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COLLABORATIVE VERSUS NON-COLLABORATIVE KNOWLEDGE TRANSFER MECHANISMS IN EXTERNALLY STIMULATED INNOVATIONS

BY

ASSOCIATE PROFESSOR PETER GALVIN

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Associate Professor Peter Galvin

Graduate School of Business

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ABSTRACT

Externally stimulated innovations require some form of knowledge transfer to move appropriate knowledge into the innovating organization. These knowledge transfer mechanisms may take a variety of forms, though within the academic literature there is an implied emphasis upon different forms of collaborative relationships. This focus is demonstrated through a review of six prominent journals in the field. This paper seeks to test whether this emphasis upon collaboration is justified. In doing so, a basic knowledge transfer classificatory system was developed to classify how knowledge was transferred for 61 externally stimulated innovations in the bicycle industry. The results indicated that knowledge transfer mechanisms that involved no direct collaboration were used far more frequently than the different collaborative style mechanisms. This result contrasts significantly to the existing literature, possibly suggesting that the focus upon collaborative relationships in the innovation process in somewhat misplaced.

INTRODUCTION

Innovations are not necessarily inspired and developed entirely within a single firm. Studies such as those by McAdam and McClelland (2002), and von Hippel (1988) and have shown that innovations are often stimulated outside of the firm that undertakes much of the new product development work prior to the release of the product into the market. But how does knowledge from external parties actually get transferred to the innovating firm? The purpose of this paper is to develop a basic classificatory scheme that captures the variety of different knowledge transfer mechanisms that exist, and to assess the extent to which these different mechanisms are used in relation to externally stimulated innovation. This study differs from previous studies that have reviewed the importance of different sources of innovation as innovation sources are not necessarily linked to the way that knowledge is transferred. For example, having customers as a source of innovation does not indicate whether the knowledge came from personal networks developed through ongoing focus groups, from long term partnerships with key customers, or from a customer suggestion that arrived without any relationship to this source of innovation. It is this gap in our understanding of the innovation process – how knowledge from externally stimulated innovations is actually transferred – that this paper seeks to fill.

The innovation process is a complex one as it is influenced by a range of factors and situations that can change over time. Nonaka (1994) suggests that innovation can be conceptualized as a process in which an organization creates and defines problems and then actively develops new knowledge that can be applied to solve these problems.

Similarly, Myers (1996) suggests that knowledge of an applied form is required for the development of innovations. Knowledge and its creation and transfer (within and between firms) is therefore a key factor in the innovation process, but it is not clear how knowledge moves between organizations when the innovation is externally stimulated. In studying the way that knowledge is transferred between organizations, this paper takes the view that the transfer of information (being knowledge upon its acceptance and embodiment in a firm's activities) is the process whereby information diffuses from the host organization and is acquired by another organization (through whatever means), such that the recipient firm increases its knowledge stock.

Recently there has been considerable discussion regarding the development and utilization of knowledge within the firm – much of it forming part of the evolving 'knowledge based view of the firm' (e.g. Grant, 1996; Grant and Baden-Fuller, 2004; Spender, 1996). How knowledge is transferred between organizations is less well researched, with much of the contemporary literature focusing upon various cooperative measures (Mowery, Oxley and Silverman, 1996; Rodan and Gulunic, 2004; Russ and Camp, 1996). For example, interorganizational networks, joint ventures and strategic alliances have been popular focal points for studying innovation development. At present, there is a trend in the business literature that sees cooperative/collaborative strategies as an important part of developing the capabilities to be able to compete in the 21st Century. Whether this emphasis upon these collaborative mechanisms is well founded in relation to knowledge transfer from external sources in the innovation process is not well established and forms the starting point for this research.

