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Paper title: The Strategic Value of Oscillating Tie Strength in Technology Clusters

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Keywords: Science and Technology Parks, strong and weak ties, innovation networks, clusters, Brisbane Technology Park, high-tech SMEs.

The Strategic Value of Oscillating Tie Strength in Technology Clusters

Abstract

This paper focuses on the innovation networks of high-technology Small and Medium-sized Enterprises (SMEs) within a Science and Technology Park (STP). More specifically, the study examines the role of network ties in high-technology SMEs by focusing on the linkages employed by small businesses to learn, adapt to technological change, and innovate. The paper presents evidence from a recent survey of Brisbane Technology Park (BTP) and this illustrates how the competitiveness of local high-tech firms will be enhanced by the suggested model, which describes the need for oscillation between weak and strong ties at different stages of the innovation process and diffusion.

Keywords: Science and Technology Parks, strong and weak ties, innovation networks, clusters, Brisbane Technology Park, high-tech SMEs.

Introduction

In order to ensure future longevity, nations and companies alike must adapt to changes in the environment, and focus their efforts on the process of innovation and the development of competitive advantage (Lalkaka, 2002; Hamel & Valikkangas, 2003). It is now widely recognised that innovative outcomes do not occur in isolation, but are best achieved through interactions with other environmental actors, particularly those with complementary skills and resources **(**Hattori & Lapidus, 2004; Horn, 2005). Chesbrough (2003) has referred to this expanded approach to information and resource sharing through interactions as 'open innovation' system and stressed the importance of such a model in the development of accelerated technology outcomes and their wider diffusion.

Indeed, a growing body of research has demonstrated the success of the emergent inter-organisational arrangements such as networks, collaborations and various forms of innovation clusters in the development of innovation across a wide field of interest (Huxham, 1996; Dewick & Miozzo, 2004; Powell et al., 1996). Science and Technology Parks (STPs) are examples of this emphasis on clustering for innovation. While some STPs have emerged spontaneously over time (most famously 'Silicon Valley'), a vast majority have been formed deliberately in an attempt to emulate the perceived ability of such entities to derive spill-over effects at the regional and national level through innovation and Research and Development (R&D) efforts (Phan et al., 2005).

Through their participation in clustering within STPs, Small and Medium-sized Enterprises (SMEs) are able to exploit the benefits of geographical and sectoral concentration (such as the division of labour and specialisation resulting in normally unattainable scale economies), leading to the creation of an environment that is conducive to knowledge sharing, joint-action, and ultimately innovation (Schmitz, 1995). Entering clusters and networks also allows for the formation of linkages and relationships between people and organisations. The structure and strength of these linkages is important – weak ties are said to foster access to

new and novel information, while strong ties provide the coherence (trust, commonality) necessary to achieve collective goals (such as innovation). While some suggestion exists that firms should concentrate on developing either strong or weak relational ties, a growing understanding is emerging that both strong and weak ties are necessary for innovation (see for example Elfring & Hulsink, 2003).

Despite the agreement in the literature on the need for differentiated tie or relationship strength for innovative outcomes, how these intersect and role of the other relational mediating factors for diffusion of innovation have remained largely unexplored. This paper examines the duality role of network ties and by using a case study of a South-East Queensland STP to provide insights, the paper will focus on the nature of relationships and exchanges between SMEs of a technology park and their stakeholders. It argues that the nature and strength of the linkages between firms and their stakeholders, and across sectoral boundaries, influence the scope and purpose of various business activities and the innovation process. In fact, the nature and characteristics of these linkages often help to determine the effectiveness of the innovation process and diffusion. For this purpose, firstly the paper will look at the literature related to networks, innovation and network ties highlighting the factors necessary to support the process. Following this literature review, the methodology used to build the case study and key findings are presented. Finally a discussion of the relationships within the BTP network cluster and mediating factors, and its application to the model derived from the literature will be presented, with some concluding comments.

Literature Review

Networks & Innovation

While innovation is viewed from a number of different perspectives by a range of interest groups (such as economists, researchers, managers, geographers, and government departments), Marceau and Dodgson highlight the importance of its systemic nature, either

within internal organisational systems made up of various departments which encompass an overall innovative 'team effort', or of more significance to this study, the view of innovation as an outcome of complex network interactions between innovating firms and a range of other entities, such as suppliers, customers, universities and government (1999). Through such interactions, innovation can be developed to effectively meet the needs of a range of stakeholders, thus increasing the likelihood of its success.

Given the often unclear perceptions that exist about innovation, particularly from the perspective of organisational leaders, Ulrich (2002) presents three premises of innovation; firstly he suggests that "Innovation matters" – it is critical to growth and survival. Secondly, he states that "Innovation is multifaceted" – influenced by a variety of different factors, and affecting organisations at various levels. Finally, Ulrich states "Innovation is a culture, not an event" – highlighting the importance of innovation being considered a cultural issue within an organisation. Recognition of these premises, it is suggested, will allow for a greater understanding of the nature of innovation and its benefits. These views are consistent with Tushman and Nadler's statement that "Organizations can gain competitive advantage only by managing effectively for today while simultaneously creating innovation for tomorrow" (1986: 92).

