research model that this study will explore empirically. This research model is shown in Figure 5:

Figure 5: Research model



5.4 Research methodology

5.4.1 Sample and data collection

The focus of this study is on the relationship between knowledge transfer relationships and innovation outcomes at the firm level. The units of analysis are NTBFs located in the Gauteng region of South Africa. Gauteng was chosen because it has one of the few well-functioning systems of innovation in South Africa (Lorentzen, 2009). Firms chosen for this study fulfil the criteria of NTBFs: small firm size (number of employee including directors/CEOs less than 50), young firm age (less than 10 years since establishment) and highly technology-based (for example, ICT, biotech, electronics industries). This research applies a quantitative research methodology. Data regarding firms' knowledge transfer relationships and innovative performance were gathered through questionnaires sent to CEOs or directors of NTBFs. To assure the quality of feedback, most questionnaires were distributed personally with short interviews to assist the completion of the questionnaires. A total of 52 valid questionnaires were returned, 24 of which came from NTBFs situated in The Innovation Hub (a science park) and 28 came from independent NTBFs not located on a science park. The collected data were analysed by applying multivariate regression analyses using SPSS software.

5.4.2 Measurement of variables

Table 12 lists the items that were used in the questionnaire to measure the variables proposed in the research framework. The items were based on measures proposed in the literature and some were measured using a five-point Likert-type scale. Moreover, Table 12 shows the literature that was sourced to construct the measurements, as well as the reliability statistics (Cronbach’s alphas) of the scales used.

Reliability tests were done for the independent variable "unintended knowledge transfers" and the dependent variable "relative innovative performance", which were measured using multiple items (both have six items using a 5-point Likert scale). Cronbach’s alphas of these two variables are 0.702 and 0.656 respectively. Cronbach’s alpha of 0.6 was used as a threshold value and this is sufficient for exploratory studies. Thus, these two variables can be measured with a single, uni-dimensional latent construct.

Table 12: Item(s) of variables and their sources

Independent variables		**Item(s)**
Intended knowledge transfers (Otte and Rousseau, 2002)	Formal relationships	Number of organisations (suppliers, buyers, consultants, competitors, universities, public labs and sector institutes) with which the respondent firm has formal/contractual agreements to acquire knowledge.
	Informal relationships	Number of organisations (suppliers, buyers, consultants, competitors, universities, public labs and sector institutes) with which the respondent firm interacts on a non-contractual basis (i.e. informal, social basis) to acquire knowledge.
	Social relationships	Number of persons in organisations (suppliers, buyers, consultants, competitors, universities, public labs and sector institutes) with whom the CEO/director of the respondent firm interacts socially to acquire knowledge.
Unintended knowledge transfers Howells (2002)		How often does your firm use the following sources from other organisations/actors to acquire knowledge for your firm's innovations? (1) employing key scientists and engineers (including poaching key staff); (2) acquiring key information at conferences and workshops; (3) reverse engineering of technological knowledge embedded in products developed/produced by other firms/organisations; (4) accessing patent information filed by other firms/organisations; (5) knowledge embedded in organisational processes or routines of other firms/organisations; (6) publications in technical and scientific papers by other firms/organisations. (5-point Likert scale: never, rarely, sometimes, regularly or always; α = 0.702)
Dependent variable		**Item(s)**
Firm's innovation outcomes Sales items: Laursen and Salter (2006) Scope item: Oerlemans and Meeus (2005)		Three indicators of innovative performance were used: (1) Innovative sales 2008 new to the firm: the percentage of sales of product/services that were technologically new to the firm. (2) Total innovative sales 2008: the percentage of sales of products/services that were technologically improved and technologically new. (3) Scope of innovation outcomes 2008: other results of innovative performance. For last item, the following question was asked: To what extent did your firm's product and/or service innovations result in: (a) reduction of development and maintenance costs; (b) quality improvement of products and/or services; (c) increase in production capacity; (d) improvement in delivery times; (e) increase in sales; (f) increase in profits? (5-point Likert scale: 1 = very little, 3 = not little / not much, 5 = very much; (α = 0.656)).
Control variables		**Item(s)**
Firm size		Total number of employees, including the CEOs and directors, in 2007.
Firm age		Number of years a firm exists.
SP location		Is the firm located in The Innovation Hub (y/n)?

5.4.2.1 Dependent variables

In this study innovation outcomes are conceptualised as a multidimensional construct. This study distinguishes two types of innovation outcomes: innovative sales (Laursen and Salter, 2006) and the scope of outcomes (Oerlemans and Meeus, 2005). The innovative sales aspect captures the economic outcome of innovations expressed as the percentage of sales of innovated products and services. The scope of innovation outcomes is a qualitative dimension indicating that "part of the innovative efforts of firms are directed at, for example, a reduction of cost prices, quality improvements or the speeding up of internal processes" (Oerlemans and Meeus, 2005: 96). The three indicators used in this study as proxies to innovation outcomes are:

- Innovative sales new to the firms: measured as the percentage of sales of products and services that were technologically new to the firm.
- Total innovative sales: measured as the percentage of sales of products and services that were technologically improved and technologically new.
- Scope of innovation outcomes: measured as other results due to innovations, for example, reduction in production capacity.

5.4.2.2 Independent and control variables

This study distinguishes between "intended knowledge transfers" and "unintended knowledge transfers" as specification of the general concept of "knowledge transfers". Intended knowledge transfers are measured by taking three types of knowledge relationships into account: after all a firm can acquire intended knowledge via formal, informal and social relationships.

