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Inter-Firm Knowledge Transfer And Innovation In SMEs: A Fuzzy-Set Qualitative Comparative Analysis

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Abstract

This study investigates the conditions leading to higher levels of innovation using fuzzy-set qualitative comparative analysis (fsQCA). More specifically, using fsQCA, this study explores the impact of inter-organisational knowledge transfer networks and organisations' internal capabilities on different types of innovation in Small to Medium size Enterprises (SMEs) in the high-tech sector. A survey was used to collect data from a sample of UK SMEs. The findings show that although individual factors are important, there is no need for a company to perform well in all the areas to improve innovation performance. The fsQCA method, using different combinations of the key factors, revealed that there are many paths to achieve better incremental and radical innovation performance and companies need to choose the one that better matches to their abilities and fits with their resources.

Keywords

Innovation, Inter-firm Networks, Knowledge Transfer, fsQCA,SMEs

1. Introduction:

The ability to innovate, and to manage inter-organisational relationships and knowledge transfer, are two widely recognized critical factors for business success. Although prior studies have examined inter-firm networks and their effects on innovation (e.g. Ahuja 2000, Moller *et al.* 2007, Rodan and Galunic 2004), most have studied network effects on overall innovation performance. Only a few articles (De Propris 2002, Gilsing *et al.* 2008) have considered the effects of inter-firm networks on different types of innovation. Moreover, the majority of studies on the degree of novelty of innovation have focused on large firms (Amara *et al.* 2008) ignoring the fact that small firms are not simply smaller versions of larger organisations (Moller *et al.* 2007), thus findings from large organisations may not be applicable to small firms.

Previous studies have not included innovation strategy, human resource or creativity/idea management as internal factors. These factors reflect the internal capabilities of a company for innovation and play an important role in its innovation performance. Companies without internal capabilities for innovation will not be able to benefit from their superior network position (Zaheer and Bell 2005).

To address these gaps and advance our understanding of inter-firm relationships and innovation performance, this research aims to examine the impact of inter-organisational knowledge transfer networks and organisations' internal capabilities on different types of innovation in SMEs, using fuzzy-set qualitative comparative analysis.

2. Literature Review

2.1. Radical and Incremental Innovation

Innovation is a heterogeneous phenomenon, thus a distinction between different types of innovation is necessary (Moller *et al.* 2007). There are different classifications of innovation but the most established is that into radical and incremental innovation (Subramaniam and Youndt 2005). Radical innovation is the development of new products that require significantly new technology or ideas that did not exist in the market before, or require fundamental changes to the existing market (McDermott and O'Connor 2002). Incremental innovation is defined as minor changes or extensions to the current products, existing services or processes of the organisations (Dewar and Dutton 1986). Being a radical innovator is an important factor for firms' long-term survival. This type of innovation is an engine of economic growth and lays the foundation for other new product development (McDermott and O'Connor 2002). However, O'Reilly and Tushman (2004) argued that companies need to perform well in both types of innovation in order to be successful.

2.2. Social Networks and Innovation

During the last two decades there has been a growing interest in the study of social networks in business. The reason for this growing body of literature was the change in the nature of competition between organisations. Nohria (1992) indicated that previously there were single organisations competing with each other, but by the early 1990s this changed to groups of organisations together competing with other groups of organisations. Innovation requires a variety of resources and establishing relations with people who already have these resources is one of the solutions to address this issue. The relation between people, groups and organisations is the fundamental part of social networks. Liebowitz (2007 p. 3) defined social networks as "a set of relationships between a group of 'actors' (the 'actors' could be individuals, departments, and so on) who usually have similar interests". Networks are an important medium to transfer knowledge and provide access to resources in different contexts. Studies suggest various motives for establishing inter-firm relationships, including spreading the cost, sharing risks and knowledge sharing (Ahuja 2000, Barringer and Harrison 2000, Beckman and Haunschild 2002), the most cited reason for inter-firm collaboration being the acquisition of knowledge and capabilities from partner firms (Mowery *et al.* 1996). Research findings suggest that firms which establish relationships with other organisations are more innovative (Ahuja 2000, Powell *et al.* 1996).