With regard to the drivers of innovation, Hyland and Beckett state that "Amidst the diverse views relating to innovation is a recurring theme, namely that innovation is a *people-centred* process, which commonly involves *technology* and requires some kind of systematic approach to achieve consistent results", suggesting that innovation is invariably driven by people (demand-driven innovation) or technology (supply-push innovation) **(**2004, 36-37**)**. Another commonly identified driver of innovation is that of *location*, which has gained considerable interest over the past several years within research on technology clustering. One of the main reasons that location is said to influence innovation is that close proximity to other innovators and stakeholders facilitates knowledge transference, which is particularly

important when much of the knowledge to be transferred is *tacit* in nature, making it difficult to be articulated and shared between geographically dispersed actors, in contrast to easily documented *explicit* knowledge **(**Nonaka, 1994). It is argued that the outcome of the transference of knowledge between different actors is the creation of new knowledge, some of which may later become innovations (Ibrahim & Fallah, 2005).

Furthermore, new product development, particularly in high technology industries, can be driven through co-operation between individuals with "Partially overlapping tacit knowledge of a technical source" (Lawson & Lorenz, 1999: 310). Therefore, to quote Baptista and Swann, "So long as much technological knowledge has a tacit nature and cannot be codified through plans, instructions or scientific articles, it seems reasonable to expect a greater geographic concentration of innovators" (1998: 528).

Recognising the highlighted benefits of knowledge exchanges within geographical regions, Ulhøi (2004) has proposed the greater adoption of *open-source* based innovation, particularly in cases where proprietary licensing is costly or ineffective, and the speed of technological development is crucial (such as in high technology industries). If such ideals are to be adopted, the establishment of stable social relationships between innovators and other interest groups will be necessary, providing the opportunity for the dynamic patterns of communication that form part of the knowledge generation process (Ulhøi, 2004). These relationships may be formal or informal in nature and can be characterised as a 'network'.

In the context of this study, a network is viewed as a "basic social form that permits inter-organisational interactions of exchange, concerted action, and joint production" (Alter & Hage, 1993: 46). As previously highlighted, through interactions with a variety of different actors (such as cluster members, customers, suppliers, and professional associations), firms are able to create, obtain, and diffuse knowledge and resources, which in turn encourages the creation and diffusion of innovation within the network (Swan & Newell, 1995). While the literature acknowledges the value of networking, it also suggests a paradox between

competition and cooperation that affects firms involved in networks. Through participation in network arrangements, particularly within tight cluster arrangements, firms simultaneously *cooperate* (to expand the rewards and resources available to network participants) and *compete* (for division of these rewards and resources) with each other, inevitably resulting in positive efficiency and effectiveness outcomes within clusters (Wilkinson & Young, 2002).

Given recognition of the influence networked relationships have on innovation, some researchers have promoted the concept of 'interactive innovation,' which attempts to model innovation as an outcome of complex interactions within organisations, the broader scientific community and the marketplace (Rothwell & Zegveld, 1985; Fontana & Sørensen, 2005). Further, these authors contend that such interactions in turn influence an innovating firm's technological capabilities and attempt to match them to market needs. Although this model was quite effective at explaining innovation in the mid-1980s, recent application of it to high-technology based industries (such as telecommunications) have found that it fails to take into account the disruptive nature of rapid technological change, and the effects of multiple networks of stakeholders simultaneously influencing innovation (Fontana & Sørensen, 2005). Other attempts to model effective network interactions that provide access to varying forms of knowledge argue on the grounds of *relationship strength* and *network density* (for example, Burt, 1992; Granovetter, 1973; Uzzi, 1997a), as discussed in the following section.

Networks and Ties

Within the context of network tie theory, *relationship strength* is a function of time (spent developing the relationship), emotional intensity, intimacy (mutual confiding), and the degree of reciprocity present in a relationship between two parties (Granovetter, 1973). *Network density*, on the other hand, is viewed as the extent to which network nodes are directly connected to one another – in a completely dense network; every network node would be directly connected to all others (Reagans & Zuckerman, 2001). According to these authors, increases in network density "indicate the enhanced capacity for a team to coordinate its

action, thereby enhancing performance" (2001: 503**)**. From this literature, two main arguments have emerged, which will be briefly discussed below.

Granovetter's seminal work *The Strength of Weak Ties* argues that networks based on 'weak ties' (distant and infrequent relationships) are more efficient at sharing knowledge as they provide access to novel information from otherwise disconnected parties (1973). In contrast networks characterised by 'strong ties' lead to information redundancy, due to frequent interactions amongst a small group of parties that quickly become aware of everything the others know (Granovetter, 1973).

A number of studies have extended their support to the value of weak ties for a variety of different reasons. In a review of the effects of strong ties on economic action, Uzzi (1997a) found that weak 'arm's-length' ties were more effective at facilitating economic exchanges, as firms with such ties frequently entered into broad price sampling strategies, rather than becoming entrapped in bargaining situations with a small number of inefficient network members. Hansen (1999) promotes the value of weak ties on the grounds that they are much cheaper to maintain than strong ties, which require frequent interactions between network members. Furthermore, Hansen suggests that weak ties provide a better basis from which to search for new knowledge, as they do not constrain a firm's actions as greatly as strong ties (particularly on the level of reciprocity expectations), and they also promote searching outside of established relationships (rather than concentrating on a select group with which to interact). Weak ties have also been indicated as a method to reduce the risk of *group-think* within networks, through emphasis on interacting with parties outside of regular business and social circles with whom consensus is common (McEvily & Zaheer, 1999). Weak ties also can benefit originators of new technological knowledge by bringing them into closer contact with a wider selection of possible users (Robertson, 1998).