Unintended knowledge transfers are observed by the firm’s "imitative" or "opportunistic" behaviours, such as "reverse engineering" or "monitor other firms' innovative activities".

The recipient's firm size, firm age and science park location (yes/no) are included as control variables. "Firm size" and "firm age" are controlled, given that these two firm attributes have been important factors for the propensity of firms to acquire and exploit knowledge resources (Bresman et al., 1999, Agarwal and Gort, 2002, Cavusgil et al., 2003). Smaller and younger firms often face significant risk and uncertainty due to lack of knowledge resources (liability of newness). In this study "science park location" was also controlled because out of the 52 NTBFs that were surveyed, 24 firms are situated in The Innovation Hub, which is the first internationally accredited science park in South Africa. In the literature, science park location (SPL) is believed to make many value-added contributions to firms (Fukugawa 2006). Science park firms are thought to have more networking opportunities with other resident firms due to close geographical distance. Besides close geographical distance, which provides the possibility of face-to-face encounters, one of the tasks of a science park management team is to organise networking activities such as seminars and social events for on-park firms as well as with organisations located outside the science park premises. Thus, science park location plays a role in facilitating knowledge transfers and the innovative performance of firms.

5.5 Empirical results

5.5.1 Descriptive statistics

Means and standard deviations associated with the variables under study are provided in Table 13. On average, NTBFs access intended knowledge from 8.75 partners formally and 10.42 partners informally. Directors or CEOs of the NTBFs interact socially on average with 25 people to access intended knowledge. The average of the unintended knowledge transfer score is close to 1 on a scale of 5, showing that on average NTBFs rarely access unintended knowledge transfers. In general, NTBFs report that 72.21% of their sales come from innovated products and services, which is high but not usual for young, high-tech firms. In 2007, about 30% of sales was generated with products or services that were technologically new to the firm, whereas about 42% of innovative sales was generated with products and services which were technologically improved.

The scores for the scope of innovation outcomes (other results due to innovations) is 3.68, indicating a relatively high level. The averages of firm age and size are 5.13 years and 9.25 employees respectively. This shows that the sample firms are young and small. About 46% of the firms in the sample are located on a science park location.

Table 13: Means and standard deviations

Variables	Mean	S.D.
Independent variables		
Intended knowledge transfer through formal relationships	8.75	12.516
Intended knowledge transfer through informal relationships	10.42	10.273
Intended knowledge transfer through social relationships	25.04	30.497
Unintended knowledge transfer	0.987	0.480
Dependent variables: innovation outcomes		
Innovative sales 2007 new to the firm	30.10	30.33
Total innovative sales 2007	72.21	31.567
Scope of innovation outcomes	3.680	0.682
Control variables		
Firm size	9.25	9.91
Firm age	5.13	3.61
SP location?	0.46	0.50

5.5.2 Multivariate regression analysis

The models in this study were estimated by using SPSS to perform Ordinary Least Square-based hierarchical regression analyses. All variables mentioned in the previous section were entered in three steps:

Model 1: Model with only the control variables;

Model 2: Model1+ intended knowledge transfers+unintended knowledge transfers;

Model 3: Model 2 + moderator effect.

Model 1 contains the control variables, including firm size (FS), firm age (FA) and science park location (SPL). Next, intended knowledge transfers (IKT) and unintended knowledge transfers (UKT) are entered in Model 2 to test hypotheses 1 and 2. To investigate Hypothesis 3, the moderating effect of unintended knowledge transfer on the relationship between intended knowledge transfers and innovative performances, a product term of the original variables (IFT*UKT) is included in Model 3. For each indicator of innovation outcomes, there are three sets of models: for formal, informal and social knowledge transfer relationships respectively. Tables 14 to 16 show the results of the regression analyses.

5.5.2.1 Innovation outcomes: total innovative sales 2007

In Table 14, only the Models 1 (with the control variables) have statistically significant F-values ($p < 0.1$), so it can be confidently assumed that the proposed regression models fit the data. In these models, science park location has a positive relation with total innovative sales in 2007. The related coefficients are highly statistically significant ($p < 0.05$). This variable explains about 13% of the variance in total innovative sales 2007. In other words, firms located on this science park are more innovative (from a sales perspective) as compared to comparable firms not located on a science park. Interestingly, none of the interorganisational variables turned out to generate statistically significant results. This implies that network activity does not impact on total innovative sales (including technologically improved products and services). As has been seen in the previous paragraphs, these relationships do matter for innovations with a higher level of newness. Overall, for this type of outcome, it can be concluded that none of the hypotheses is confirmed.