SOURCES OF INNOVATION

Early research into innovation focused on discerning the factors that influenced innovativeness in relation to 'technology push' and 'demand pull' models. The result was a series of linear innovation process models that were predominantly internally focused (e.g. Daft, 1978; Ettlie & Goes, 1980). However, innovation is often not an entirely internal process (nor it is necessarily linear) as Marquis and Myers (1969) illustrated in their finding that over three-quarters of 500 important industrial innovations owed their origins to users. Similarly, von Hippel (1988) studied a range of different industries finding that the number of innovations stimulated from external sources varies between 6 percent (the tractor shovel industry) and 90 percent (pultrusion process industry). The result has been that more contemporary models do consider (or even focus on) potential external sources of innovation. For example, Rothwell (1992) introduces what he refers to as the Systems Integration and Networking (SIN) model of innovation which emphasizes:

> "Fully integrated parallel development..... Strong linkages with leading edge customers ('customer focus' at the forefront of strategy). Strategic integration with primary suppliers including co-development of new products..... Horizontal linkages: joint ventures; collaborative research groupings; collaborative marketing arrangements, etc. Emphasis on corporate flexibility and speed of development...." [1992: p.236].

A variety of other authors have proposed similar models, discussing the necessity of both horizontal and vertical linkages with external organizations as a method of helping stimulate and influence the innovation process (Dyer and Page, 1988; Josty, 1990; Tang, 1998; and Teece, 1989).

Outside of the innovation process literature, numerous empirical studies have considered a range of external sources from which knowledge may originate and the way that the knowledge is transferred to the innovating organization. Communication and cooperating with customers, suppliers and competitors, engaging in joint ventures, strategic alliances and other types of collaborative structures, utilizing one's personal or social network of contacts, and links with universities and other research oriented organizations have all been studied in terms of their role in the innovation process (Cohen, Nelson and Walsh, 2002; McAdam and McClelland, 2002). In addition, a range of less cooperative mechanisms have also been identified including reading professional and trade magazines, attending fairs and exhibitions, searching the world wide web and other basic boundary spanning type activities (Salter and Gann, 2003). The breadth of different knowledge transfer mechanisms is considerable and a number of the different mechanisms overlap. Furthermore, different papers discuss possible knowledge transfer mechanisms in different contexts and using different terminology. For example, social networks (Rodan and Galunic, 2004), interpersonal networks or interorganizational networks (at the personal level) (Oliver & Liebeskind, 1998), social capital (Burt, 2000), strong and weak ties (Granovetter, 1973), working with colleagues in other companies (Appleyard, 1996), collaborative networks (Ahuja, 2000) and even

aspects of the concept of milieu (Willoughby, 2004) all cover the same basic concept in slightly different ways and in differing contexts. For this reason, this paper seeks to develop a generalist classificatory system that covers all types of potential knowledge transfer mechanisms.

DEVELOPMENT OF A KNOWLEDGE TRANSFER SCALE

Classificatory schemes covering interorganizational relationships to date have focused on collaborative, organizational level relationships and have used different organizational, legal and governance structures as the basis for their configurations. For example, Oliver (1990) discusses six different types of relationships from trade associations to corporate financial interlocks. Similarly, in reviewing innovation in the California hospital system Goes and Park (1997: 676) move beyond the multiple terms used "such as strategic alliances, licensing, sourcing agreements, coordinated contracting" and instead cover structural links, administrative links, institutional links and resource links. Finally, Contractor and Lorange (1988) again focusing on collaborative links suggest a hierarchy of inter-firm linkages that moves from cross-equity holdings (strongest) to technical training/start-up assistance (weakest). This scale has since been adapted to cover other types of interorganizational linkages and to provide numerical scores for the strength of different relationships (Nohria and Garcia-Pont, 1991).

For the purposes of this research, these previous scales are problematic in two areas. Firstly, there is the concern that they do not actually focus on knowledge transfer

mechanisms explicitly. However, it is a minor step from classifying these different types of relationships to suggesting that knowledge transfer occurred because of collaboration within the strategic alliance, joint venture or some other form of relationship. The second, and more significant problem, is that all of these scales consider just formal collaborative arrangements. As previously indicated, knowledge can come from a range of different sources and be transferred through non-collaborative mechanisms such as trade and professional magazines, as well as from non-formal collaboration that might exist in the form of personal networks, but which is not recognized at an organizational level.