A key contribution of strong ties is their cohesive element. That is, the ability through closer relationships and interactions to achieve the collective processes often necessary in

innovation (Powell et al., 1996). Further, although acknowledging the benefit of weak ties, Uzzi states that strong ties are highly valuable to diffusion of fine-grained information "…More proprietary and tacit than the price and quantity data traded in arm's-length [weak] ties" (1997a: 45); within relationships based on strong ties, mutual trust and shared meanings exist (leading to less need for formal governance mechanisms), and joint-problem solving efforts are more common (Uzzi, 1997a), thus such relationships clearly extend themselves to innovation processes.

Additional support for strong ties within the literature circulates mainly around the issue of tacit knowledge diffusion. For example, in a study by Reagans and McEvily (2003) results indicated that both tacit and explicit (codified) knowledge was transferred more effectively through strong ties. However, the point was made that due to the increased resource demands of maintaining strong ties, it is inefficient to transfer explicit knowledge through strong ties, given that weak ties are just as effective in this regard. In addition, support for strong ties on the grounds that it fosters *trust* (faith that exchange partners will not act in self-interest at the expense of others) within inter-firm relationships has emerged, the outcome of which is increased contributions to the network relationship (such as valuable knowledge and resources) beyond the expectations of an exchange partner (Uzzi, 1997b).

The collective impact of increasing trust, more detailed and even confidential information sharing, and stronger ties between organisations leading to more collaborative and innovative outcomes has also been noted in other fields (Thompson and Sanders, 1998; Brown and Keast, 2003). For example, based on relational and structural aspects Brown and Keast (2003) have developed a 'Continuum of Connectedness' (115-122), which rates a network type as either *cooperative, coordinated,* or *collaborative* and suggests that different relationship structures should be used to achieve specific outcomes. Similarly, Hattori and Lapidus (2004) present a matrix of relational dynamics with which to define the state of a

networked relationship, based on the state of trust within the relationship (ranging from *distrust* to *high investment* in joint outcomes).

While much of the literature in this field argues for the establishment of either strong or weak ties within network relationships, support also exists for the creation of networks with characteristics of both approaches. Hansen's (2002) work provides an example of such an approach, proposing that while strong (direct) network ties are effective in transferring non-codified tacit knowledge, they potentially cause harm to organisational effectiveness when used to transfer codified knowledge due to the network maintenance costs involved; in such circumstances, weak (indirect) ties should be used to transfer codified knowledge (consistent with the findings of Reagans and McEvily, 2003). This condition of duality is expressed concisely by Lechner and Dowling who state, "Knowledge creation seems to depend on strong ties while knowledge acquisition depends on weak ties" (2003: 21).

Drawing from the extant literature, the following model presents the importance of weak and strong ties in the innovation process, which can be applied within the context of STPs.

Insert Figure 1 here

Flowing from left to right, this model suggests that firms within or outside STPs should primarily focus on the establishment of a large network of weak ties, linking themselves to other members within their STP and also to a variety of external actors (such as suppliers, customers, investors, government, and universities). Through this network of weak ties, firms will be able to identify novel ideas, knowledge sources, and opportunities for closer cooperative efforts. Upon identification of an opportunity for innovation (light bulb) within the network of weak ties, the ties with those involved should then develop into strong ties facilitating an environment of trust and tacit knowledge sharing, conducive to innovation development. This process of firms converging around new opportunities for development can be connected to the analogy of moths being drawn to a bright light (new idea) that is

switched on, providing the moths (SMEs) with a sense of direction and the capacity for a higher level of creative interaction and innovative solutions (Keast, 2004). Finally, after the development of innovative ideas into new products or processes, the firm's focus shifts to the diffusion of their innovations through another network of weak ties, given its identified ability to connect firms to a wide variety of potential users and customers.

Although this model provides a basic to guide the process of innovation within STPs through oscillating tie strength, a more detailed understanding of the nuanced is required to move from conceptualisation to implementation. Through further development of the model within the discussion section; strategies to facilitate the propagation of these outcomes within STPs will be unpacked. The following sections outline the methodology and address the key findings of the study.

Methodology and Sample

This research project forms part of a larger research project examining cluster formation, governance, linkage patterns and success factors at a Technology Park, located in South-East Queensland. Within this broader case study context, the current study pays particular attention to the examination of the nature and strengths of relationships occurring within the technology parks and how they impact on innovation outcomes and diffusion. Further, the study seeks to gain additional insights to distil key linkage supporting mechanisms within the park such as role of the park managers. The study adopts a largely inductive research approach that seeks to draw on the insights provided by the case to enhance the innovation model (Patton, 1990).

The dynamic, evolving and often uncertain environment in which both SMEs and their networks exit and the relatively unknown detail of what cluster members are actually doing to build relationships and create networks lends itself to a case study approach (Pandit and Cook, 2005). More specifically, a single case study has been selected because of is its ability

to focus on an individual unit, establish a more detailed 'view' of its operation, track and explore the 'lived experiences' of participation in a cluster arrangement as well as provide a fine grained understanding of processes and mechanisms (Yin, 2003).