Table 14: Results of regression analysis for total innovative sales 2007

Variables	Dependent variable: total innovative sales in 2007								
	Formal relationships			Informal relationships			Social relationships		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	69.880***	71.859***	65.946***	69.880***	68.683***	65.668***	66.130***	64.586***	66.287***
FS	-0.167	-0.189	-0.191	-0.167	-0.159	-0.175	-0.081	-0.076	-0.057
FA	0.056	0.039	0.047	0.056	0.068	0.070	0.031	0.035	0.052
SPL	0.367***	0.369**	0.378**	0.367***	0.378**	0.390**	0.395***	0.395**	0.389**
IKT		0.055	0.253		-0.062	0.1		-0.032	-0.287
UKT		-0.016	0.090		0.029	0.082		0.030	-0.007
IKT*UKT			-0.254			-0.205			0.283
R^2	13.3%	13.5%	14.2%	13.3%	13.5%	13.8%	15 %	15.1%	15.3%
ΔR^2	13.3%	0.2%	0.7%	13.3%	0.2%	0.3%	15%	0.1	0.3%
F-value	2.448*	1.433	1.239	2.448*	1.438	1.198	2.760*	1.597	1.329
ΔF-value	2.448*	0.055	0.370	2.448*	0.065	0.135	2.760*	0.025	0.143
VIF	1.059-1.155	1.188-1.460	1.200-9.138	1.059-1.155	1.163-1.597	1.165-16.326	1.042-1.149	1.122-1.451	1.219-29.196

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

5.5.2.2 Innovation outcomes: innovative sales 2007 new to the firm

In Table 15, the results of regression analysis for the innovation outcome indicator "innovative sales 2007 new to the firm" are shown. The discussion will start by looking at the indicators of model fit (F-value and its level of significance), followed by the statistically significant coefficients of the independent variables in the models (only for those models that fit the data).

With the exception of Model 2 and Model 3 of the estimations for formal knowledge transfer relationships, all proposed regression models fit the data. All other models have F-values at significant levels of $p<0.1$ to $p<0.01$ The exception is Model 2 for informal knowledge transfer relationships, which represent the best fitting model with significant level of $p<0.01$. R squares range from 14.1% (Model 1: social knowledge transfer relationships) to 28.5% (Model 2: informal relationships).

- ***Formal knowledge transfer relationships***

Formal knowledge transfer relationships turn out to have little importance for the innovative sales of products and services new to the firm. This conclusion can be drawn from the finding that only the model with the control variables is statistically significant. The implication is that Hypothesis 1 is rejected in the case of the relationship between formal ties and innovative sales (new to the firm).

Table 15: Results of regression analyses: innovative sales 2007 new to the firm

Variables	Dependent variable: innovative sales 2007 new to the firm								
	Formal relationships			Informal relationships			Social relationships		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	43.754***	32.159**	28.653	43.754***	22.511*	21.464	43.128***	27.197*	30.656**
FS	-0.310**	-0.279*	-0.28*	-0.310**	-0.222	-0.228	-0.283*	-0.236	-0.196
FA	-0.05	-0.034	-0.029	-0.05	0.047	0.048	-0.055	-0.019	0.016
SPL	0.28**	0.224	0.23	0.28**	0.292**	0.296**	0.282**	0.276*	0.263*
IKT		0.003	0.124		0.426***	-0.368		-0.287*	-0.814
UKT		0.168	0.234		0.391**	0.410*		0.304*	0.228
IKT*UKT			-0.157			-0.074			0.586
R^2	14.6%	17.1%	17.3%	14.6%	28.5%	28.5%	14.1%	22.6%	23.8%
ΔR^2	14.6%	2.4%	0.3%	14.6%	13.8%	0.0%	14.1%	8.5%	1.2%
F-value	2.740*	1.893	1.572	2.740*	3.658***	2.987**	2.563*	2.625**	2.285*
ΔF-value	2.74*	0.677	0.146	2.74*	4.446**	0.021	2.563*	2.477*	0.678
VIF	1.059-1.155	1.188-1.460	1.200-9.138	1.059-1.155	1.163-1.597	1.165-16.326	1.042-1.149	1.122-1.451	1.219-29.196

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

- ***Informal knowledge transfer relationships***

Model 1 shows that smaller firms and firms located at the science park generated a higher proportion of their sales in 2007 with products and services new to the firm. The addition of the variables "intended knowledge transfer through informal relationships" and "unintended knowledge transfer" in Model 2 leads to additional insights. The firm size variable loses its significance, whereas science park location holds its positive impact. Interestingly, a higher number of informal knowledge transfer relationships and a higher level of unintended knowledge transfer are associated with a higher percentage of innovative sales from products and services new to the firm. Consequently, hypotheses 1 and 2 are confirmed for this type of knowledge transfer relationships. The inclusion of the moderator variable results in an insignificant model, which means a rejection of Hypothesis 3.

- ***Social knowledge transfer relationships***

As for social knowledge transfer relationships, one finds again that smaller firms and firms located on a science park generate a higher proportion of sales with innovated products and services which are new to the firm (see Model 1). In Model 2, it shows that higher levels of unintended knowledge transfer are positively associated with higher levels of innovation outcomes, whereas a higher number of intended knowledge transfer relationships of a social nature has a negative impact on innovation outcomes. In a next section, an attempt will be made to explain this counterintuitive finding. Also, in these models, science park location seems to be beneficial and no moderator effects could be noted. In sum, for this type of knowledge transfer relationships Hypothesis 2 is confirmed, whereas hypotheses 1 and 3 are rejected.

5.5.2.3 Innovation outcomes: scope of innovation outcomes

A first observation from Table 16 is that the models for informal and social knowledge transfer relationships are not statistically significant. This implies that none of variables indicating interorganisational network activity of these types impacts on this dimension of innovation outcomes.