To build these additional knowledge transfer mechanisms into the classificatory scheme a slightly different approach to that of Contractor and Lorange (1988) is required. The strength of the relationship that underpins Contractor and Lorange's work would allow for the various boundary spanning approaches to knowledge transfer to be incorporated, however, it is not clear how personal networks would be added to the model. That is, are such relationships stronger or weaker than formal relationships such as joint ventures? The solution proposed in this paper is to utilize the dimension of trust as a highly related variable to these different types of cooperation. In essence, using a trust dimension allows us to differentiate between knowledge transfer mechanisms where there is a very high level of trust (as is often found in interpersonal networks), lower levels of trust (as may be found in joint ventures) and situations where there is no trust required (various boundary spanning activities).

Cooperation by its very nature tends to expose firms to the possibility of opportunistic behavior as it creates a level of mutual dependence between parties. In such a scenario, trust is required for this cooperation to work. There are numerous definitions of trust, with Child and Faulkner (1998: 45) defining it as "the willingness of one party to relate with another in the belief that the other's actions will be beneficial rather than detrimental to the first party, even though this cannot be guaranteed".

There are a number of pathways or factors that create trust. Underlying personal networks is 'cognition-based' trust and 'affect-based' trust (McAllister, 1995). Cognition-based trust relies upon the knowledge we have of others and the evidence we have of their trustworthiness. Affect-based trust is founded on the emotional bonds that exist between people. Both of these types of trust can develop over time as positive behaviors can further improve a person's trustworthiness, as well further strengthening the emotional ties between individuals. The result is that this informal and voluntaristic cooperation is based on behavioral norms rather than contractual obligations and is often reliant upon a perception that the parties will be in contact for a long time making it beneficial to cooperate (Smith, Carroll and Ashford, 1995). Greater flexibility and adaptability, and less formality lie at the heart of relationships based upon cognition and affect-based trust.

Calculative trust – the trust that develops from the expectation that the other party will fulfill their obligations based on calculating the costs and benefits of this versus other courses of action – is an alternative form of trust (Lane, 1988). This type of trust is

particularly relevant to “relationships which are new and hence can only proceed on the basis of institutionalized protection (incorporating deterrence)” (Child and Faulkner, 1998: 48). If the personal networks style of relationships are similar to Ouchi’s (1980) clan structure, then the formal interorganizational relationships built on calculative trust are more about contractual obligations and formal structures. These formal relationships based on calculative trust can evolve over time such that the basis of trust becomes cognition or affect-based (Ring and Van de Ven, 1994).

Using these different forms of trust, this paper clusters the different knowledge transfer mechanisms covered in the literature into three basic groups – cognitive and affect based trust mechanisms (e.g. interpersonal networks), calculative trust based mechanisms (e.g. strategic alliances) and mechanisms where there is no trust involved/required (e.g. boundary spanning approaches). Knowledge transfer mechanisms based on cognition and affect-based trust tend to cover the various forms of interpersonal, social or ‘informal’ networks. Research into interpersonal networks initially started in anthropology and sociology, however, there is now a strong innovation flavor to much of the research, courtesy of the innovation networks approach to the topic (e.g. Pouder and St. John, 1996; Saxenian, 1991). In such cases, information flows between organizations independently of any specific arrangements. The lack of contractual obligations that underpin the informal interpersonal relationships suggests a high level of trust that does not require formal structure.

Knowledge transfer mechanisms based upon calculative trust include various formal interorganizational linkages. Such cooperative, but formal relationships may be focused upon a range of organizational activities from supply arrangements to joint research and development. In this way, these formal linkages may involve inter-firm knowledge transfers leading to the development of innovations. Formal alliances differ from the informal interorganizational or interpersonal networks, in that they are generally more clear-cut than the often fluid nature of interpersonal networks (Freeman, 1991). Formalized alliances tend to rely upon set agreements covering the nature of the agreement in comparison to the evolving nature of relationships in soft networks. Thus, these formal collaborative arrangements are rated lower in terms of trust due to the contractual arrangements that are relied upon in terms of deterrence.