The Brisbane Technology Park (BTP) has been purposely chosen to form the basis of this study for a number of reasons. Firstly, although the BTP has been in existence since the 1980s, it has experienced a number of fluctuations in terms of its membership composition and related tie strength. It is envisaged that this variation in membership and cohesion will provide useful insights into processes for building and maintaining cooperative networks. Secondly, as BTP is not located in direct proximity to universities and other such research institutions, valuable network connections to such institutions will require purposeful establishment by BTP members. Furthermore, BTP is an initiative of the *Department of State Development, Trade and Innovation*, and forms part of Queensland's 'Smart State' program, designed to create/stimulate growth in employment and state economy. The key objectives of BTP as outlined on its official website are to:

- Develop as a community that makes visible and evident, a range of business, economic and scientific skills;
- Provide resident companies involved in the commercialisation and exploitation of technology with a sense of identity; and
- Provide an environment that develops a sense of community in which all residents contribute to the healthy exchange of scientific and other knowledge between businesses and individuals (BTP, 2005).

Such objectives appear consistent with those of the majority of technology parks identified within the literature, in that most are seeking to achieve economic returns at the park and regional level (Phillips, 2002). Another feature common to STPs is the presence of a park management body, charged with the task of maintaining infrastructure and driving the region to meet set objectives; in the case of BTP, a combination of a public and a private sector organisation is involved in both park precinct management and park development management, to ensure both State government and park objectives are achieved.

For the review, combinations of quantitative and qualitative data were collected, by means of a questionnaire and face-to-face interviews. The structured questionnaire was designed to identify the nature and type of relationships of BTP firms, the perceived importance of these linkages, and to map the scope of cooperative networks. The questions were formulated in two different ways: (a) 'factual' questions requiring a dichotomous (yes/no) response; and (b) questions which were answered on scale-type responses, indicating intensity of the linkages, location and importance of the information and knowledge ranging from little importance to very important. Further to map the relationships between the firms within the BTP with other organisations the following questions have been explored during the survey: Which partners within the park do firms interact with in the innovation process? How important are these interactions? how important is the BTP network compared with their local and global networks? And what sort of linking mechanism may assist in the way the BTP network functions?

Quantitative data were subject to descriptive analysis techniques. The linkage data were collated into a linkage matrix that initially provided aggregate frequency scores of the interaction between agencies across identified variables as one indicator for strength of ties (Granovetter, 1973).

Additionally, follow-up discussions and interviews held with senior managers of selected firms were undertaken in order to investigate in more qualitative detail the nature of the their relationships and their experience of the learning and sharing processes within innovation networks. Some of the questions asked during interviews include; how the firms perceive their participation in the park as beneficial to their activities? Where are major customer-supplier networks located? What mechanisms or approaches have been used to manage and coordinate the activities of the BTP network? And what are some of the factors that may contribute to the success of a Technology Park like BTP?

All interview responses were transcribed verbatim and analysed using a thematic analysis approach. Themes and sub-themes that emerged from the data were subsequently pieced together to produce a comprehensive picture of the experience of the respondents and their linkages. The resulting themes and insights were considered in the context of the preliminary innovation model and used to populate an expanded model.

The sample of firms used in this study was drawn from the Directory of companies available on the BTP's website. The firms within BTP largely belong to the sectors of multimedia, software development, electronic services, telecommunications and biotechnology; the so-called high-technology firms. All 56 of the firms located with BTP at the time of this study were chosen to receive questionnaires. The five-page questionnaire was first e-mailed to companies in BTP. Follow-up telephone calls and emails were also made. In total, 24 usable firm responses were received, yielding a response rate of ≈43 per cent. Out of these firms 13 are SMEs, while 10 are branch offices of existing firms and only one is a corporate spin-off. Among these firms 10 firms have less than 20 employees, nine between 20 and 100, and four have over 100. The relatively low response rate can be explained in part by a period of turbulence within BTP, during which several members entered and exited the cluster, making it difficult to gain access to firms active within the park.

Ethical considerations

Given the sensitivities of conducting research into a small and relatively close-knit facility such as the BTP and the particular issues associated with qualitative research generally (Patton, 1990), ethical considerations were given paramount consideration. Standard ethical requirements such as informed consent, voluntarism and confidentiality were achieved by the application of key components of the research ethics framework developed by Miles and Huberman (1994). First in addressing informed consent (Miles and Huberman, 1994) all respondents were fully informed at the time of initial contact and prior to participation about the nature and purpose of the research, what their contribution would involve as well as what

they could expect from the research team. Also at the beginning of the questionnaire and prior to each interview, a signed statement of consent was secured via a standardised script detailing the research processes, expectations and the ability to withdraw for any or all of the questions. Finally, individual confidentially was assured through an aggregation of quantitative responses and by a careful and judicious selection of qualitative statements and quotations.

Findings

In order to achieve a more detailed understanding of the type and nature of the relationships occurring between BTP members and their impact on the exchange of knowledge and the fostering of innovation within the park, as mentioned, a set of questions based on network linkages, advantages of clustering and the role of network facilitators was administered. The first question, administered in the form of a network linkage survey contained within the questionnaire, provided a list of possible BTP members and asked respondents to indicate which organisations they had regular contact/exchanges with against a set of variables such as type of interactions (e.g. technical advice, informal contacts, etc.) (see Table 1).