Table 16: Results of regression analysis for the scope of innovation outcomes

Variables	Dependent variable: scope of innovation outcomes								
	Formal relationships			Informal relationships			Social relationships		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	3.685***	4.070**	4.199	2.346***	2.7***	2.948***	2.281***	2.554***	2.621***
FS	-0.252*	-0.410**	-0.408**	0.080	0.051	0.078	0.106	0.090	0.105
FA	0.255	0.136	0.129	0.053	0.021	0.018	0.044	0.029	0.043
SPL	0.160	0.193	0.184	0.208	0.205	0.184	0.214	0.204	0.199
IKT		0.363**	0.164		0.141	-0.136		0.148	-0.054
UKT		-0.172	-0.280		-0.130	-0.221		-0.117	-0.147
IKT*UKT			0.256			0.351			0.225
R^2	9.9%	19.7%	20.4%	6.3%	7.8%	8.6%	7.0%	8.8%	9.0%
ΔR^2	9.9%	9.7%	0.7%	6.3%	1.5%	0.8%	7.0%	1.8%	0.2%
F-value	1.766	2.252*	1.920*	1.074	0.780	0.703	1.188	0.874	0.727
ΔF-value	1.766	2.784*	0.404	1.074	0.381	0.372	1.188	0.444	0.084
VIF	1.059-1.155	1.214-1.420	1.210-9.138	1.059-1.155	1.226-1.597	1.165-16.326	1.042-1.149	1.122-1.451	1.219-29.196

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Apparently this is not the case for the models of formal knowledge transfer relationships. From Model 2, it follows that the smaller the responding firm, the broader the scope of its innovation outcomes. Moreover, it is found that the more formal interorganisational relationships the focal firm has in which intended knowledge transfer takes place, the broader the scope of its innovation outcomes is.

5.6 Conclusions and discussion

5.6.1 Findings and implications

The primary objective of this study was to explain the mixed findings on the performance of firms located on science parks by investigating the effects of different knowledge transfer on firms' innovation outcomes. Two types of knowledge transfer were explored in this study: intended and unintended knowledge transfers. Using these two types of knowledge transfer, this study tried to answer the research question: To what extent do intended and unintended knowledge transfers explain the innovative performance of science park firms? Based on a review of the literature, three hypotheses were formulated.

In the empirical section of the chapter a sample of NTBFs located in the Gauteng region, which is the economic engine of South Africa (a country with an emerging economy), was used. Data were collected at the firm level by structured interviews with questionnaires targeted at the directors or CEOs: 52 valid questionnaires were obtained and about 50% of these firms were located on a science park. Statistical analysis using multivariate regression models, presented several interesting findings, which will be discussed below.

The discussion of the results of this study starts by reflecting on the extent to which firms in the sample used knowledge exchange channels. One interesting result is that the number of social knowledge transfer relationships is much larger than the other two channels that were distinguished. Comparable results were presented by Mitchell and Co (2004), who investigated the networks of a sample of entrepreneurs in South Africa. They found that South African entrepreneurs predominantly maintain social ties. However, having mainly relationships of this kind is not necessarily beneficial to firm performance (see below).

The main question to be answered in this study was how the mixed findings in the science park literature could be explained. Unfortunately, the study did not come up with a straightforward answer to this question. As a matter of fact, two answers are possible, depending on the view one takes.

The first answer to the question is that the theoretical explanation (Hypothesis 3) was not empirically confirmed. It was proposed that the positive relationship between intended knowledge transfer and innovation outcomes would be negatively influenced by higher levels of unintended knowledge transfer. However, this hypothesis was rejected in all empirical models. Apparently, this negative effect does not hold. Alternatively, this spillover effect is not observed by the responding firms, leading to no behavioural consequences and performance impacts.

The second answer to the same question is that science park location does play a significant role in the models in which innovative sales is the dependent variable, but not in models in which a different indicator of innovation outcomes is used. From the study, it can be concluded on the one hand that science park location brings these NTBFs the "right" environment and apparently enables them to use their resources more efficiently (for example, with the help of the science park management team) in order to generate higher levels of innovative sales. On the other hand, whether or not science park firms are regarded as successful depends on the way success is measured.

Are higher innovation outcomes also the results of interorganisational knowledge transfer? The findings show that this is especially the case for innovations with a higher level of newness (new to the firm). In these models, both science park location and intended knowledge transfer via informal business relationships have a positive impact. The latter finding supports Hypothesis 1. In some cases, Hypothesis 2 was also confirmed. Interestingly, social relationships have a negative impact. One explanation is that social relationships often are maintained with actors who are very similar. This so-called homophily effect (McPherson et al., 2001) in networks has a negative effect on innovation because similar actors have similar knowledge. An alternative explanation is related to the quantity and quality of the knowledge and information acquired through social relationships. As has been seen, NTBFs have many social ties, which could lead to an information overload, whereas at the same time the knowledge possessed by these external social actors is not necessarily the most relevant from a business perspective. In general, it must be concluded, however, that there is only weak support for the hypotheses on interorganisational knowledge transfer.

The findings of this research have important implications for managerial practice. The success of NTBFs relies heavily on the success of new product or service innovations, due to the increasing market competition. This study shows that different types of knowledge transfer can help to achieve certain innovation outcomes. The practical value of the findings of this study enables managers of NTBFs in South Africa to understand how the configuration of knowledge transfer channels affects innovative performance. Unintended knowledge transfers (often a result of opportunistic behaviour) are important to innovation outcomes in the South African context. This corresponds to findings in a study by Oerlemans and Pretorius (2006), where they report that South African firms tend to be imitative in nature. This is not necessarily a bad thing in an economy that lacks all kinds of (knowledge) resources. As Yamamura, Sonobe and Otsuka (2005) show for the Japanese motorcycle industry, an imitation strategy can be beneficial in the early growth stages of firms and industries.

