# Cluster Network Model for Inter-SME Diffusion of Innovation

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Abstract: Since Rogers (1995) first gave a typology of innovation diffusion, there have been many studies on the role of networks in the topic of innovation diffusion and adoption. Bradley (1995) defined technology diffusion as the spread of a new technology from one SME to another; whereas DiMaggio and Powell (1991) emphasized that under conditions of uncertainty, inter-organizational diffusion of innovation occurs through imitation (adaptation). Other authors have investigated rate of innovation where importance was given to the number of firm linkages and geographical proximity (Florida 1995, Van Oort 2004). Although the role of ties has been studied with regard to innovation diffusion and knowledge sharing, to the best of our knowledge, there has been no published research concerning efficient innovation diffusion and adoption within SME cluster networks, where efficient innovation diffusion with cluster is defined when most SMEs within each cluster could adopt innovation. Here, we present a cluster network model for inter-SME diffusion of innovation where SMEs represent nodes, and innovation adoption and adaptation between any two SMEs represent ties. In such a model, we differentiate between SMEs as either sources or beneficiaries of innovation, and discuss creation of ties among those SMEs and among cluster of SMEs. This study presents a conceptual piece, where we provide three propositions a) The network model contains both source and beneficiary of innovation, where the beneficiary adopts an innovation from source, or adapts to the innovation of another beneficiary, b) The more efficient diffusion of innovation from one SME cluster to another is when two clusters interconnect strongly rather than loosely, c) The rate of innovation adoption among SMEs depends on their network dependency.



## 1 INTRODUCTION

*Innovation* is shown to be interactive, cooperative and cumulative (Ahuja, 2000; Burt, 2004), where its emergence requires many sources of knowledge connected through a network. As products become modular and knowledge within a complex system is distributed among individuals within the system, collaboration becomes essential for new product development, since individuals do not possess all the required knowledge to accomplish innovation (Baldwin and Clark, 1997). Innovation usually results from interactions among different bodies or sources of knowledge (scientific, educational, public-private institutions), where these sources of knowledge aggregate into clusters with industrial, academic or public players interacting within clusters (intra-cluster) and between clusters (Inter-cluster).

*Diffusion* theories of innovation initially introduced by Rogers (1958) explained adoption of technological change by farmers. Rogers (1999) defined "innovation diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system". The literature includes various papers on diffusion of innovation in manufacturing and service industries, public policy, healthcare and education (Nutley and Davis, 2000). Generally, the study of innovation covers generation (new product, process, and market), communication, adoption, implementation and resulting behavior. Rogers (1995) gave the first typology of *innovation diffusion* covering innovation, innovativeness, opinion leadership, diffusion networks, and rate of adoption in different social systems, communication channels, and consequences of innovation.

Huber (1991) suggested that organisational units transfer knowledge and learn from other units. But not all units have external access and internal capacity to learn knowledge and apply it. Internal capacity can be achieved by increasing R&D ability. Gurisatti et al



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(1997) emphasized accumulated knowledge and expertise as an important factor determining whether firms are likely to adopt new technology. On the other hand, external access to new knowledge can be improved by networking. In this regard, Hansen (1999) modeled an organization as a complex network with inter-unit links, where knowledge transfer can be investigated by analyzing the inter-organizational network.

Bradley (1995) mentioned that "technology diffusion can be defined as the spread of a new technology from one SME to another". Many studies have investigated SMEs' innovation activities and some studies have examined networks of innovation where firms collaborate on projects (Batterink et al 2010, Ngugi et al 2010). However, not many studies have discussed the role of firms within the network (Gardet et al 2012). Narula (2004) showed that SMEs often lack resources and capabilities to innovate exclusively, and this makes a network essential for SMEs to access innovation diffusion. Other authors have investigated the role networks in increasing knowledge sharing. Ma and Agarwal (2007) discussed the role of *perceived identity* in augmenting knowledge sharing. Kraut (2007) investigated the role of *similarities* in direct reciprocity and design of online communities. An alternative approach argued that under conditions of doubt and uncertainty, inter-organizational diffusion of innovation occurs through *imitation or adaptation* (see DiMaggio and Powell 1991) where organizations learn from similar organizations or from industry leaders. We propose a network model for inter-SMEs diffusion of innovation, as shown in Figure 1. For any given technology innovation, some SMEs play a source role and others act as beneficiaries of innovation, where the beneficiary can either adopt innovation from the source, or adapt to the exiting innovation of another beneficiary.