Finally, there are knowledge transfer mechanisms in which there is no trust involved. Such knowledge transfer mechanisms are cooperation neutral as firms tend to use them as a low-cost way of linking their internal structure to external sources of information. Boundary spanning is critical for firms attempting to appropriately utilize the vast body of technical and other knowledge that exists at any given time. Knowledge transfer mechanisms covered by the term boundary spanning can include publications, electronic information networks, technical conferences, materials produced by experts at universities and government agencies (Rosegger, 1996). Due to the relatively low cost of obtaining information from these sources, it is possible for firms to monitor multiple sources simultaneously. Given the lack of trust required for boundary spanning

activities, this knowledge transfer medium is placed at the opposite end of the classification schema to cognition and affect-based trust mechanisms.

This trust-based scale for classifying different knowledge transfer mechanisms is shown below in Figure 1. High trust-based mechanisms (centered on cognition and affect-based trust) sit at one end. Mechanisms that do not involve any trust are placed at the other end of the continuum. In theory, it is possible to extend this trust-based scale of knowledge transfer mechanisms to include mechanisms based on the opposite of trust – that is where firms are opportunistic and break the trust that exists between firms/individuals. These mechanisms are not shown on the scale as they do not feature in the literature that covers externally stimulated innovations.

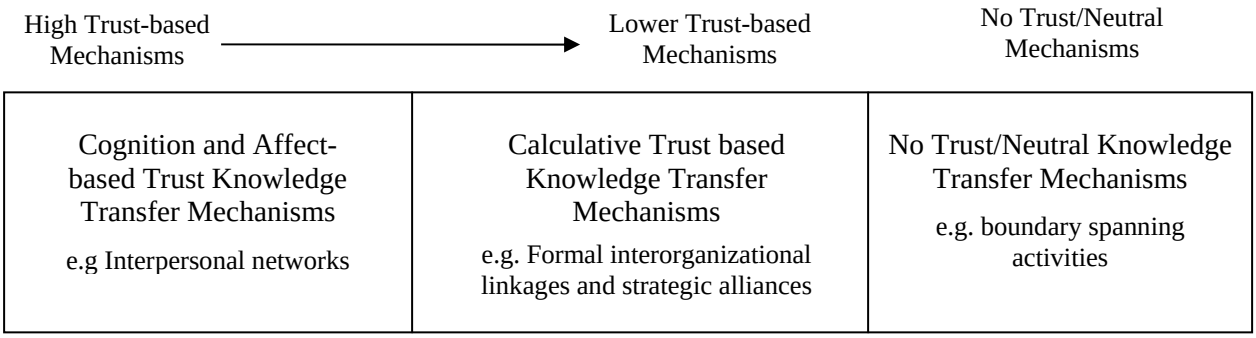

Figure 1: A classificatory scheme for knowledge transfer mechanisms

Do these levels of trust correlate with the level of cooperation? Probably not. High trust-based knowledge transfer mechanisms do not mean that there will be more cooperation than lower trust-based mechanisms. In fact, it is highly possible that strategic alliances see more cooperation occurring than people that thoroughly trust each other as part of a social network. Instead, what this classificatory scheme does is allow different scenarios in different organizations to be classified for the purposes of comparison, and for a review of the literature to occur such that it is possible to compare

innovation sources and possible knowledge transfer mechanisms in a consistent manner. The plethora of different terms in the literature (as they are often industry specific) make it very difficult otherwise to summarize the results of past studies effectively. For example, collaborative networks (Ahuja, 2000) and regional networks (Saxenian, 1990) both cover relationships (and likely knowledge transfer mechanisms) that would seem to be based on cognition and affect-based trust and they can thus be grouped together.

PREDICTIONS FROM THE LITERATURE

To the knowledge of the author, no empirical studies have been conducted that have looked at the different knowledge transfer mechanisms. There have been a number of studies that have looked at the importance of different sources of innovation, but these have not directly addressed the question of how the knowledge is transferred (Agrawal and Henderson, 2002; McAdam and McClelland, 2002; Salter and Gann, 2003). For example, many of these studies use categories such as competitors, and suppliers in collecting data as to the source of various innovations. However, is the knowledge that forms the basis of the innovation in question transferred because two people (one from each organization) have a long-standing relationship that goes back to university and they share information? Or, does the knowledge move from one organization to another because of a formal strategic alliance in place? And, it could also be that there is no cooperation whatsoever and that the innovator simply sees the suppliers/competitors product in the market and this becomes the inspiration for an adapted (but innovative) version of the original. In essence, there is a considerable difference between the sources of innovation and the actual knowledge transfer mechanisms.