5.6.2 Limitations and direction for future research

Although this study reveals valuable insights in the relationship between (un)intended interorganisational knowledge transfers, science park location and innovation outcomes at the firm level, some limitations remain. First, these findings are limited to the case of small technology-based firms in South Africa. Therefore, it would be worthwhile to examine the relationships proposed in this study in other contexts. Second, the dependent variable in the models (innovation outcomes) does not take *process* innovations into account. However, from the preliminary data analysis, the business and innovation activities of most firms in the sample are not focused on process development, but more focused on product or service development. Thus, although the results of this study do not give a complete picture of technological innovation in NTBFs, they still are valid in the South African context. Third, although this research took a differentiated approach by distinguishing between formal, informal and social knowledge transfer relationships, only the *number of direct ties* was taken into account. This is a commonly accepted approach in the field (Ahuja, 2000) but it implies that other relevant aspects of network are not included in the models. Examples are the strength of ties (Gilsing and Nooteboom, 2005) and the characteristics of partners in the networks (Tether, 2002).

This research raises a number of directions for future research. First, the third hypothesis on the moderating effect of unintended knowledge transfer was not empirically supported in this study. Other moderator variables may be explored to further examine which factors may have an influence on the relationship between intended knowledge transfers and innovative performance. An example could be the type of partner, because the probability of unintended knowledge transfer is higher when the collaborative partner is, for example, a competitor (Hamel, 1991). Second, this research was performed in an emerging economy. Similar studies can be done in other countries with emerging economies to benchmark the results of this research. Third, as mentioned earlier in the limitations of this study, other aspects of network characteristics can be included in future studies. For example, knowledge from networks established with "technological similar" partners may enhance incremental innovations, whereas, with partners who have totally different technologies (for example, ICT versus biotech), radical innovations could open up an entirely new market (Laursen and Salter, 2006).

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Chapter 6

Conclusions

6.1 Introduction

One of the initiatives that South Africa implemented in its National System of Innovation policy was the establishment of a science park in the Gauteng region, known as The Innovation Hub. It is the first internationally accredited science park in South Africa (IASP) and aims at contributing to the transformation of Gauteng into a "smart province" by actively supporting technology-rich and innovation-based businesses. Science parks stimulate and enable the management of the flows of knowledge and technology between science park firms (that is, firms locating on the science park premises), universities, research centres and the market, so that innovations are viable to sustain the knowledge-based economy. Despite all the great assumed benefits a science park location promises, many researchers questioned the positive effects of science park location by conducting comparative studies examining the presence of performance differences between science park and off-park firms (firms without a science park location). Some researchers reported that firms with a science park location perform better, whereas others reported that firms perform the same, regardless of location (more details in Chapter 5). The scientific relevance of this research is to provide explanations for these mixed findings found in the literature review. Therefore, the following main research question can be stated:

"*How does one explain the mixed findings found in previous research studies regarding innovative performances by science park firms?*"

To answer the above over-arching research question, a *relational* approach was used in four studies reported in Chapter 2 to Chapter 5, in which *inter-firm relationships* are explored. Each study addresses a specific subquestion:

- Chapter 2 answers the theoretical subquestion: *Which theoretical explanations can be given for the mixed findings regarding the performance of science park firms?*
- Chapter 3 answers the empirical subquestion 1: *Which knowledge exchange behaviours do science park firms show?*
- Chapter 4 answers the empirical subquestion 2: *If science park firms behave differently with regard to knowledge exchange, do these differences matter for firm performance?*
- Chapter 5 answers the empirical subquestion 3: *How can one explain the mixed findings from an empirical point of view?*

The next section of this concluding chapter will provide a summary of the research framework and the theoretical explanations for the mixed findings. The subsequent section will discuss the main outcomes of the empirical studies reported in chapters 3 to 5. Section 6.4 addresses the relevance of the extended resource-based view model as well as the addition of geographical dimension for this study. Based on the findings and interpretations of the empirical studies, some policy recommendations will be proposed and discussed in Section 6.5. Lastly, the limitations of this study and possible future research directions will be addressed in Section 6.6.

6.2 Theoretical framework: an introduction

The concepts of NSI and knowledge-based economy focus on *knowledge* flowing between elements of the system. In the literature, knowledge is regarded as an intangible resource of a firm, which can enhance a firm's performance and innovativeness (van Wijk, 2008). In the past, many researchers have asked the question: Why do firms perform differently? The resource-based view (RBV) model was developed to answer this question.

To answer the research question on the mixed findings reported in the science park literature, knowledge is considered as a resource of a firm, which is a node characteristic, and the RBV is used as this study's theoretical framework.

However, another important dimension of NSI is the *relationships* between elements; in other words, the interorganisational *relationships*. This relational dimension is not part of the conventional RBV, which does not take into account the "network resources" that a firm may gain from interfirm interactions. In Lavie's extension of the RBV model, he includes the benefits the alliance partners bring to the focal firms in interfirm networks. According to his extended RBV model, a focal firm may gain "appropriated relational rent" (that is, "intended knowledge flows" in the study) as well as "inbound spillover rent" ("unintended knowledge flows"). If one wishes to use this extended version of the RBV model in the study of the performance of science park firms, one finds that another dimension is missing and should be included, namely geographical distance between knowledge-exchanging firms. The rationale behind this argument is that most actors (firms, universities and research centres) in a science park are *geographically* concentrated within space. In the literature, geographical distances (or so-called *geographical proximity*) impact on the relationships between actors (for example, Baptista and Mendonça, 2009) because proximity is thought to facilitate the exchange of, especially, tacit knowledge. Chapter 2 developed a research framework by using a relational approach and by adding the geographical dimension to Lavie's extension of the RBV model. Adding the latter dimension signals the theoretical relevance in this study.