*Proposition 1: A network model contains both source and beneficiary of innovation, where the beneficiary adopts the innovation from source, or adapts to the innovation of another beneficiary.*

Innovation cluster is defined as an ensemble of various firms and institutions that interact formally and informally via agreement and transactions or informal occasional meetings and collectively contribute to innovation within a given industry. Literature has rendered different perspectives on clusters: learning, knowledge sharing (geographic and cognitive distance), governance and transaction cost economics (Williamson 1975),exploration (discovery, development of idea) and exploitation

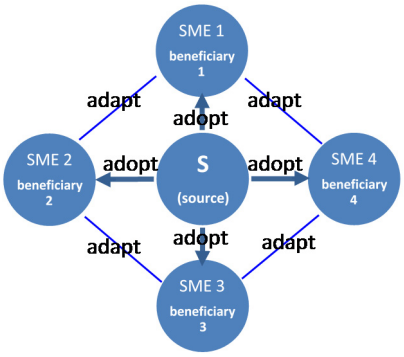


Figure 1: Illustration of SMEs as source and beneficiary of innovation; where beneficiary adopts from source and beneficiary imitates (adapts) from another beneficiary.

(implementation of idea) (Holland 1975). Innovation exists in all areas of products, processes and market structure that all affect network dynamics. Many small enterprises cooperate with other small or big enterprises in order to explore and exploit new technology, while one has to make distinction between sharing know-how and physical assets, and knowledge or information spill-over. Coleman (1990) and Uzzi (1999) argued that strong ties within a dense network are efficient for exchanging complex knowledge, and redundant ties lead to more trustful and cooperative behavior. Burt (1992) argued on the contrary that strong ties are inefficient for acquiring external knowledge because they lack diversity in the resources needed for innovation, and at the same time increase communication costs as a result of tie redundancy. Although the role of ties has been studied with regard to innovation diffusion and knowledge sharing, to the best of our knowledge, there is no published research concerning efficient innovation diffusion and adoption within SME cluster networks. Efficient innovation diffusion implies that most SMEs within each cluster could adopt innovation. In this study we present a cluster network model for inter-SME diffusion of innovation where SMEs represent nodes, and innovation adoption and adaptation between any two SMEs represent ties, and propose that:

*Proposition 2: The more efficient diffusion of innovation from one SME cluster to another cluster is when two clusters interconnect strongly rather than loosely.*

Granovetter (1973) proposed a network theory for linking micro and macro levels of sociological theory through an analysis of various types of weak ties. Strong ties are relationships with individuals whom we know very well, but weak ties provide bridges which

allow innovations to cross boundaries between social groups (clusters), which themselves are strongly tied., A definition of weak tie was used by Hansen (1999) to investigate the transfer and sharing of knowledge in an organizational system. Kogut (1992) and Tsai (2000) suggested that social networks facilitate creation of new knowledge within organizations. In another study, Tsai (2001) focused on the question "How can an organizational unit gain useful knowledge from other units to enhance its innovation and performance?", and emphasized the role of strong ties in intra-corporate and strategic alliances.

Authors have also discussed role of ties on rate of innovation, where Ahuja (2000) and Shane et al (1994) discussed firm's network relationship impacting the rate of innovation, where network allows for knowledge sharing and information flow. Others have studied role of networks within topic of knowledge sharing and innovation adoption where importance was given to the number of firm linkages and geographical proximity (Florida 1995, Van Oort 2004) impacting rate of adoption. This also applies to our proposed network model based on innovation adoption and adaptation within SMEs network.

*Proposition 3: Rate of innovation adoption and adaptation among SMEs depends on their network dependency.*

There are some conceptual and contextual assumptions regarding our proposed theory:

- Innovation usually results from interactions among different sources of knowledge (here, SMEs are sources of knowledge).
- Intra-cluster ties are assumed to be strong which allow for faster exchange of knowledge and inter-cluster ties are to be weak and long which allow for better access to external knowledge.
- At any given time, an SME is either the source or beneficiary of innovation, not both simultaneously. However, at another time, it could reverse its status as source or beneficiary of innovation.
- SME-beneficiary will adopt innovation from another SME-Source provided that the source agrees to transfer the innovation and at the same time, the beneficiary has the internal capacity to adopt the innovation.
- If SME-beneficiary cannot adopt innovation from another SME-Source, it attempts to adapt (imitate) to innovation of another SME-beneficiary.

Our proposed theory constructs are yet to define (Innovation adoption and adaptation). *Innovation adoption* refers to adoption of SME beneficiary from source of innovation. *Innovation adaptation* refers to imitation of SME beneficiary to existing innovation of another beneficiary. Our phenomenon of interest is *"Efficient diffusion of Innovation"*.