Ouimet et al. (2004) were among the first to look at the relationship between network characteristics and specific types of innovation. They examined the link between network position of a firm and radical innovation. Their findings suggest that degree centrality[1] and effective size are positively correlated with radical innovation. However, they could not find any relationship between betweenness centrality[2] and radical innovation. Gilsing et al. (2008)

[1] Degree centrality is the number of a firm's direct partners in a network (Freeman, 1979).

[2] Betweenness centrality refers to the frequency with which a firm falls between two other firms in the shortest path linking them (Freeman, 1979).

studied network effects on firms' exploration and exploitation activities by conducting a longitudinal study in the chemical, automotive and pharmaceutical industries. Their findings indicate that betweenness centrality, technological distance and network density [3] have an inverse U-shaped relationship with the exploration activities of the company. They also suggest that the interactions between technological distance and betweenness centrality, and between betweenness centrality and network density have a positive effect on exploration. Although these studies offer insights, their findings are not conclusive and they did not consider the facilitating role of companies' internal capabilities. These latter play a key role in the companies' abilities to benefit from their network positions and enable them to use the available resources. The next section explores this matter further.

2.3. Innovation Management Practices

To innovate effectively, all stakeholders of an organisation have to participate actively in the innovation process. For example, innovation should not only come from the R&D department in a manufacturing company or the strategic planning group of a service company (Goffin and Mitchell 2010). Different functional areas can contribute significantly to innovation activities. Goffin and Mitchell (2010) indicate that the functional areas that need to be involved are: research and development, marketing, operations, finance and accounting, human resource management, as well as outside resources such as suppliers, customers or universities. It is the responsibility of the general managers to motivate the different parts of an organisation to work together on innovation.

Innovation management practices refer to solutions that companies use to manage the process of developing an innovation (Oke 2002). Several innovation management frameworks have been developed, but they are mainly for manufacturing companies (Drew 1995, Peters and Waterman 1982, Song *et al.* 1999). There are other organisational factors that impact on innovation performance and they have to be taken into account. Goffin and Mitchell (2010) have introduced an innovation management framework, Pentathlon, which includes the main elements of innovation management and their relationships and addresses a number of soft organisational and process issues, thus tackling the shortcomings of previous models. It covers the five areas where companies need to perform well in order to be able to achieve successful business management (Goffin and Mitchell 2010).

Innovation Strategy: This helps the entire organisation to focus on the same innovation goal and provides it with a clear path through its innovation process.

Creativity/Idea Management: Idea generation is an important part of the innovation development process. Ideas are the raw material of innovation and have to be generated from both inside and outside the firm.

Portfolio Management: It is important to have an efficient process in place to choose ideas for development that are in line with the innovation strategy of a company.

Implementation: This requires fundamental capabilities to quickly and efficiently develop and commercialise an idea into a new product, process or service innovation.

[3] Network density is the extent to which network partners are connected to each other (Gilsing et al, 2008).

Human Resource Management: Goffin and Mitchell (2010) suggest that there are many people and organisational climate issues related to the human resource management of a company (e.g. training policies, job design, creating an effective organisational structure) that play a significant role in innovation performance.

3. Factors impacting on radical and incremental innovation

The network perspective is based on the idea that economic activities are embedded in a social network of relationships (Gulati *et al.* 2002). An 'ego' network approach has been adopted as it helps to explain how being part of a network affects firms' actions and outcomes (Provan *et al.* 2007). Ego networks are defined as networks consisting of one focal actor (ego) together with all partners in the first order neighbourhood (alters) of the ego and all the links among the partners (Everett and Borgatti 2005). Three aspects of ego networks are identified: 1) structural properties (Burt 1992), 2) relational properties (Gulati *et al.* 2002), and 3) nodal properties (Beckman and Haunschild 2002).

Inter-organisational relationships and knowledge transfer, in the context of this study, refer to all types of formal knowledge transfer relationships between a company and any of its partners. These relationships can be with any type of organisation, customers, suppliers, partners, universities or laboratories.

3.1. Structural properties

Betweenness centrality: The main benefit of betweenness centrality is that a firm that lies between two other firms that are not connected to each other directly has control on the information and resource flow (Freeman 1979). This may enable a firm to extract more value from the network because of its strategic position. Firms' betweenness centrality helps them to find opportunities to develop non-redundant relations with other companies (Gilsing *et al.* 2008) which will contribute to the novelty of information and knowledge that is being transferred to the company.