As discussed in Chapter 2, two types of knowledge flows can be distinguished: intended (knowledge transfer through networking) and unintended (knowledge spillovers) knowledge flows. The theoretical framework is developed with the research aim of explaining the mixed findings found in science park literature. The main hypothesis, providing a theoretical explanation of the mixed findings, of this research framework is:

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 as compared to off-park firms due to close geographical distance.

The rationale for the above main hypothesis is that when firms are closer to each other, it is easier for firms to observe any misuse of their knowledge or technology by their partners. Once this misbehaviour of their partners is realised, the already existing relationship (a formal or informal tie) between them may be weakened or even broken. The poor performance of some science parks, which is reported in the literature, could be explained by the accumulated negative effects of the use of unintended knowledge transfer.

To explore the framework further, three empirical studies were performed (using the relational approach developed) to address three topics: *knowledge exchange behaviours* (Chapter 3), *knowledge transfer effectiveness* (Chapter 4) and *knowledge transfers and innovative performances* (Chapter 5). The next section will provide a summary of the empirical findings and interpretations of these three empirical studies.

6.3 Main empirical findings and interpretations

6.3.1 Knowledge exchange behaviours

The results of the first empirical study were reported in Chapter 3. It explored the knowledge exchange behaviours (framework developed in Chapter 2) of on-park firms (firms with SP location) located in The Innovation Hub in Gauteng. The descriptive analysis in the first part yielded interesting findings: off-park ties are more frequent, more technologically similar, more organisationally close, knowledge received from off-park actors is more useful, off-park actors are of a more diverse nature, and more unintended knowledge flows come from off-park firms. In other words, off-park ties are relevant sources for on-park firms, rather than ties between each other (on-park ties) in The Innovation Hub. A negative interpretation is that The Innovation Hub does not perform its function of stimulating and supporting the knowledge flows in the park to the fullest. This resulted in on-park firms seeking for knowledge outside the park rather than co-operation between on-park firms. However, as is proposed in the literature, most knowledge exchange relationships are reciprocal, thus, The Innovation Hub could be regarded as focal driver of technological development to off-park firms.

The second part of the analysis discovered that there were two groups among on-park firms: a group that did not interact with other on-park firms and who interacted only with off-park firms (denoted as Group 0) and a second group that interacted both with other on-park firms and off-park firms (denoted as Group1). The most interesting finding when comparing these two groups' knowledge exchange behaviours was that Group 0 interacts more with public knowledge sources (such as universities and research centres) where as Group 1 interacts with private knowledge sources (such as suppliers, buyers and consultants). An interpretation of this finding is that firms in Group 0 are in the early stages of the innovation cycle (research and development) because they use more fundamental knowledge and Group 1 firms are in a later stage (commercialisation). Another interpretation is that for Group 0, The Innovation Hub is not primarily for networking purposes, but more for a reputation-building purpose (as it creates an image of an innovative firm). Moreover, Group 0 firms have higher patent outputs as compared to Group 1. This may be due to the fact that knowledge received by Group 0 firms (from public knowledge sources such as universities or research centres) is scientific knowledge, which is important for new or radical innovations where patents are necessary and worthwhile to invest to protect such innovations. On the other hand, the knowledge that firms in Group 1 received (from private knowledge sources such as competitors or suppliers) is more market-related. This kind of knowledge supports the development of incremental innovations. Patenting this kind of innovation may not be cost-effective and could be the result of the fewer patent outputs found in Group 1.

6.3.2 Knowledge transfer effectiveness

A relational view of knowledge transfer effectiveness was applied in Chapter 4. It is argued that knowledge transfer is not a frictionless process. Therefore, three types of barriers to effective interorganisational knowledge transfer were discussed: partner (dis)similarities (seen as organisational and technological similarities), frequency of knowledge transferred, and the knowledge receiver's learning culture. Research models to study the relationship between these barriers and knowledge transfer effectiveness were developed and explored within small new technology-based firms in the Gauteng region. The effectiveness of knowledge transfer was measured as the *usefulness* of knowledge received by a focal firm. The findings supported the hypothesis that frequent knowledge transfers was positively related to the usefulness of knowledge received. In other words, firms should interact more frequently to find more useful knowledge. The study found a U-shaped relationship between technological similarity and the usefulness of knowledge received. The finding suggests that firms should interact with partners with very similar technological knowledge bases so that the knowledge is easier to absorb and use for innovation or with very dissimilar knowledge bases so that novel ideas can be generated. The mixture of very similar or very dissimilar knowledge bases should be avoided because firms may be indecisive about their innovative direction. Moreover, this study showed a negative impact of organisational proximity on usefulness of knowledge received. An interpretation of this result, looking from the perspective of a dissimilarity in the firm sizes of two partners, may explain such finding. The sampled firms in this study are small technology-based firms (also known as new technology-based firms (NTBFs)). When they interact with partners who are larger, in principle they exchange with organisations that are organisationally different. An important reason for small firms to interact with larger firm may be to counteract the problem of liability of newness that is encountered by NTBFs, so that larger firms may: (i) bring NTBFs image or status in the market, and (ii) provide NTBFs with useful knowledge, due to their larger and richer knowledge bases. The hypothesis on the positive importance of the learning culture of the receiving organisation is not supported in this study. The non-significant role of learning culture can be interpreted by looking at the South African firms' innovative nature, namely that they often innovate by imitation. Furthermore, this research result shows that firms have a satisfactory learning culture and that the learning capabilities may not aim at learning "new knowledge", but at learning the "already existing technologies" (which can be imitated) from other firms.