In the first section of paper, Source and Beneficiary of Innovation, we discuss definitions and differences of adoption and adaptation, the types of innovation are, and the reasons for adoption and adaptation. In the second section of the paper, we discuss business and social network models and how our proposed network model is different in terms of network structure. In the next section, we discuss the roles of ties in diffusion of innovation and the ambiguities in the literature with respect to efficient role of ties on innovation diffusion. In the next section, we propose our cluster network model by showing a model diagram and investigate the role of cluster coupling in efficient diffusion of innovation. Finally, we propose that the rate of adoption is influenced by resources acquisition, number of linkages, and tie number and heterogeneity.

# 2 SOURCE AND BENEFICIARY OF INNOVATION

New technology exists in all the areas of products, processes and market structure that all affect network dynamics. Many small enterprises cooperate with other small or big enterprises in order to explore and exploit new technology. In the network of SMEs, there are a few percentages of SMEs as innovators which are source of innovations, while others adopt innovations. How can we differentiate between those SMEs: 1) those which innovate themselves and are source of innovation; 2) those which adopt innovation but are also source of innovation; 3) those which adopt innovation and are beneficiary for innovation; and 4) those which imitate innovation? Therefore, we pose the questions:

*a) What are the differences of adoption and adaptation? and what are the types of innovation?*

*b) What are the reasons for adoption and adaptation?*

## 2.1 Adoption versus Adaptation

Adoption is defined as an organization's emulation of another organization innovation. Organization's definition of core purpose and domain and expertise specify whether to adopt or not. Alternatively, *adaptation* is defined in two ways:

1. as organization's reformatting to the needs of its

environment after adoption. In the topic of technology innovation, an existing technology is either sufficiently adapted to new circumstances, or a new or improved technology will be adopted. By this definition, both processes of adaptation and adoption are inter-linked, where adaptation of existing technology happens before adoption of new technology, or adaptation happens during the process of adoption of new technology, or adaptation happens after adoption of new technology.

Table 1: SME adoption and adaptation of innovation.

| | | | |
|---|---|---|---|
| SME | Adoption | 1. Product | 1. Source SME<br>2. Source MNE |
| | | 2. Market | ----- |
| | | 3. Process | 1. Source SME<br>2. Source MNE |
| | Adaptation | 1. Product | 1. Beneficiary SME<br>2. Beneficiary MNEs |
| | | 2. Market | ----- |
| | | 3. Process | 1. Beneficiary SME<br>2. Beneficiary MNEs |

2. as organization's imitation of existing technology. We refer to innovation adoption and adaptation as new technology adoption from a *source* or imitating an existing technology from another *beneficiary*. As illustrated in Table 1, SME-beneficiary adopts from SME or MNE source, but adapts (imitates) to innovation of other SME or MNE beneficiary.

## 2.2 Reasons for Adoption and Adaptation

As illustrated in Table 2, SME-beneficiary adopts innovation from SME-Source based on the conditions if the source agrees to transfer innovation; and at the same time beneficiary has the internal capacity to adopt innovation. If any of these two conditions is not fulfilled, then the beneficiary adapts to innovation of other SME beneficiary, as demonstrated in Table 2.

Table 2: Reasons of adoption and adaptation, where S.A. implies whether Source Agree to let beneficiary adopt innovation or not; B. I.C implies whether Beneficiary have Internal Capacity or not.

| S. A./B. I.C. | 1 | 0 |
|---|---|---|
| 1 | Beneficiary adopt innovation from this cluster Source | Beneficiary adapts to innovation of one of this cluster beneficiaries |
| 0 | Beneficiary adopt innovation from another cluster source | Beneficiary adapts to innovation of one of another cluster beneficiaries |

# 3 CLUSTER NETWORK MODELS

Networks are defined as relationships between actors where these actors include individuals, groups or organizations (Aldrich and Zimmer 1986, Burt 1982, 1992, Ireland et al 2001).

## 3.1 Firm Business and Knowledge Sharing Network Models

Network relationships among organizations constitute different forms such as joint ventures, sub-contracting, strategic alliances, and more that in fact exchange or share, co-develop new products (A. J. Groen, 2005).

Researchers have investigated importance of network on knowledge sharing and impact of collaboration on network overall performance. Authors have discussed firm's network relationship impacting the rate of innovation (Ahuja 2000, Shane et al 1994), where network allows for knowledge sharing and information flow. Knowledge sharing network elements are categorized in Table 3.