Network density: Absorptive capacity is the "ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990). Previous research argues that network density will increase absorptive capacity by limiting novelty creation (Gilsing *et al.* 2008).

Degree centrality: Companies with higher degree centrality have more visibility in the network (Gulati *et al.* 2002) and can attract more resource-rich partners (Gulati 1999). Another benefit of degree centrality is the experience gained in firm cooperation (Gulati *et al.* 2002). Power of endorsement is another benefit of having higher status in the network (Stuart 2000).

3.2. Relational properties

Strength of ties: Rowley, Behrens and Krackhardt (2000) define tie strength between firms as "frequency of interaction between partners and their level of resource commitment to the relationship". Strong ties are sources of private information and critical resources and increase trust and reciprocity between firms (Gulati *et al.* 2002).

In an exploitation environment where firms try to use their current information, technologies, skills and abilities, firms that belong to a network with strong ties are more likely to perform

better (Gulati *et al.* 2002). Frequent interactions with network partners and commitment of resources are necessary for building strong ties (Granovetter 1985).

Diversity of ties: Diversity of ties refers to different types of knowledge (e.g. training, market knowledge, technological knowledge) that may be transferred to the focal firm through its ties with partners. Tie diversity will provide the focal firm with complementary resources and opportunities to overcome resource barriers and uncertainties in its business. Diversity of ties helps the focal firm to acquire a better perspective and holistic development (Srivastava 2007).

3.3. Nodal properties

Diversity of partners: Diversity of partners refers to the differences in ego network members' abilities such as experience, resources and practices. This has an impact on the focal firm's innovation (Kaufmann and Todtling 2001). Ego networks with diverse nodes provide the focal firm with access to information and resources in different areas and shed light on different approaches and technologies (Pennings and Harianto 1992). This will provide the opportunity for the focal firm to use various channels to seek different solutions in its business (Laursen and Salter 2006).

3.4. Innovation Management Practices

Goffin and Mitchell (2010) argue that innovation strategy is the heart of innovation management which affects and shapes all the other innovation management practices in a company. Previous studies (Cooper *et al.* 1999, Griffin 1997) suggest that companies with high innovation performance are guided by a clear strategy for new products/services. From a networking perspective, innovation strategy guides partnerships with others to explore new opportunities (Goffin and Mitchell 2010). Thus innovation strategy guides innovation directly by providing a clear path for a company's innovation activities and indirectly by shaping other innovation management practices and networking activities. Therefore innovation management practice will impact on both radical and incremental innovation. Table 1 shows all the constructs to be examined in the study.

	Constructs	Outcome variables
1	Betweenness Centrality	Radical Innovation
2	Network Density	
3	Number of Weak Ties	
4	Diversity of Ties	
5	Diversity of Partners	
6	Innovation Management Practices	
7	Degree Centrality	Incremental Innovation
8	Number of Strong Ties	
9	Innovation Management Practices	

Table 1: Constructs of the study

4. Research Methodology

4.1. Research Design and Setting

This study focused on SMEs in two industry sectors: software supply and consultancy, and manufacture of chemicals and chemical products. These sectors were chosen for the need (potentially) to engage in both radical and incremental innovation involving product, service

and process. Empirical data was collected through online and postal survey. In the questionnaire, respondents were asked about their knowledge transfer activities with their network in 2010 and their innovation performance in 2011. Moser and Kalton (1971) argued that a 12 month period is practical for respondents to remember the required information.

4.2. Sample Selection

The FAME database (Financial Analysis Made Easy) was utilised to obtain a sample of 1400 SMEs in the UK. One week after the main questionnaire a reminder was sent to the companies, and two weeks later another reminder and a copy of the questionnaire was sent to those who had not responded. 417 companies replied back by telephone, sending back the blank questionnaire, email or mail mentioning that the addressee is not in the company anymore or they are too busy to fill in the questionnaire. In total over a period of three months 103 usable responses were collected. Therefore the response rate was 10.4%.