6.3.3 Knowledge transfers and innovative performance

The relationship between knowledge transfers and innovative performance was investigated in Chapter 5 to empirically explain mixed findings in science park research. In that chapter, a multidimensional construct for innovative performance was proposed. Three hypotheses were formulated to answer the research question of this chapter: To what extent do intended and unintended knowledge inflows explain the innovative performance of science park firms?

The findings yielded interesting insights. Not all intended knowledge inflows impact positively on a firm's innovative performance. Intended knowledge inflows via formal and informal networks have a positive impact on firms' relative and new innovations respectively. On the other hand, the intended knowledge inflows via social networks have a negative impact on firms' new innovations. To interpret this finding, it was proposed that, compared to informal interorganisational network relationships, inter-personal social network ties are less able to transfer high-quality knowledge, due to social conversations that may mislead the direction of innovative activities; this could be as a result a poor innovation outcomes. Unintended knowledge inflows have a positive impact on a firm's new innovation outcomes only when the firm is involved in informal and/or social networks. This implies that knowledge spillovers happen through informal networking activities. The main hypothesis stating that "the relationship between the number of intended knowledge transfer relationships and innovation outcomes of firms will be negatively moderated by higher levels of unintended knowledge transfers" was not supported empirically in this study. In other words, this assumed moderating effect by spillovers was not observed by the responding firms. Consequently, no behavioural consequences and performance impacts could be measured.

Despite the fact that the theoretical explanation proposed for the mixed findings in science park research was not empirically confirmed at this stage, this research has provided a sequence of empirical studies which also investigated the factors that relate to performance heterogeneity (differences in patents outputs, knowledge transfer effectiveness, and firms' innovative performances).

6.4 Theoretical relevance of the study

This research is theoretically relevant because it proposes and uses a further extension of the extended RBV framework by adding a geographical dimension. Based on the findings in previous chapters, two questions relating to the theoretical relevance can now be answered:

1. Does the extended RBV framework work?

The answer is a clear "yes". It was empirically shown that networking with partners enhances the effectiveness of knowledge transfer (Chapter 4) and specific innovative performances (Chapter 5). Moreover, Chapter 4 pointed out three relational features that are of importance. Firstly, more *frequent* interactions with partners have a positive impact on usefulness of knowledge received. Secondly, if firms network with partners that are very *technologically* similar or distant, the knowledge they acquire will be perceived to be more useful. Moreover, NTBFs that partner with firms that are *organisationally* different (in this case, bigger firms) will be able to get rid of the problem of being “new” in the market and also at the same time obtain knowledge from their partners who have already accumulated their own knowledge bases.

Chapter 5 revealed the benefits of intended and unintended knowledge inflows through various network relationships. When firms interact with partners through formal networks, the intended knowledge inflow they receive will enhance their relative innovations. Additionally, these knowledge inflows via informal networks will enhance firms' new innovations. Moreover, when a firm is involved in informal and/or social networks, the unintended knowledge inflows (or so-called "inbound spillover rent" in Lavie’s study) will benefit a firm’s new innovations. The abovementioned benefits can be regarded as the "appropriated relational rent" that is proposed in Lavie’s study.

2. Does the extended RBV and its addition (that is, including a geographical dimension) work?

The answer is "no". SP location (SPL) does not play a significant role. No significant results appeared in models 2 and 3 in chapters 4 and 5. SPL is entered as control variable in the models developed in chapters 4 and 5 in which on- and off-park firms appear. In Chapter 4, the results showed that SPL was statistically significant in Model 1 (the model with only the control variables). In other words, this version of the model showed that firms with SPL, as compared to those without SPL, found the knowledge they received from their partners to be more useful for their innovative activities. However, SPL becomes statistically insignificant in models 2 and 3. This means that the three relational features, namely frequency of knowledge transfer, organisational similarity and technological similarity, outperform the importance of SPL with regard to the usefulness of knowledge received by firms.

In Chapter 5, SPL is again entered as a control variable in all models empirically explored. Although SPL does play a significant role in the models in which innovative sales is the dependent variable, it does not in models in which a different indicator of innovation outcomes is used. This shows there is little evidence that for this set of South African firms SPL (as a geographical dimension) matters when one looks at innovative performance from multidimensional aspects.

6.5 Policy recommendations

The empirical findings presented in this study lead to a number of policy recommendations. Below are the main recommendations that policy makers could take into account.