Insert Table 1 here

As Table 1 displays, BTP firms are involved in an array of linkages, of which exchange of information (51), informal contacts (42) and formal contracting (42) are the most frequent. This result is not surprising since shared information exchange is understood to be the most common and least risky form of exchange between organisations, and as Pake has noted, "Beneath most formal ties … lies a sea of informal relations" (1986: 36). It should be noted, however, that while at first glance it appears that participating firms are involved in a high level of interaction; on average it is quite low in comparison to other studies (Schmitz, 1995). For example, each of the 24 firms indicated that they engaged in formal contracts with

only 2.33 other firms of the total 56 located in the BTP at the time of the study. Nevertheless, the existence of multiple ties is an indication of a level of strength of ties occurring between firms, providing a stronger basis for cohesive activity toward innovation outcomes (Powell et al., 1996; Chesbrough, 2003). Further, a more detailed interrogation of the linkages uncovers the existence of a core group that is involved in multiple types of exchanges. This result provides some evidence that several park members have entered into relationships based on higher levels of trust, involving the exchange of information and technological advice, suggesting that some firms have been able to achieve strong ties within BTP.

Additionally, participants were asked to identify any major links with other outside networks and rate the importance of these in terms of their business activity; three rating levels, high, medium and low, were provided. It is clear from the data collected that networks for BTP firms extend beyond the local region (see Table 2).

Insert Table 2 here

Nearly 50 per cent of the firms reported the importance of national and global networks. Data suggest that most of these networks are between firms in the supply chain (suppliers and customers). This evidence suggests that despite acknowledging the value of local 'networking' between firms in the park, firms have not actively involved themselves in localised information sharing or relationship building/networking as a particularly important factor in their general business activities. This emphasis on external relations was underscored in interviews carried out with firms within the park. For example one respondent noted:

> Suppliers, most of them are international, ranging from Italy to Canada to the United States and the United Kingdom. Then my clients are basically Australian and New Zealand. (Interview 24 May 2005)

As well as providing specific support services and resource advantages, linkage to additional external networks can facilitate access to knowledge and opportunities. Because regional and broader institutions interact within relatively larger networks of linkages, they can act as innovation facilitators. Evidence of the utilisation of external networks to obtain

knowledge has been identified in interviews conducted in this study, with one firm suggesting they had easier access to knowledge other than within the technology park:

> Inwardly we have a lot of knowledge within the company, so there are very few occasions where it would require me to go to anyone within the Park, not because they haven't got the knowledge, don't get me wrong about that. It's just that I have easier access to knowledge in other places. (Interview 13 April 2005)

To analyse the degree of willingness and commitment to knowledge exchange and economic advancement within BTP, respondents were asked if they believed that friendly contacts with other firms in BTP were an important asset for their firm; approximately 65 per cent of respondents indicated a perceived value in their relationships within BTP. Some uncertainty as to the source of this value, however, was evident, as indicated in the following interview extract:

> It's difficult to say just what the advantage will be but as I just said there are advantages. To discover that someone's got some products that you can use, or even that you can manufacture the product that the other guy wants to do, we've got software here, you've got developers, we've got testers and graphic parts, if a small company grabs that, there has got to be advantages. (Interview 23 May 2005)

In this way, there is an evident recognition of the potential benefits of relationships within BTP, particularly given knowledge of other people and their products; however, due to the uncertainty of the advantages to be derived from relationships within the park, trust (or a 'leap of faith') is required to take steps to seek these advantages.

Interestingly, when respondents were asked if they considered the same outcomes could be achieved if located outside of the park (16 respondents indicated they had developed new products and processes while located at BTP), 68 per cent of respondents believed they could. This finding is particularly noteworthy, given the emphasis in the literature on the difficulties faced by SMEs operating autonomously; one explanation of this finding is that several of the interviewed firms were branches of existing firms, which may be capable of providing them with the required support for innovation. Finally, respondents were asked to detail the frequency with which they exchanged ideas or experiences with other firms - a

majority of them (16 firms) responded only 'occasionally' and only three firms indicated 'often'. The responses of six firms, however, indicated that they have never exchanged ideas or experiences with other firms.

Another interesting finding that came out of this research was the identification by SMEs of the need for trust and cooperation within STPs to facilitate innovation, but in some cases such as BTP, there was a partial failure in achieving these outcomes. In general, relationships tended to be underpinned by a contractual aspect. This notion of individualism and competition within clusters such as BTP is highlighted in the following quote:

> Why should I [share knowledge] - he's my competitor. And I have absolutely no problem with destroying his business, so intellectually why would I bother giving him an advantage? We don't – its human nature. Certainly if you have ever been associated with something … where you have got to fight for everything and every battle that you will if it includes getting the advantage over a competitor you take it, like *war*. (Interview 13 April 2005)

Clearly, likening business relations within a technology park to a competitive war zone does not appear consistent with the objects of BTP previously outlined, or conducive to establishing trust and cooperation to achieve innovative outcomes within the cluster.