Whilst no studies covering the relative importance of different knowledge transfer mechanisms have been identified, it is possible to look at the broader literature regarding the implied importance of the different behaviors (ie collaborative versus neutral) that underpin the different knowledge transfer mechanisms. To do this, a review of six journals was taken from 2000 until May 2004. The journals covered

included the three top-rated general management journals in terms of technology and innovation management issues – *Strategic Management Journal*, *Administrative Science Quarterly*, and *Management Science*. In addition, three top innovation specific (from a non-engineering orientation) were also reviewed – *Journal of Product Innovation Management*, *Research Policy*, and *International Journal of Technology Management* (Harzing, 2004; Linton and Thongpapanl, 2004). Each journal was then reviewed by the author as to the number of articles that covered innovation in the context of the different types of external relationship (or orientation in the case of boundary spanning). All selected articles had to focus upon some form of cooperative relationship or boundary spanning activity in the context of innovation. The articles that fell into this group covered a very broad range of topics from a range of perspectives.

To determine the implied level of importance in the literature of the different behaviors that underpin the various knowledge transfer mechanisms, a basic count of the number of articles that related to each broad category was undertaken. This does not mean that one knowledge transfer mechanism is more important than another, but it does indicate our (as researchers in the field) area of focus and indirectly is probably a measure of what we consider to be important or worth researching within the field. Further details of the literature survey, including the process for selecting the journals can be seen in appendix 1. Basic counts of the different themes in the literature are provided in Table 1.

Journal	**Interpersonal/ informal networks**	**Formal interorganizational linkages**	**Boundary spanning activities**
Strategic Management Journal	0	5	2
Administrative Science Quarterly	1	0	0
Management Science	3	6	3
Research Policy	4	17	3
Journal of Product Innovation Management	2	9	2
Int. J. of Technology Management	7	13	3
TOTAL	**17**	**50**	**13**

Table 1: Frequency of articles covering sources of knowledge/ideas for innovations

Whilst this review of the literature is imperfect in that is covers only six journals, less than five years worth of articles and involves a certain degree of subjectivity on the part of the author, it does indicate the heavy emphasis on formal interorganizational networks in relation to innovation. In comparison, informal networks and boundary spanning activities were the subject of far less research in the context of innovation.

RESEARCH METHOD

The data used in this paper comes from a study of the global bicycle industry that considered innovations developed in the industry in the 1990s. The bicycle industry is a particularly appropriate industry to study as it has produced an almost constant flow of product innovations over the past 25 years. For example, frames and other bicycle parts are now manufactured from a range of materials including carbon fiber, and other composites. In addition, new processes such as bladder molding and computer numeric controlled (CNC) machining have also allowed for the development of product innovations.

The data for this paper was collected in two stages. The first stage was to identify the product innovations that had occurred in the industry. This was done using secondary sources - primarily trade journals and detailed product catalogs. The total number of innovations totaled 186. The second stage involved tracking the way the innovation was developed including the knowledge transfer mechanism where appropriate in as many cases as possible. This was done through secondary sources and through personal interviews with industry participants. In essence, this meant conducting a mini-case study for each innovation. Many of the more significant innovations have been detailed in the trade and general enthusiast literature to the extent that there are detailed descriptions as to how the innovation came about and who the participants were. In other cases multiple sources including interviews were used. Of the 186 innovations identified, the innovation process could be sufficiently tracked for 121 of these. Sixty innovations were stimulated and developed within the boundaries of a

single firm, leaving 61 innovations that were externally stimulated – meaning that some knowledge transfer mechanism was required.

The knowledge transfer mechanisms were classified according to the type/level of trust in place. For example, a number of innovations were developed through interactions with customers. In some cases, there were formal alliances in place – most often when a firm sponsored top riders or even teams of riders to help them in relation to certain innovations. However, there was also an innovation developed simply by a customer providing feedback and ideas to a firm (ie there was no trust involved here as there was no relationship in place). As well as the three types of knowledge transfer mechanisms previously discussed, there were three cases of opportunistic behavior that involved the breaking of trust.