Chapter 3 pointed out two important issues. Firstly, firms located in The Innovation Hub had more and stronger interactions with off-park firms than with colleague science park firms. Since science parks are established with the aim of facilitating knowledge flows between on-park firms, it is recommended that the management team should pay more attention to establishing links between on-park firms, for example, by scanning new tenant firms in terms of their potential to partner with other resident firms. Moreover, the management team could investigate knowledge problems that innovating SP firms encounter and introduce other SP firms that may solve these problems by a joint effort between them. However, intellectual property issues have to be taken into account, as they often act as barriers to joint problem-solving activities (for example, Sawers et al., 2008). SP management could try to involve lawyers who specialise in intellectual property rights to overcome the problems caused by intellectual property rights between the two partnering firms. Secondly, it turned out that there are two groups of on-park firms. One group could be regarded as technology developers whereas another group appeared to be closer to commercialising their innovations. Based on the observations that these two groups are at different stages of the innovation process, The Innovation Hub management team could tailor their services to these two groups' needs. For technology developers, more research seminars could be organised on the park, whereas for the other group, which is closer to commercialising their innovations, more strategic marketing campaigns, for example, to build a closer link with venture capitalists, could be provided by the park management team.

In Chapter 4 it was discovered that technological proximity and frequency of interaction enhance the effectiveness of knowledge transfer. So, when designing a science park or evaluating new tenants, select firms that are very technologically similar (for example, in the same sector) and/or totally technologically dissimilar (for example, from completely different sectors). Moreover, a management team could arrange networking activities between them with the purpose of contributing to problem-solving rather than increasing general knowledge from guest speakers.

The empirical results further showed that there is a lack of interactions between NTBFs and research institutions such as public research labs or universities where fundamental scientific knowledge lies. Therefore, policy makers could pay more attention to establishing a closer industry-academic link, which is necessary to improve innovative outcomes. This could, for example, be done by giving government subsidies to those firms or university departments that collaborate in joint research projects, thereby increasing the willingness to establish such links. Moreover, universities could improve the efficiency of their boundary organisations that are supposed to advance these collaborations with SP firms. This could also be done by improving the structure of the boundary organisations, for example, a separate team could be added to the structure to monitor the progress of the joint projects between the assigned university personnel and SP firms.

Chapter 5 indicated that one could take into account the configurations of knowledge transfer channels as well as the multidimensional construct of innovation outcomes. In other words, certain configurations of knowledge transfers could help to achieve certain dimensions of innovation outcomes. For firms which have the aim of achieving innovations with higher levels of newness, it is recommended that intended or unintended knowledge transfer via informal business relationships should be the focus. This could be done by organising strategic (only R&D researchers are invited) informal business lunches or golf event with partnering firms.

6.6 Limitations and future research

There are several limitations to this research. Firstly, the results of this study cannot be generalised to all other emerging economies, because samples were taken from firms located in a specific region of South Africa. Therefore, all findings, interpretations and recommendations are only valid for the Gauteng region. To draw a bigger picture that can be generalised, similar studies should be conducted on the effects of science park location in other regions of South Africa (for example, the Western Cape where Technopark Stellenbosch is situated) or other emerging economies of developing countries. Then a truer picture of science park phenomenon would be established.

Secondly, the data collected in this study are cross-sectional and thus not longitudinal. In countries like South Africa where supporting academic research is not on the top priority list of businesses, collecting longitudinal data from them would be a problem. In order to fine grain the analysis, one could seek evidence from longitudinal case studies as a research methodology in many other studies (for example, Stevens and Dimitriadis 2004, Corso et al, 2009). Longitudinal research is important, since SP firms are usually very young firms that need time to develop and grow. Moreover, most SP firms generate innovations and the innovation process takes time to show results (from an idea to R&D to prototype to commercialising products).

Thirdly, this study focuses only on egocentric networks, that is, on a focal firm and its direct ties, as it is assumed that the boundary of the network of science park firms is difficult to determine because on-park firms could also have many links with off-park firms and the network structure of this latter group of firms is hard to determine. It is therefore only the *degree centrality* that is investigated as an indication of structural network characteristics. However, if one looks only at firms located on a science park and only investigates the direct interactions of firms, several other structural network characteristics, for example, density *structural holes* and their effects on innovation outcomes (Kenis and Oerlemans, 2008), cannot be investigated. Consequently, their influence on innovative performances of science park firms is disregarded.

Finally, the off-park samples were chosen on the assumption that they had not previously been located on any SP. It could be interesting to investigate those who have left a SP, to determine the process that led to their decision to leave the park. Such studies could reveal the problems that SP firms may encounter and thus provide further suggestions for improving the functioning of SPs. Moreover, such studies could also explore whether a previous SPL experience still has an effect on the performance of firms who have left a SP.

This research used a relational approach to investigate the role that SPL plays in an emerging economy. Although the theoretical explanation of the mixed findings found in SP literature is not empirically supported, this research has investigated interorganisational network relationships and reported various factors that significantly impact at different levels of firm performances (that is, factors behind performance heterogeneity). Moreover, the discussion in the recommendation section pointed out certain issues that could account for the mixed findings. In other words, the mixed findings in SPs (some researchers found SPs to be important and some think otherwise) may be accounted for by the differences in their scanning processes of new entrant firms, the nature of networking activities, services provided by the SP management team, academic-industry links and configurations of knowledge flows.

Although SPs are often seen as engines for a rapidly growing economy, this study pointed out that SPL, as a geographical phenomenon in which knowledge interactions take place, is only significant in certain aspects (namely innovative sales) of innovative outcomes and not when one takes other aspects of innovation outcomes into account. More empirical studies are needed to investigate the role of SPs from various approaches so that a richer and fuller picture of SPs in the knowledge economy can be painted. Future empirical studies may also help policy makers to further improve the designs of SPs and enhance their roles of supporting innovative activities in emerging economies.

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