From analysis of the data collected at BTP, it also appears that while firms generally acknowledge the benefits of working together to achieve innovative results they have not made the adjustments necessary to shift from competition to cooperation. This situation is likened to the *precontemplation* stage associated with addition interventions, where, despite an awareness of the advantages of a behaviour change, clients continue with prior non-productive actions (Velicer et al., 1995). This *acceptance of the mediocrity* of interactions was highlighted during an interview of a BTP firm:

> We have an association there, we know the people there, sometimes we do a little bit of stuff, but it is rare. (Interview 13 April 2005)

With regard to the role of the network facilitators the findings suggest that the difficulty faced by STPs such as BTP is the lack of emphasis of park management with

regards to their relationship facilitation roles, which identified during interviews conducted at BTP:

> …I don't think that they have understood what needs to be done to engender this … the word is synergy. Whether it is speaking together, to the government or seeking to increase facilities. (Interview 23 May 2005)

Expanding on this statement, the same interviewee goes on to state:

> I think of all the knowledge that we are missing, there are all these strangers out there and we don't know what they do and they don't know what you can do, so you really need some kind of means of making it happen. You cannot always make this happen, obviously the park manager can't force people to make people be involved but there are ways of engendering enthusiasm. (Interview 23 May 2005)

These views may suggest why responses regarding the need for cluster facilitators/ managers at BTP appeared indifferent, receiving support from less than half of the firms surveyed (≈45 per cent).

In summary, this case study has presented a range of findings on the nature and type of networked relationships within the BTP. The following section will discuss further the key findings and will further develop the model of network ties in the innovation process derived form the literature and presented in Figure 1.

Discussion

In the previous section, a range of findings relating to the linkage of BTP members, reasons for clustering and the role of network facilitators was presented. Drawing from the body of these findings two key issues relevant to the emphasis of this paper will be discussed in further detail, namely the nature and strength of these linkages and the role of the mediating factors, such as network facilitators.

Nature and Strength of Network Linkages

While the findings suggest that an element of strong ties may exist between some BTP firms, in general, relationships appear to be established and governed principally by economic transaction contracts, suggesting a lack of trust within the technology park. Further, the findings broach the fact that BTP firms appear more interested in building on relationships

outside of the park than tapping into the benefits available locally; this phenomenon could be referred to as an 'innovation slippage' in which potential advantages to cluster members have 'slipped' out of the local network and entered the broader/distant network. This notion of *innovation slippage* within BTP may suggest that a lack of commitment to valuable knowledge exchange exists within the park.

While the respondents indicated that they valued the provision of supportive infrastructure (consistent with the literature previously highlighted), there was some deviation from the literature in a number of areas, principally relating to the amount of emphasis placed on external networking rather than developing internalised cooperative networks (Boland & Tenkasi, 1995), sometimes referred to as 'communities of knowing'. As a consequence, BTP firms may be failing to capitalise on the opportunities presented to them locally, inevitably also costing them greater amounts of the time and money necessary to develop geographically dispersed relationships.

Moreover, it appears that many of the members of this particular technology park have entered for reasons other than just the collaborative advantage of cluster locales. While technology parks/clusters offer members a wide range of benefits, their propensity to facilitate networking amongst members is generally seen as their greatest advantage. Co-location within STPs additionally promotes the transference of more complex tacit knowledge, which may lead to opportunities for innovation, one of the primary goals of a majority of technology parks, including BTP. In the case of a number of surveyed and interviewed BTP members, however, their focus, at least initially, was on the establishment of their own businesses. In this way networking (that is, establishing contacts and learning about the operations of others and their resources) and searching for potential synergies within the park were often overlooked.

Further, members within BTP indicated that their primary motives for entering the park were to present a good *image* to their customers, or the lower overheads within the park

and easy access to parking. These findings may suggest a need to perform more stringent testing on all potential technology park members beyond whether they can afford to pay rent, and instead place a greater emphasis on identifying any valuable capabilities they may have to offer and on their willingness to become actively involved within the cluster environment.

A final potential reason for a lack of collaboration and trust being developed within STP networks is a shortfall in member SME skills in networking and knowledge capturing processes, which Macpherson et al. (2003) have identified as vital functions of owner-operator SMEs. Additionally, these authors highlight the need for support agencies to provide SMEs with assistance to develop and maintain learning networks and identify further opportunities to enhance their knowledge base; technology park management/facilitators are an example of such a support agency capable of providing this service.

The Role of Mediating Agents

Thus far, cultural and behavioural issues have been highlighted within this discussion as dampeners to cooperation and trust within STPs. To overcome these issues, there is an identifiable need for mediating agents and arrangements to occur between both the firms within a cluster, and also between the cluster and the external environment. Broadly, the literature presents this role as that of a 'change agent' (Rogers, 2003), however, given their proximity to STP members, a combination of park management and technology diffusion agents as network facilitators is suggested to fulfil this role.

Within the literature, facilities management bodies are often presented as central players in the formation of a cluster environment (Dettwiler et al., 2006). However, to achieve the most advantageous outcomes for park members, management bodies need to extend their focus beyond the provision of infrastructure and towards the promotion of relationship development and synergy creation. As Santz (2002) notes, cluster firms may receive some added value from nice landscaping, big parking lots or a cafeteria/restaurant within the park, but truly benefit when offered a range of value-added services that they

could not easily access on an individual basis, made available through synergies provided by the Park and its management team.