RESULTS

The frequency of each type of knowledge transfer mechanism is shown in Table 2. Within each broad category, the numbers for some specific types of knowledge transfer mechanism are covered.

Cognition and Affect-based Trust Knowledge Transfer Mechanisms		Calculative Trust Knowledge Transfer Mechanisms		No Trust/Neutral Knowledge Transfer Mechanisms		Opportunistic/Trust-Breaking Knowledge Transfer Mechanisms	
8		10		40		3	
Interpersonal networks	8	Joint ventures	6	Arm's length transactions	18	Movement of personnel	2
		Formal alliances	2	Boundary spanning	12	Industrial espionage	1
		Formal relationships with customers	2	Movement of personnel	9		
				Ideas from customers	1		

Table 2: Frequency of different knowledge transfer mechanisms

DISCUSSION

Before discussing the types of knowledge transfer mechanisms that were found to be exist in relation to innovations developed in the bicycle industry, it is worth noting some

of the characteristics of the bicycle industry. Firstly, the bicycle industry is heavily reliant upon technology developed in other industries. For example, tire manufacturers in the bicycle industry are, in almost all cases, also manufactures of tires for motor vehicles. Thus while the innovation is developed internally, it is often done so on the basis of competencies developed in other (much larger) parts of the organization – as the bicycle component of the business is often very small. Where innovations are stimulated from outside the firm, they often originate in the defense/aerospace and motorcycle industries, with some from other sports such as skiing. From these other industries come ideas for what are completely new products (such as the aero handle-bars sought to replicate the position of a down-hill skier to minimize wind resistance), adapted products (such as front suspension which was based on the suspension system used in motorbikes), new processes (such as bladder molding to produce single piece carbon fiber frames) and even new materials that allow for new products (titanium, carbon fiber and metal matrix composites).

Second, the bicycle is a highly modular product with no one firm manufacturing an entire bicycle. Instead, it is the frame manufacturers that tend to assemble bicycles using a variety of components from different manufacturers. This product modularity has led to a situation where innovations are predominantly incremental and modular, rather than being radical or architectural in nature (Galvin, 1999). In addition, there is relatively little inter-firm communication or coordination of activities, even when it comes to developing innovations (Galvin and Morkel, 2001).

Thirdly, the bicycle is subject to constant (primarily incremental) innovation. As a competitive sport with a large following of major events such as the Tour de France, manufacturers are constantly seeking ways to improve performance and are often provided large budgets to do so by sponsors of major teams, or do so of their own volition to attain the publicity and guaranteed sales that come from supplying winners of major professional bicycle races. The result is that the majority of innovations occur in high-end products and some of these eventually diffuse to cheaper bicycles. All of

these characteristics of the bicycle industry have the potential to make it somewhat idiosyncratic.

In terms of the results, there were only eight (13 percent) innovations developed where the knowledge transfer mechanism involved cognition and/or affect-based trust. All of these cases involved interpersonal networks. Most of these interpersonal networks involved one person operating in the bicycle industry working with one person from another industry. For example, the Ballou frame was developed when a defense contractor who has been involved in developing a carbon fiber honeycomb that would eventually be used in the B-1 Bomber worked with a friend who was manufacturing frames. The result was a very thin-tubed frame that maintained its rigidity via a core of this honeycomb material. A regular feature in the bicycle industry was the number of people that started off in other industries and entered the bicycle industry for lifestyle reasons. The friends that remained in these other industries were the source of many new product ideas and processes, with collaboration between these friends common.

Ten (16 percent) of innovations developed using calculative trust-based knowledge transfer mechanisms. Of these, six were via joint ventures, with half of the joint venture partners being non-bicycle industry companies and the other half operating in the bicycle industry. A further two innovations developed when knowledge was transferred through long term formal alliances and the remaining two came from sponsorship of professional riders who provided ideas as to what would assist their performance. For example, an electronic gear changing system developed by Mavic was initially developed, altered and then upgraded using the input of no less than three European-based professional road cycling teams.