Table 3: Details of firm knowledge network model.

| | |
|---|---|
| Node | Firm |
| Tie | Knowledge sharing activity |
| Tie strength | Frequency of activity |
| Tie diversity | Type of activity (joint team, project collaboration) |
| Tie content | Knowledge (know-how, information, asset) |

## 3.2 Proposed SME Cluster Network Model

Innovation cluster is defined as ensemble of various firms and institutions that interact formally and informally via agreement and transactions or informal occasional meetings and they collectively contribute to innovation within given industry. Nonetheless we discuss how SMEs network made of source (S) and beneficiary SMEs are connected and propose a new clustered network model detailed in Table 4 in terms of node type, tie strength, diversity, and content.

Table 4: Details of proposed SME Cluster Network model.

| | |
|---|---|
| Node | SME source, SME beneficiary |
| Tie | Innovation adoption, adaptation |
| Tie strength | Rate of adoption, adaptation |
| Tie diversity | Weak-vs-Strong and Intra-vs-Inter cluster |
| Tie content | Innovation (new product, process, market) |

As observed in Figure 2, if clusters overlap via SMEs, then those clusters strongly inter-connect, while separated clusters loosely inter-connect. We define three types of SME clusters' connections.

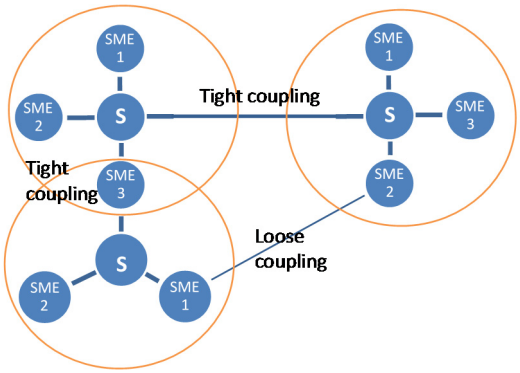


Figure 2: Illustration of intra (inter) SME-cluster links, where SME adopts from Source (S), and SMEs adapt to the innovation of other SMEs.

Two beneficiaries could inter-connect, two sources could inter-connect, or one beneficiary could inter-connect with one source.

*1. When two clusters overlap via one or more SMEs, then these two clusters interconnect strongly.*
*2. When two clusters do not overlap, but interconnect via source-source connection, then these two clusters interconnect strongly.*
*3. When two clusters do not overlap, but inter-connect via dependency among two beneficiaries from two clusters, then these two clusters interconnect loosely.*

# 4 ROLE OF TIES IN DIFFUSION OF INNOVATION

## 4.1 Innovation via Access to External Knowledge

Organizational systems have provided three solutions for access to external knowledge in complex networks (Goduscheit 2009): a. integrated system, b. modular system, c. networks.

a. Simon (1962) viewed firms as hierarchical systems made of subsystems that are loosely coupled vertically and horizontally and interact based on input and output. Loose coupling implies that interactions among subsystems are much weaker than interactions within subsystems.

b. When systems grow big, the number of interactions among subsystems becomes numerous and an integrated structure could be no longer used for coordination and management. An alternative solution for organization of production and innovation would be a modular system (Baldwin and Clark 1997 and Langlois 2002) which implies a nearly decomposable system. However, in reality firms do not appear as purely integrated or purely modular in terms of organization of production and innovation, but feature a variety of interactions and benefit from both modularity and integration (Brusoni and Prencipe, 2001).

c. The third solution would be a network, which relies on heterogeneous resources across firms. Integration among firms reduces costs of accessing dispersed knowledge leading to innovation (Ahuja 2000, Kogut 2000, Powell 1990). Innovation usually results from interactions among different bodies or sources of knowledge, where these sources of knowledge aggregate into clusters with players interacting inside (intra-cluster) and outside (Inter-cluster). In the context of organizational systems, innovation cluster is defined as an ensemble of various firms and institutions that interact formally and informally via agreement and transactions or informal occasional meetings and they collectively contribute to innovation within a given industry.

## 4.2 Ambiguity in the Role Efficiency of Tie in Diffusion of Innovation

Granovetter (1973), Burt (1992), Hansen (1999) emphasized the role of weak ties (distant ties) in acquiring external knowledge needed for innovation. Granovetter (1973) proposed a network theory for linking micro and macro levels of sociological theory through an analysis of various types of weak ties that bridge groups. Burt (1992) argued that strong ties are inefficient for acquiring external knowledge as they lack the diversity in resources needed for innovation, and at the same time increase communication costs as a result of redundancy of ties. Therefore, weak ties (non-redundant, less-frequent) are more appropriate for communicationto allow access to a variety of knowledge. In the context of organizational systems, Hansen (1999) also noted that weak ties between units are more advantageous than intra-unit ties, because infrequent and distant relationships are less likely to provide redundant knowledge and more likely to preclude duplicity of documents.