4.3. Survey questionnaire design

4.3.1. Dependent variable: Innovation performance

This research measures innovation performance by asking respondents to benchmark their performance against the competition in their industry. The following questions were used to measure incremental and radical innovation performance (product, process and service):

Incremental Innovation Items

- We often improve or revise existing products or services (Darroch and Jardine 2002).
- We add new products or services to our existing ranges (Darroch and Jardine 2002).
- We make changes that reinforce our prevailing product/service lines (Subramaniam and Youndt 2005).
- We often reposition existing products or services (Darroch and Jardine 2002).
- We exploit the potential of the established design (Henderson and Clark 1990).
- We often change the way we make products or deliver services (Darroch and Jardine 2002).
- We introduce new or significantly improved processes for producing or supplying products (goods or delivering services) which are new to our firm (Reichstein and Salter 2006).

Radical Innovation Items

- We develop products or services that offer greater advantages to customers than any other products or services currently available (Darroch and Jardine 2002).
- We develop products or services that better meet the needs of customers than any other product or service currently available (Darroch and Jardine 2002).
- We develop products or services that require customers to substantially alter their behaviour (Darroch and Jardine 2002).
- We introduce new products/services to an existing market (Oke *et al.* 2007).
- We introduce new products/services to a new market (Oke *et al.* 2007).
- We develop new product/services that require significantly new technology or ideas that did not exist in the market before (McDermott and O'Connor 2002).
- We create new major product/service programs leading to expansion of current markets (Koberg *et al.* 2003).
- We develop innovations that make our prevailing product/service lines obsolete (Subramaniam and Youndt 2005).

- We introduce new or significantly improved processes for producing or supplying products (goods or delivering services) which are new to our industry (Reichstein and Salter 2006).

Respondents were asked to rate their performance in comparison to their competitors in the same sector (1: much weaker to 5: much stronger). This makes the data comparable at cross-industry level.

4.3.2. Independent variables

Network data is collected through name generator and name interpreter questions. Companies were asked to write the initials of up to 10 partners with whom they had knowledge transfer in 2010 (name generator questions). Then there were closed-ended questions about the relationship with each partner, their business and frequency of contact with them (name interpreter questions).

Betweenness Centrality: Betweenness centrality was calculated using the method of Everett and Borgatti (2005).

Network Density: This is measured as the number of existing ties among partners of the ego, divided by the total number of possible ties among the partners.

Degree Centrality: This is measured as the number of alters which are directly connected to the ego (Marsden 2002). For an ego network, degree centrality is N-1, where N is the number of nodes.

Number of Strong and Weak Ties: Tie strength is measured using the frequency of relationships with each of the partners. Ties with daily and weekly contacts are considered strong ties and ties with monthly and quarterly contacts are considered as weak ties. A similar approach was used in the study by Ouimet *et al.* (2004).

Diversity of Ties: Companies were asked about types of knowledge that they have transferred with their partners. The number of these types is counted. This method is similar to that of Beckman and Haunschild (2002).

Diversity of Partners: Following the method of Laursen and Salter (2006), companies were asked about the main business of each partner and the type of the partner (supplier, customer, competitor, etc.). Using this information and the classification by Laursen and Salter (2006) the diversity of partners is calculated as the number of unique resources that they are using.

The study adapted the questions developed by Oke, Burke and Myers (2007) to measure the concepts in the Pentathlon framework (innovation strategy, creativity and idea management, portfolio management, implementation, human resource management).

4.4 Analysis method: Fuzzy-Set Qualitative Comparative Analysis

Analysis was conducted using Fuzzy-Set Qualitative Comparative Analysis (fsQCA). This method examines the interaction between different causal and outcome factors, whereas regression methods are not able to understand the variables as configurations even by adding interaction terms (Ragin 2008). Recent studies (Fiss 2007, Fiss 2009, Greckhamer *et al.* 2008) recommend using QCA and fuzzy sets in organisations and strategy settings due to the new insights and understandings that this method can offer on causally complex issues.

fsQCA enables the researcher to find different combinations of causal conditions that may lead to the same outcome (Berg-Schlosser *et al.* 2009). Conventional statistical methods are concerned with the net effect of an independent variable on an outcome, but in practice there are many other conditions and relationships that impact on the outcome variables. In addition, it is hard for organisations to perform well in all the antecedents of a phenomenon. fsQCA considers multiple and different causal paths that are satisfactory as causal conditions (Berg-Schlosser *et al.* 2009). It is necessary to bear in mind that this method of analysis does not overrule the contribution of conventional statistic methods. The fsQCA method attempts to describe different combinations of the factors that exist among the comparable cases that result in higher radical and incremental innovation performance.