While the literature on innovation highlights the importance of diffusion of innovation as particularly beneficial, little evidence in the data collected from BTP highlights much focus on this process. Small firms, in particular, may need additional assistance in the marketing and diffusion of innovation, often via the use of *diffusion agents* (referred to by some as 'technology transfer units' or 'technology intermediaries') – sources of connection to a wide variety of stakeholders to whom innovations can be promoted, and from whom new ideas can be sourced (Trott, 2005**).**

The work of Rogers (2003) identifies two main approaches to diffusion that are applicable to STPs, ranging on a continuum from *centralised* to *decentralised* diffusion systems. Under a centralised approach (top-down, technology push), diffusion is driven by a party with technical expertise in relevant fields, who is connected to a network of influential stakeholders (opinion leaders) that bolster the adoption of an innovation; this approach is said to be most appropriate when the innovation requires a high-level of technical expertise of its users (consistent with high-technology innovations), and in situations where diffusion of an innovation is part of a government directive for which a need is not generally perceived.

Conversely, in a decentralised approach, innovations are developed to address the needs of local end users, and are diffused by networks of peers in a spontaneous, unplanned manner. Consistent with the findings of Rogers (2003), there does appear to be a role for a hybrid model within some diffusions systems, such as those within STPs, in which a combination of a centralised coordinator role, and decentralised decision making on which innovations should be diffused, is utilised. This should allow for adequate interaction of SMEs with potential clients to identify their needs, while at the same time ensure that STP and public policy objectives related to innovation are achieved.

In recognition of the importance of fostering trust and cooperation within STPs to facilitate knowledge exchange and innovation development, and the later benefits of innovation diffusion, this paper suggests further development of the model presented in Figure 1, highlighting the identified role of mediating agents such as park management and diffusion agents in the innovation process.

The following model (see Figure 2) is proposed to provide a new approach to the conceptualisation of the innovation process within technology cluster/parks.

Insert Figure 2 here

In its previous form, this model suggests that firms within STPs should focus on the establishment of a large network of weak ties through which to identify novel ideas, knowledge sources, and opportunities for closer cooperative efforts. After identification of an opportunity for innovation, the need for the establishment of strong ties with those related to the opportunity is then highlighted, aimed at creating an environment to foster this innovation, based on trust and tacit knowledge sharing. Finally, the initial version of this model suggests the need to diffuse the innovation through a network of weak ties, which provide greater exposure to potential users of the new innovation. In the version presented in Figure 2, the additional factors of technology park management and diffusion coordinators/agents have been included, in recognition of their valuable role in driving the innovation process within STPs.

This supplemented model suggests a clear purpose for management of technology parks beyond maintenance of infrastructure, extending to the process of networking establishment and support for local firms and the identification of potential synergies. Furthermore, it proposes that STP management can play a crucial role in promoting a culture conducive to strategic oscillation between weak and strong ties during cooperative and collaborative innovative efforts between park members.

Additionally, this model highlights the existence of a role for innovation diffusion coordinators/agents in capturing the outcomes of innovative efforts and marketing them to appropriate external stakeholders and endeavouring to produce positive outcomes for park members and the broader region. By utilising a diffusion coordinator/agent, innovative firms are able to concentrate on the identification of new opportunities through the dissolving of their temporary strong ties and oscillation back to their explorative network of weak ties.

Some of these benefits have been achieved in the case of Brisbane Technology Park. For example, the establishment of localised technology support mechanisms such as *QMI Solutions* or *Australian Institute of Commercialisation* (AIC) build on regional strengths to stimulate innovation activities and diffuse technology to SMEs. However, local agents should now expand cooperative agreements, alliances and consortia involving public institutions, local firms and foreign organisations. It is clear that there is a need to develop and strengthen technology exchange networks, technology transfer mechanisms and liaison agents to promote diffusion of knowledge among firms, research institutions and regions.

Conclusion

Innovation is important for the survival of firms, particularly for those involved in rapidly evolving high-technology industries. To overcome the financial and technological limitations, which typically fall in the areas of access to technological information and guidance on quality control; access to finance; assistance in purchase of materials or equipment, it is widely argued that inter-firm cooperation and linkages involving SMEs will have a strong impact on growth and performance of firms. Given the identified success of SMEs to innovate, and to operate effectively alone, the emergence of STPs designed to support SMEs through cluster arrangements.

Firms within STPs have been identified in the literature as needing a variety of network ties ranging from loose/weak ties designed to identify new opportunities, through to

strong ties based on trust and cooperation designed to facilitate the innovation process. Using a case study of an STP, insights into the functioning and network orientations of several SMEs have been described, as well as some of the mediating factors in the pursuit of innovation have also been identified.

Drawing on the literature and findings of the case study, this paper confirms the model derived from the literature that describes the need for oscillation between weak and strong ties at different stages of the innovation process. Further, in providing an expanded conceptualisation of the model the role of park management and diffusion agents as drivers of the innovation process within STPs are acknowledged.