On the other hand, Coleman (1990) and Uzzi (1999) argued to the contrary that strong ties within dense network are required for exchange of complex knowledge, and redundant ties lead to more trustful

and cooperative behavior. Kogut (1995) argued that a dense innovative cluster provides quick transfer of information, knowledge sharing, more interactions, better integration, and better coordination; it also favors the organization in terms of lower transaction cost and risk and shared trust and identity.

As one sees, for the purpose of innovation, there are ambiguities in the benefits of networks: one concerns the distinction between strong and weak ties (Granovetter 1973, Nelson 1989), the second is between sparse network structures (Burt 1992) versus dense network structure (Walker et al 1997).

# 5 EFFICIENT DIFFUSION OF INNOVATION AMONG SME CLUSTERS

## 5.1 Proposed Model Diagram

We investigate efficient diffusion of innovation among SME clusters by proposing the hypothesis that *the more efficient diffusion of innovation from one SME cluster to another cluster is when two clusters interconnect strongly rather than loosely,* where efficient innovation diffusion implies that most SMEs within each cluster could adopt innovation.

In the model map, given in Figure 3, we use a moderator variable (cluster coupling) in order to explain relation of the constructs "inter-SME tie (innovation adoption and adaptation)" with the outcome "efficient innovation diffusion". When cluster coupling is strong, this leads to more SMEs adopting innovation, i.e. efficient cluster diffusion. When cluster coupling is loose, this leads to just immediate neighbors adopting innovation, i.e. less efficient cluster diffusion of innovation.

Inter-cluster tie moderated by its strength allows access to external knowledge via weak ties and faster exchange of knowledge via strong ties; and that lead to efficient role of tie in innovation diffusion.

## 5.2 Role of Cluster Coupling in Efficient Diffusion of Innovation

In this section, we attempt to elaborate role of cluster coupling shown in Figure 4 in efficient diffusion of innovation. If clusters overlap via SMEs strong inter-connection, this leads to efficient diffusion of innovation among SMEs, most SMEs of either cluster can connect to each other via joint SME connections. When an SME adopts or adapt to an external innovation, all other SMEs within cluster adapt to innovation as well.

If separated clusters strongly interconnect via SME Source-Source connection, this leads to efficient diffusion of innovation among SMEs, as SMEs of either cluster can adopt innovation from its cluster source (S). Whereas, if two clusters interconnect loosely via SME-SME link, one SME (beneficiary) adapts to the innovation of other SME (beneficiary) and this leads to:

- Source (S) of each cluster cannot adopt this innovation from the beneficiary SME, since the S – SME link is one-sided from source to beneficiary. Therefore, this weak inter-cluster connection renders less-efficient innovation diffusion.

- Immediate neighbors of SME (not ALL SMEs) can adapt to the innovation that has been adapted from the other cluster. Therefore, this weak inter-cluster connection renders less-efficient innovation diffusion.

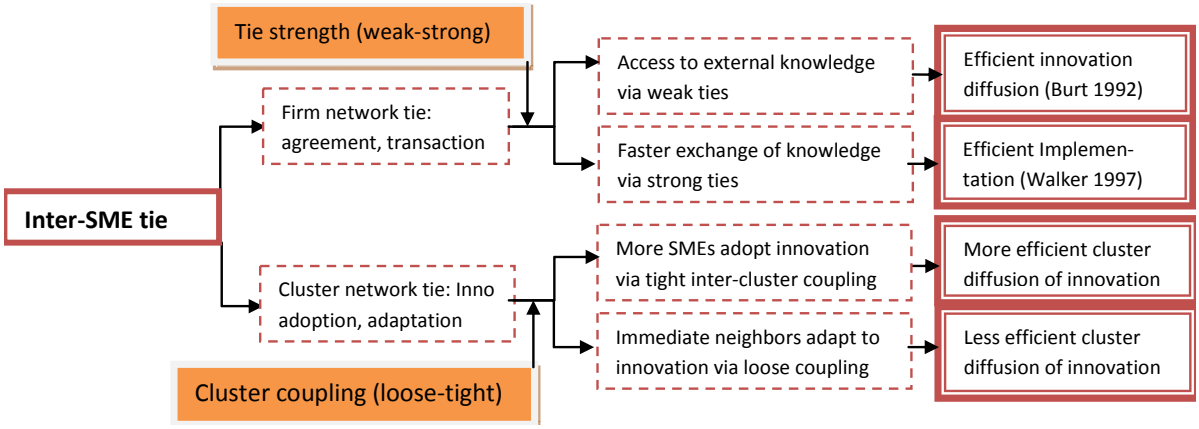


Figure 3: Illustration of the theory model diagram.