Variable	Range	0.05	0.5	0.95
Betweenness Centrality	0 – 45	8.5	17	31
Degree Centrality	0 – 10	1.5	3.5	8
Tie Diversity	0 – 4	0.5	1.5	3.5
Network Density	0 – 1	0.09	0.53	0.83
Number of Strong Ties	0 – 8	1.6	3.5	7
Number of Weak Ties	0 – 4	0.5	2.5	3.5
Partner Diversity	0 – 8	0.5	2.5	5.5

Table 2: Anchor points for calibrating the network variables

In this study, the network characteristics and innovation management practices are the causal conditions and the radical and incremental innovation performances are the outcome conditions. The first step in fsQCA analysis is calibrating the causal and outcome conditions. In this research the direct method was adopted as the method of calibration (Ragin 2008). Data was first imported into the Tosmana package to determine the anchor points for calibration of each network variable. Then the data was imported into fsQCA (Ragin *et al.* 2006) software for fuzzy set qualitative comparative analysis, for calibration and the next steps of the analysis. Table 2 shows the anchor point of each network variable.

Table 3 shows an example of truth table for incremental innovation. It reports the results of the set-theoretic consistency assessment for the cases that meet the strength of evidence threshold (configurations with 2 or more cases and consistency value above the explained threshold).

strategy	idea	portfolio	implement	hr	dcent	strong	number	inc	Raw consist.
1	1	0	1	0	1	1	2	1	1
1	0	1	0	0	0	0	2	1	1
1	1	1	1	0	1	0	4	1	1
1	1	1	1	1	0	1	2	1	1
1	1	1	0	0	1	0	4	1	1
1	1	1	1	1	1	1	3	1	1
1	0	0	0	0	1	0	2	1	0.99

1	1	1	1	1	1	0	5	1	0.99
1	1	0	1	1	1	0	2	1	0.99
1	1	1	1	0	0	0	3	1	0.99
0	0	0	0	0	0	0	4	1	0.98
0	1	0	0	0	0	0	3	1	0.98
1	1	1	1	1	0	0	10	1	0.98
1	0	0	0	0	0	0	3	0	0.96
0	0	0	0	0	1	0	4	0	0.96

Table 3: Incremental innovation truth table

5. Findings

Table 4 summarises the intermediate solutions for radical and incremental innovation.

Configuration solutions for higher radical innovation performance									
	1	2	3	4	5	6	7	8	9
Innovation Management Practices									
Innovation Strategy		●	●	●	●	●	●	●	●
Idea Management	○	○	●	●	●	○		●	●
Portfolio Management	○	○	●	●	●	●	●	●	○
Implementation	○	○	●	●	●	○	○	●	●
HRM	○	○	○	●	○	○	○	●	●
Social Network Properties									
Betweenness Centrality	○	○	○	○	●	○	○	○	○
Tie Diversity	●	●	●				●	●	●
Network Density	○	○		○	○	○	○	○	●
Number of Weak Ties						●	●	●	●
Partner Diversity	●		○	○	●	●	●		●
Raw Consistency	0.96	0.94	0.92	0.90	1	0.97	0.97	0.97	1
Raw Coverage	0.24	0.31	0.40	0.47	0.06	0.21	0.21	0.26	0.11
Unique Coverage	0.01	0.03	0.03	0.12	0.03	0.01	0.00	0.02	0.01