The majority of innovations saw knowledge transferred via mechanisms that did not rely upon trust. Of the 40 (66 percent) of innovations in this category, 18 saw knowledge transferred by arm's length transactions. These often involved things such as buying materials or equipment (developed in other industries) such as CNC machines that would allow components such as cranks to be made out of billet aluminum. In 12

cases, the knowledge came from traditional boundary spanning activities – notably reading the trade literature, observing developments in other industries such as the motorcycle industry and attending trade shows (again not necessarily restricted to the bicycle industry). This is how mountain bike suspension was initially developed, when the basic concept was adapted from motorcycle systems. The movement of people into the bicycle industry has also been a significant source of new knowledge in the industry. These are not staff exchanges, but simply people changing jobs (and often industries) of their own volition. For example, as Boeing cut its workforce in the early 1990s many skilled trades-people ended up in the bicycle industry and used knowledge gained from their previous employer. Similar situations occurred when people entered the bicycle industry from various defense contractors, NASA and the chemical industry. Finally, there was one idea from a customer on the basis of feedback provided that was also classified being a neutral knowledge transfer mechanism as there was no relationship in place.

In the case of three (5 percent) of innovations the knowledge was transferred through a means that saw trust being broken. Two of these cases saw employees head-hunted by a rival firm and they took knowledge (including proprietary knowledge in one case) with them. The final case involved copying an early prototype product by a rival firm. It is worth noting that two of these three cases ended up in the courts.

The results clearly show that in the case of the bicycle industry the neutral knowledge transfer mechanisms are responsible for far more innovations that either the cognition and affect-based trust, and the calculative trust based forms of knowledge transfer. Such a result does not correlate with either the contemporary innovation process models, or the general emphasis on strategic alliances and other forms of formal collaboration in respect of innovation that dominate the literature. In fact, these results are almost diametrically opposed to the implied emphasis in the literature. This study showed that more than two-thirds of externally stimulated innovations came about through neutral or even competitive behaviors. In comparison, there were few studies that focused exclusively upon boundary spanning or other neutral forms of knowledge

transfer, with more than two-thirds of reviewed articles focusing upon collaborative behaviors in respect to innovation.

These results suggest one of two possible scenarios. The first is that our emphasis on cooperation and collaboration in the innovation process is somewhat misguided. Such behaviors are obviously important, but it is basic boundary spanning activities that are likely to have a bigger pay-off in the long-run. Alternatively, the results from this study could be something of an exception given the idiosyncrasies of the bicycle industry with its highly modular structure (both in terms of the product and the organizations in the industry), the almost complete dominance of incremental innovations and its reliance upon other industries for the stimulation or ground-work for many of the subsequent innovations.

Which of these two scenarios is the best explanation for these results is difficult to say. Whilst there have been numerous 'sources of innovation' studies, to the knowledge of the author, there are no other studies that consider how knowledge underpinning externally stimulated innovations is actually transferred from one party to another. In essence, a lack of results from similar studies makes it very difficult to comment on the generalizability of this research. However, two previous studies do suggest that the results presented are not entirely unique. In a case study of innovation in engineering design firm Arup, it was found that the percentage of respondents who sourced ideas from reading trade or professional magazines to be 39 percent, working with on-line databases to be 26 percent and attending fairs and exhibitions to be 18 percent (Salter and Gann, 2003). While talking to colleagues was the dominant source of ideas (84 percent), with talking to clients also being important (38 percent), the results of this case study do show that the non-collaborative oriented knowledge transfer mechanisms are very important sources of ideas.

Similarly, in a study of the semi-conductor industries in the US and Japan, the results showed that journals and books, and presentations at conferences ranked as the second and third most important sources of technical information for both US and

Japanese respondents. Patents were the fourth most important source for Japanese respondents, whilst this position was held by technologists at other companies for US respondents. Colleagues in their own company was the most important source of information for both Japanese and US respondents (Appleyard, 1996). Overall, whilst these two studies do not actually study the knowledge transfer mechanism they do indicate the importance of non-collaborative sources of knowledge. Furthermore, the categories used are such that it is possible to discern the way that at least some knowledge travels, as opposed to studies that use categories such as customers, suppliers, competitors, joint ventures, consultants and university/government R&D labs (Cohen, Nelson and Walsh, 2002).