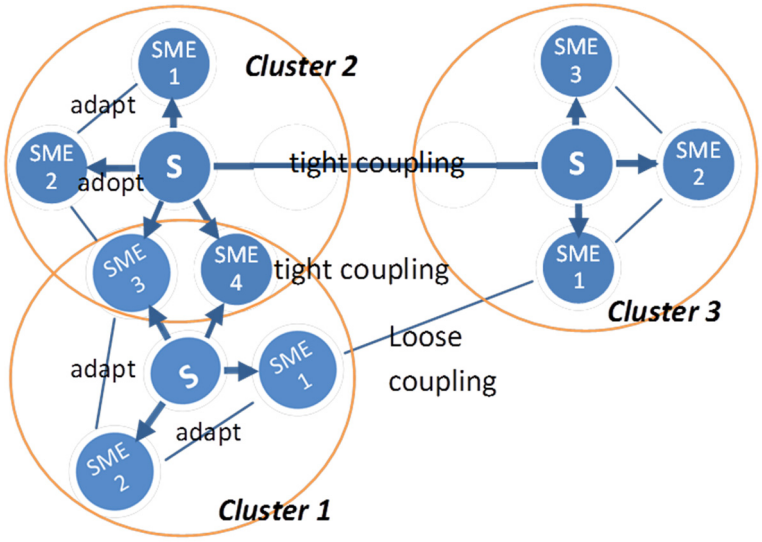


Figure 4: Illustration of intra (inter) SME-cluster links, where clusters overlap (strongly connect), S-S interconnects, or SME-SME interconnects (Weakly connect).

## 6 RATE OF ADOPTION

As Asheim and Isaksen (2002) mentioned, network afford SMEs access to resources otherwise lacking, and can be means of overcoming liability for entrepreneurial firms. The rate of dependency depends on several factors such as number of firms within network, geographic spread, and previous experience of cooperation, hub firm resources, and hub firm size.

Many studies have investigated SMEs innovation activities, and some have studied networks of innovation such as Batterink et al (2010), where firms collaborate on projects. Very few have studied the role of hub firms within SME networks and capabilities that lend to ways and mechanisms to improve coordination between hub firms and other SMEs (Ngugi et al 2010, Gardet et al 2012).

Table 5: Details of SME network analysis approaches.

| | | |
|---|---|---|
| SME network Analysis | 1. Theory of power | Prfeffer and salancik (1998) |
| | 2. Linkages and geo-graphical proximity | Florida (1995) Van Oort (2004) |
| | 3. Number of ties and ties heterogeneity | Borgatti and Foster (2003) |

As shown by Gardet and Mothe (2012), through networks, firms want to gain control over resource flows, and hub firms try to maintain their dependency on other firms in order to achieve innovation objectives. There are different approaches to dependency analysis with other SMEs. We provide different SME network analyses in Table 5 explaining our third proposition "Rate of innovation adoption and adaptation among SMEs depends on their network dependency".

1. Pfeffer and Salancik (1978) and Proven et al. (1980) proposed a theory of power within an innovation network to analyse the dependency relations that an SME hub firm has with other members (similar to our proposed model). The source of dependency is the acquisition of resources if a hub firm does not have all the required resources for an innovation project.

2. Florida (1995) has shown that number of linkages of the firm affect geographical proximity within an innovation network. Dollinger (1999) also stated that the way a network is built affects knowledge creation and sharing.

3. As shown by Sullivan and Marvel (2011), an entrepreneur knowledge set is inadequate, and this inadequacy is usually predominant during early stages of business (Collinson and Gregson 2003). Network ties are one way to overcome this shortcoming, where ties are the individuals or firms with whom entrepreneurs are in business contact. These ties could be between two SMEs where an entrepreneur adopts knowledge from another firm. Two characteristics of these network ties are the number as well as heterogeneity among ties (Borgatti

and Foster 2003). These ties may provide entrepreneurs with a knowledge advantage as well as access to other resources. Other authors such as Greve and Salaff (2003) found that the number of network ties has an inverse correlation with the early-late stages of the venture, whereas early stage ventures have usually more ties.