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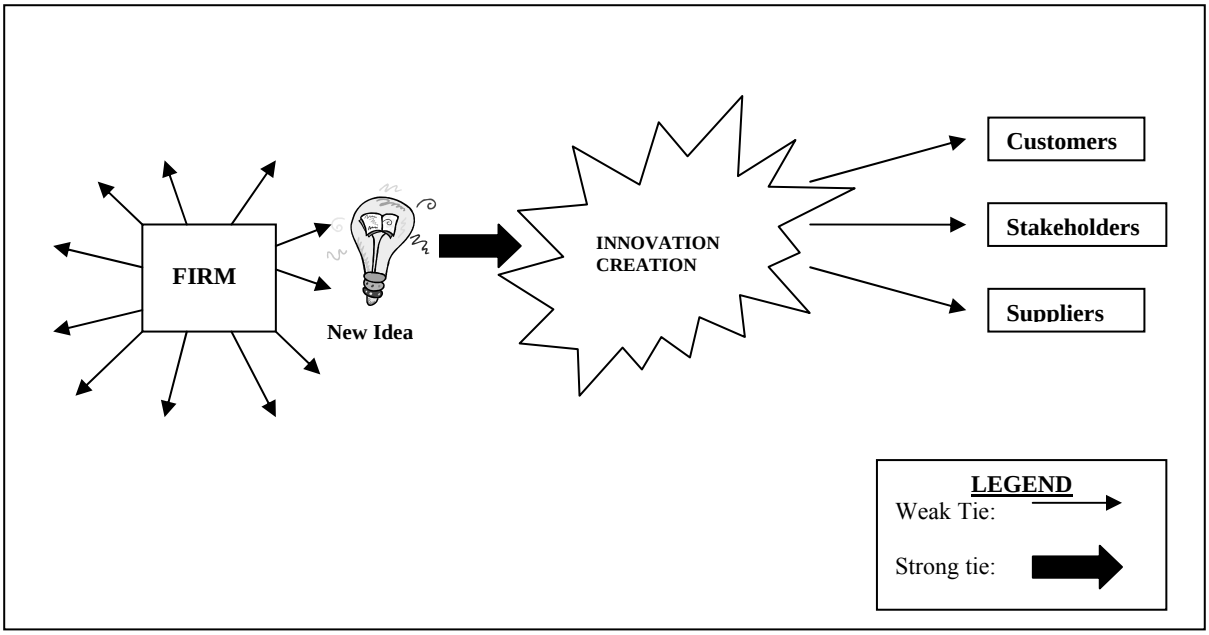

Figure 1: The role of network ties in the innovation process

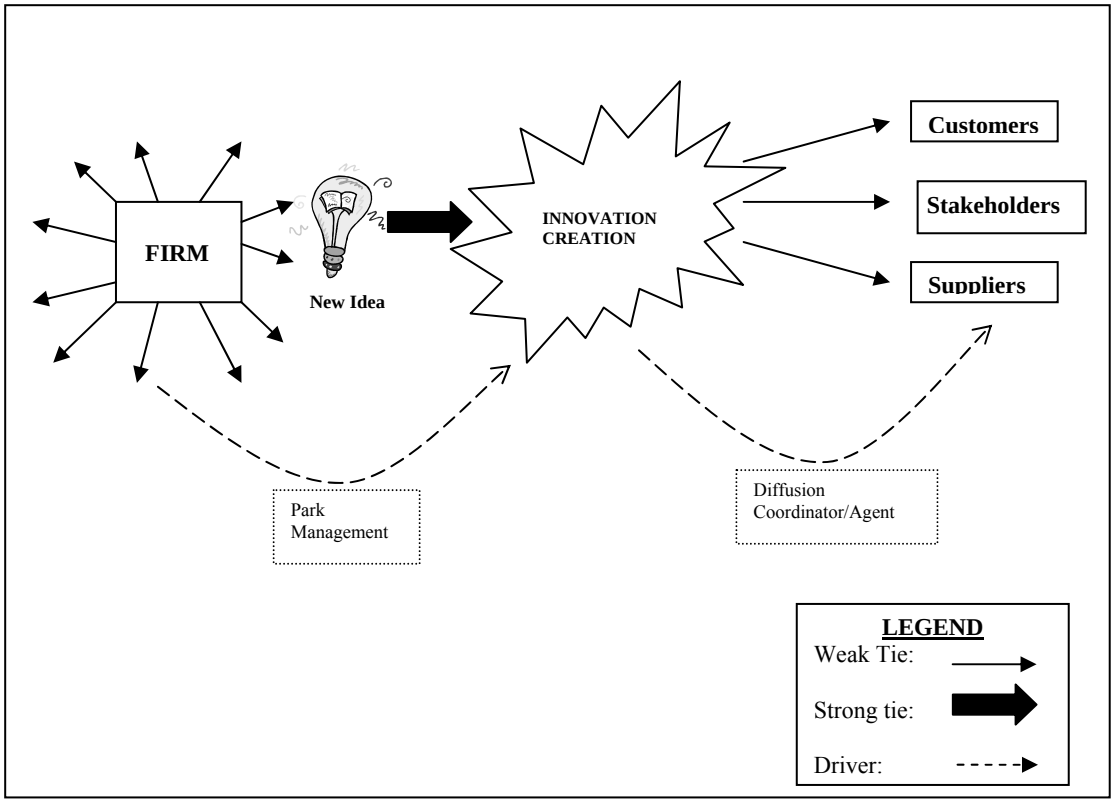

Figure 2: The Innovation process and diffusion through mediating agents

Table 1: Aggregate linkages between BTP members

Type of Interaction	Aggregate number of interactions among the whole sample (N=24)
Technical Advice	16
Informal Contacts	42
Exchange of Information	51
Formal Contract	42
Joint Funding	6

Table 2: Linkages with other networks

Networks	High	Medium	Low
BTP Network/Cluster	3	10	9
Local Network (Brisbane & surrounds)	11	6	6
National	13	8	3
Global	14	4	5