Solution coverage: 0.735
Solution consistency: 0.899

Configuration solutions for higher incremental innovation performance							
	1	2	3	4	5	6	7
Innovation Management Practices							
Innovation Strategy	●	○	●	●	●	●	●
Idea Management	●		●	●	●	○	○
Portfolio Management	●	○	●			○	●
Implementation	●	○		●	●	○	○
HRM		○	○		●	○	○
Social Network Properties							
Degree Centrality		○	●	●	●	●	○
Number of Strong Ties				●			
Raw Consistency	0.97	0.95	1	1	0.98	0.99	1
Raw Coverage	0.65	0.37	0.27	0.11	0.29	0.18	0.32
Unique Coverage	0.18	0.09	0.01	0.00	0.00	0.00	0.01
Solution coverage: 0.812							
Solution consistency: 0.959							

Black circles " ● "indicate the presence of causal conditions (i.e., antecedents). White circles " ○ "indicate the absence or negation of causal conditions. The blank cells represent "don't care" conditions.

Black circles represent the presence of the causal condition (e.g. higher betweenness centrality) and white circles represent the absence or negation of the causal condition (e.g. lower betweenness centrality). The blank cells represent "doesn't matter" conditions.

Regarding radical innovation, the first section of the table reports that all consistency values are above 0.8, indicating that these configurations are sufficient conditions causing high radical innovation performance. Solution coverage is above 0.7 which indicates that the solution explains a large proportion of radical innovation performance. In terms of raw coverage, a higher raw coverage indicates that the configuration explains a larger proportion of the outcome variable, in this case radical innovation performance.

Regarding incremental innovation, the second section of the table reports that all consistency values are above 0.95, indicating that these configurations are sufficient conditions causing high radical innovation performance. Solution coverage is above 0.8 which indicates that the solution explains a large proportion of incremental innovation performance.

6. Discussion of the Fuzzy Set Qualitative Comparative Analysis

As explained before, previous studies focus on the influence of individual factors on different types of innovation performance. These studies imply that organisations should seek to perform well in all the areas to be able to achieve the anticipated outcome. However, such a performance in all the areas is unlikely for enterprises, specifically for SMEs, due to their limited resources. Organisations are only able to focus their expertise and resources on some of these factors and therefore it is important to understand what combination of these characteristics can assist them to achieve their goals. This study looks at different configurations of these factors and identifies the paths that can lead to high radical or incremental innovation performance.

The findings of the study imply that there is no single factor that guarantees the anticipated outcome which means no one factor is key to success in higher radical or incremental innovation performance. Also, while there are different factors and different paths to achieve the desired outcome there is no single configuration or factor necessary to take for success. All of the factors for both network properties and innovation management practices appear in at least one configuration.

This study recognises some common rules behind different configurations for both radical and incremental innovation. Along with the presence of other conditions, the innovation strategy can create high radical and incremental innovation performance. There are only two configurations (one each in the radical - no.1 - and incremental - no.4 - solutions) that do not include innovation strategy.

Moreover, the result shows how the combination of some of the network variables with innovation management practices can result in a desirable outcome. For example, fsQCA revealed that the combination of degree centrality with other factors provides different avenues of achieving higher incremental innovation outcome. This shows that degree centrality when other factors are present, can play a significant role in incremental innovation performance.

Oke (2007) in his study found a significant relation between all five innovation management practices and radical innovation performance. The findings here show that although innovation management practices are important in improving the performance of this type of innovation, the presence of all these factors is not necessary to achieve this goal. Out of the nine configurations in the radical innovation solution, only two - nos.4 and 8 - demands the presence of all the innovation management practices. This finding is useful for enterprises because there may be no need for them to be perfect in all the conditions to achieve better radical innovation performance.

Another finding that contrasts with the findings of Oke (2007) is that he did not find any significant relation between innovation management practices and incremental innovation performance. However, the findings in this study show that several combinations of these factors can lead to the desired outcome (higher incremental innovation performance).

7. Conclusion

This research is one of the few studies that applies the fsQCA method to network characteristics. fsQCA helps to understand which factors are relevant to achieve the desired outcome and what combinations of these factors will lead to that outcome (Fiss 2011). It shows how different configuration of internal capabilities and network resources can lead to a better innovation performance. The findings by fsQCA analysis showed that although individual network factors are important, there is no need for a company to perform well in all the areas. This method, using different combinations of network factors and innovation management practices, revealed that there are many paths to achieve better incremental and radical innovation performance and companies need to choose one that is close to their abilities and fits with their resources.

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