# 7 CONCLUSION

There have been many studies on the role of networks within the topic of knowledge sharing and innovation adoption. On one hand, Walker, Kogut and Shan (1997) stressed the efficient role of close ties within clusters on network outcome; on the other hand Burt (1992) emphasized the efficient role of structural holes between clusters on network outcome. Although the role of tie for the purposes of innovation diffusion and knowledge sharing has been emphasized, to the best of our knowledge, there has been no research in the literature in regard to efficient innovation diffusion and adoption within an SME cluster network, where efficient innovation diffusion implies that most SMEs within each cluster could adopt innovation. We presented a *cluster network model for inter-SME diffusion of innovation* where SMEs represent nodes, and *innovation adoption and adaptation* between any two SMEs represent ties. We provided and explained three propositions:

1) A network model contains both source and beneficiary of innovation, where the beneficiary adopts the innovation from source, or adapts to the innovation of another beneficiary. Sources could be SMEs or MNEs or other sources of innovation, while beneficiaries are always SMEs. SMEs aggregate to clusters where those SME clusters strongly or loosely interconnect. We define three types of SME clusters' connections.

- When two clusters overlap via one or more SMEs, then these two clusters interconnect strongly.
- When two clusters do not overlap, but interconnect via source-source connection, then these two clusters interconnect strongly.
- When two clusters do not overlap, but interconnect via link between two SMEs from two clusters, then these two clusters interconnect loosely.

There are several contextual assumptions in regard to our proposed theory as follows:

- At any given time, an SME is either source or beneficiary of innovation, not both simultaneously. However, at another time, it could reverse its status as source or beneficiary of innovation.
- SME-beneficiary will adopt innovation from another SME-Source provided that the source agrees to transfer innovation to the adopter and at the same time, the beneficiary has the internal capacity to adopt innovation.
- If SME-beneficiary cannot adopt the innovation from another SME-Source, it will attempt to adapt (imitate) the innovation of another SME-beneficiary.

2) The more efficient diffusion of innovation from one SME cluster to another cluster is when two clusters interconnect strongly rather than loosely. If clusters overlap via SMEs (strong inter-connection), this leads to efficient diffusion of innovation among SMEs. When one SME adopts innovation or adapts to innovation of another SME, all other SMEs within the cluster adopt or adapt the innovation as well, because when two clusters overlap, most SMEs within these clusters connect to each other. Therefore, this connection renders more efficient innovation diffusion. When two clusters interconnect via source-source connection (strong inter-cluster connection), SMEs of either cluster can adopt innovation from its source (S) connected to the other source. Therefore, this connection renders more-efficient innovation diffusion too.

If two clusters interconnect loosely via SME-SME link, one SME (beneficiary) adapts to the innovation of other SME (beneficiary), and this leads to:

- Source (S) of each cluster cannot adopt this innovation from the beneficiary SME, since the S - SME link is one-sided from source to beneficiary. Therefore, this weak inter-cluster connection renders less-efficient innovation diffusion.
- Only immediate neighbors of SME (not ALL SMEs) can adapt to the innovation that has been adapted from the other cluster. Therefore, this weak inter-cluster connection renders less-efficient innovation diffusion.

3) Rate of innovation adoption (adaptation) among SMEs depends on their network dependency. There are different analyses to network dependency among SMEs: Theory of Power (Pfeffer and salancik 1998), Linkages and geographical proximity (Florida 1995 Van Oort 2004), Number of ties and ties heterogeneity (Borgatti and Foster 2003). Pfeffer and

Salancik (1978) and Proven et al. (1980) proposed a *theory of power* within an innovation network to analyse the dependency relations that an SME hub firm has with other members. The source of dependency is the acquisition of resources if a hub firm does not have all the required resources for an innovation.

## REFERENCES


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

Aldrich, H. and Zimmer, C. 1986. Entrepreneurship through social networks. The Art and Science of Entrepreneurship, 3-23

Asheim, B. and Isaksen, A. 2002. Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *Journal of Technology Transfer*, 27, 77–86.

Baldwin, C. Y., and Clark K. B. 1997. Managing in an Age of Modularity." *Harvard Business Review* 75, no. 5 pp 84–93.

Batterink, M. H., Wubben, E. F. M., Klerkx, L., and Omta, S. W. F. 2010. Orchestrating innovation networks: The case of innovation brokers in the agrifood sector. *Entrepreneurship & Regional Development*, Vol. 22 N° 1, pp. 47-76.

Borgatti and Foster. 2003. The Network Paradigm in Organizational Research: A Review and Typology. *Journal of Management* 29(6)

Brusoni, S. and Prencipe, A. 2001.Unpacking the black box of modularity: technologies, products and organizations. *Industrial and Corporate Change* 10 (1), 179-205

Burt, Ronald S. 1982. Toward a Structural Theory of Action. New York: Academic Press.