CONCLUSION

Overall, this research makes an important contribution in that it studies how knowledge is actually transferred as opposed to simply considering the sources of innovation. Such data is difficult to attain as it requires a mini-case study be conducted for each innovation, however, the potential of this research is that it has the potential to indicate whether the focus on collaboration in respect of innovation – both in the innovation process models and in the general innovation literature – is well founded. The results would suggest that this is not the case as more than two-thirds of externally stimulated innovations in this study saw the knowledge transfer mechanism being classified as requiring no trust, or breaking existing trust relationships (ie being neutral or competitive in terms of behaviors rather than collaborative or cooperative).

With limited research considering the different knowledge transfer mechanisms – either directly or indirectly – it is difficult to determine the extent to which this result is a product of certain idiosyncratic qualities of the bicycle industry versus a possibly misguided focus on collaboration within the literature. In this respect, replication in an alternative industry (possibly using an alternative method) would help contextualize this research. In addition, this research uses a small sample size (due to the complexity of obtaining this type of data) and all conclusions are made by looking at basic frequencies. Furthermore, the orientation of the trade and popular press is towards the

high end innovations and it is highly likely that some innovations developed specifically for low end equipment are not captured within this study. The literature survey that formed a comparison point in respect of the implied emphasis by TIM scholars was limited to just six journals and less than five years worth of data. More importantly however, journals such as *Strategic Management Journal* are almost certain to focus more on issues such as strategic alliances in relation to innovation, and to see more articles on boundary spanning activities (being a structure related variable) it may be more appropriate to engage more with the organizational theory literature. Similarly, articles investigating interpersonal and social networks are more likely to be found in organizational behavior and sociology oriented journals.

Nevertheless, this research forms an important starting point for research into knowledge transfer mechanisms. The classification scale based upon different types and levels of trust makes it relatively easy to position a wide-variety of scenarios into a limited number of categories and the challenge for future research is to determine whether the results of this study into the bicycle industry are any more than the results from a limited sample in a specific study. If this is not the case, then it may be that the TIM field needs to refocus some of its attention away from the phenomena of cooperation and collaboration.

APPENDIX 1: SURVEY OF THE LITERATURE

A summarized analysis of the literature was undertaken to quantitatively assess the degree of (implied) emphasis upon interpersonal networks, formal interorganizational linkages or boundary spanning. Six journals were chosen and each journal was reviewed in relation to articles covering any of these three concepts in relation to innovation. If an article covered more than one concept, then this was counted as one article for each relevant topic. Thus the total number of articles shown in Table 1 is 80, though the total articles actually identified was 65 (with 13 articles covering two concepts, and two articles covering all three concepts).

To determine which journals should be surveyed, it was decided to consider the top three general management journals in terms of their coverage of technology and innovation management (TIM) issues, and the three best TIM specific journals that covered innovation from a non-engineering perspective. Using Linton and Thongpapanl's (2004) ranking of TIM journals (which also included summaries of previous rankings in the field), it was relatively easy to chose the top three general management TIM journals – *Strategic Management Journal*, *Management Science*, and *Administrative Science Quarterly*. Identifying the top three TIM journals was more difficult. Journals such as *IEEE Transactions on Engineering Management* and *Journal of Engineering and Technology Management* have consistently been highly ranked (Linton and Thongpapanl, 2004). However, given the focus of this research, it was decide to avoid those with a heavy engineering orientation. I therefore used Linton and Thongpapanl's (2004) review and the Journal Quality List produced by Anne-Wil Harzing (Harzing, 2004). A total of ten different ranking systems beyond the standard citation indexes are provided on Harzing's list, and using all of this information and a certain amount of subjectivity the selected three TIM journals for this survey were *Journal of Product Innovation Management*, *Research Policy* and *International Journal of Technology Management*.

Special issues in the journals that had relevance to the topic made little difference to the count except for the results relating to the *International Journal of Technology*

Management where a special issue on collaboration and networking saw a high number of articles covering informal networks, and in *Management Science* where there was a special issue on University Entrepreneurship and Technology Transfer.

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