Burt, Ronald S. 1992. Structural Holes. Cambridge, Mass.: Harvard University Press.

Burt, Ronald S. 2004. Structural Holes and Good Ideas. *American Journal of Sociology*

Collinson, S. and Gregson, G. 2003. Knowledge networks for new technology–based firms: an international comparison of local entrepreneurship promotion. *R&D Management* Vol 33 (2)

Denning, S. 2000. Communities for knowledge management.

DiMaggio, Powell. 1991. The New Institutionalism in Organizational Analysis

DiMaggio, P. and Powell, W. 1983. The iron cage revisited: institutional isomorphism and collective rationality in organisation fields. *American Sociological Review* vol. 48 pp147-60

Dollinger, M. J. 1999. Entrepreneurship: Strategies and Resources" Prentice Hall, Englewood Cliffs, NJ. Florida, R. 1995. *Towards the Learning Regions. Futures*, 27, 527–36**.**

Goduscheit , R. C. 2009. Leadership in interorganisational network-based innovation projects. *International Journal of Technology Marketing* 4 (2-3), 149-164

Gardet, Elodie; Mothe, Caroline; Emerald. 2012. SME dependence and coordination in innovation networks. *Journal of small business and enterprise development.* Vol 19, n 2

Granovetter, M. 1973. The Strength of Weak Ties. *American Journal of Sociology* 78.

Grandori, A. and Soda, G. 1995. Inter-Firm Networks: Antecedents, Mechanisms and Forms, *Organization Studies*, Vol. 16 N° 2, pp. 183-214.

Haider, S. Inter-Firm and Intra-Firm Organizational Learning and Knowledge Processes: Sequence and Inter-relatedness. *Society in Science*

Hansen, M. T. 1999. The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Units" *Administrative Science Quarterly* 44

Huber, G. P. 1991. Organizational Learning: The Contributing Processes and the Literatures.

Holland, J. H. 1975. Adaptation in Natural and Artificial Systems. Uni of Michigan Press.

Kogut, B., U. Zander. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science* 3(3).

Jørgensen, F., Ulhøi J. P. 2010. Enhancing Innovation Capacity in SMEs Through Early Network Relationships Journal: Creativity and Innovation 19(4)

Lee, S. G., Trimi, S., Kim, C. 2013. Innovation and Imitation effects' dynamics in technology adoption. *Industrial Management & Data Systems*, Vol 1130, No 6

Ma and Agarwal. 2007. Information Technology Design, Identity Verification, and Knowledge Contribution in Online Communities.

Narula, R. 2004. R&D collaboration by SMEs: New opportunities and limitations in the face of globalisation, *Technovation*, Vol. 24 N° 2, pp. 153-161.

Nelson, R. E. 1989. The Strength of Strong Ties: Social Networks and Intergroup Conflict in Organizations. *Academy of Management Journal* 32(2)

Ngugi AK1, Bottomley C., Kleinschmidt I., Sander J. W., Newton CR. 2010. Estimation of the burden of active and life-time epilepsy: a meta-analytic approach. *Epilepsia*. 51(5):883-90

Nutley, S. M.; Walter, I and Davies, H. T. O. 2002b. From knowing to doing: a framework for understanding the evidence-into-practice agenda" (Discussion Paper 1) University of St. Andrews, Research Unit for Research Utilisation, 32.

O'Neill, H. M.; Pouder, R. W. and Buchholtz, A. K. 1998. Patterns in the diffusion of strategies across organisations; insights from the innovation diffusion literature. Academy of Management Review 23(1) pp98-114

Pfeffer, J. and Salancik, G. 1978. The External Control of Organizations, Harper and Row, New York.

Robertson, M., J. Swan, S. Newell. 1996. The Role of Networks in the Diffusion of Technological Innovation. *J. Management Studies* 33(3)

Rogers, E. M. 1958. Categorising adopters of agricultural practices. *Rural Sociology* 23(4) pp345-54

Rogers, E M 1995. *Diffusion of Innovations*, 4th edition

Sullivan, Diane M. and Marvel, Matthew R. 2011 Knowledge Acquisition, Network Reliance, and Early-Stage Technology Venture Outcomes. *Journal of Management Studies* Vol 48 Issue 6

Tsai, W. 2000. Social Capital, Strategic Relatedness and the Formation of Intraorganizational Linkages. *Strategic Management Journa*l 21(9).

Walker, G., Kogut, B., Shan, W. J. 1997. Social capital, structural holes and the formation of an industry network. *Organization Science*, 8(2): 109.

Williamson, O. E. 1975. *Markets and hierarchies: Analysis and antitrust implications*. NewYork: The Free Press.