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ROLE OF PROXIMITY IN SHAPING THE KNOWLEDGE NETWORK OF PRODUCT AND PROCESS INNOVATION

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Abstract

ROLE OF PROXIMITY IN SHAPING THE KNOWLEDGE NETWORK OF PRODUCT AND PROCESS INNOVATION, OWAIS ANWAR GOLRA, UNIVERSITY OF EDINBURGH BUSINESS SCHOOL, YEAR OF ENROLMENT (PHD 3RD YEAR), EXPECTED FINAL DATE (SEPTEMBER 2017), owaisanwargolra@gmail.com State of the art: The contribution of this paper is two folds. First, it aims to contribute to cluster and network studies by attempting to explain the structural properties of product and process innovation networks. Secondly, the paper contributes to the debate on the role of proximity in shaping the formation of innovation networks. Particularly, it attempts to investigate the relationship between different dimensions of proximity and the informal network of product and process innovation. Informal networks play vital role in fostering innovation and knowledge circulation in clusters and regions. Firms share technical and business advice from each other to resolve their technical problems. Proximity, a multidimensional construct, facilitates the process of inter-firm knowledge exchanges. The key dimensions of proximity are geographic, social, cognitive, organizational and institutional, which have been found to influence the formation of technical and business advice networks. However, there is very limited evidence that these different dimensions of proximity have differentiated impact on the inter-firm knowledge exchange in multiple networks. Particularly, in relation to the knowledge of product and process innovation, we do not know yet that how does different dimensions of proximity impact the network of product innovation and the network of process innovation? Research gap & research question: We appreciate that knowledge required for the development of new products is different from the knowledge that is needed for the development of new process. The literature on technology and innovation management research claims that product and process innovation widely differ from each other in terms of knowledge complexity, tacit-ness and systemic attributes, where the later is more tacit, systematic and complex in nature. We acknowledge that, cluster and network studies have investigated technical and business knowledge network though, they did not take into account the important distinction between knowledge network for product and process innovation. Therefore, we propose that it is, first of all, useful to explore the intensity of informal linkages in product and process innovation network. Hence, our first research question is How does the structure of the network of product innovation differ or relates to the network of process innovation? Secondly, the impact of different dimensions of proximity on business and technical networks have been studied, however previous studies largely ignore to study the impact of proximity on knowledge network of product and process innovation. This paper investigates,

whether and how the different dimensions of proximity influences the shaping of product and process innovation network? Is there any dimension of proximity which is more germane and relevant to the knowledge sharing in product innovation and vice versa? Theoretical argument; In a regional context, one of the most important mechanism that firms use to acquire external knowledge is through informal contacts with other partners. Scholars have widely discussed the important role of informal contacts or informal networks in fostering innovation and knowledge circulation in the regions. The extant literature on regional studies argue that 'geographic proximity' promotes face to face interaction and hence inter-organizational knowledge exchange, and it is the decisive factor in the transfer of knowledge. However, the association of proximity merely with the geographic dimension, has been questioned by number of scholars over the last decade because of growing empirical evidence that has shown that external linkages or the linkages established at far distance are equally important as the linkages that are established at close spatial distance. The scholars have now acknowledged that other dimensions of proximity namely social, cognitive, organizational and institutional proximity play very important role in knowledge exchange and networking activities between firms. However, there is very limited evidence that these different dimensions of proximity have differentiated impact on the inter-firm knowledge exchange in multiple networks. Method; data if empirical paper A Textile Cluster in Pakistan is chosen as a case for conducting a mixed method study. Interview based survey questionnaire was used as an instrument to collect quantitative data from 60 firms on dimensions of proximity and firm level characteristics. The whole network approach was used and 'roster recall' methodology was used to build a network matrix of informal linkages for product and process innovation network. Finally, semi-structured in depth interviews were conducted to first of all validate the quantitative results and also to collect further information on the other sources of knowledge, and about the driving forces behind the development of new product and process development in local cluster. Detail data analysis is in progress. Results; Preliminary results suggest that the density of knowledge network of product and process innovation slightly differ. The intensity of interaction is higher among firms when they seek advice for the development of process innovation and the interaction among firms is low in case of product innovation. The possible reason might be that the product market is same for all competitors and to avoid opportunistic behaviour they prefer to take advice from their customers and suppliers rather than competitors. Second, possible reason is that textile cluster is a traditional sector and the rate of introduction of new product is very slow and hence firms do not feel the need to interact with each other on frequent basis. On the other hand, knowledge network for process innovation is dense, and interaction among firms is higher as compared to product advice network. The possible reason for that might be the presence of community of technical engineering personnel who belong to the same national university and prefer to share technical knowledge with each other on regular basis. Regarding the impact of proximity, four dimensions significantly influence the formation of both product and process innovation. However, social and cognitive proximity favours the formation of process innovation more than product innovation. Institutional proximity does not prevail in the local network, as none of the respondents interact with university or government research institute.

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ABSTRACT:

Informal networks play vital role in fostering innovation and knowledge circulation in clusters and regions. Firms share knowledge with each other to resolve their technical as well as non-technical problems, and as a result create new knowledge. Proximity, a multidimensional construct, facilitates the process of inter-firm knowledge exchanges. The key dimensions of proximity are geographic, social, cognitive, organizational and institutional, which have been found to influence the formation of technical and business advice networks. However, the impact of all these dimensions on the formation of knowledge linkages among actors is not even. Similarly, there is limited evidence that these different dimensions of proximity have similar, overlapping or differentiated impact on the inter-firm knowledge exchange in multiple networks. Product innovation networks and process innovation networks have been studied largely by scholars, and now it is acknowledged that the two networks are different in terms of external knowledge acquisition and network configuration. Nevertheless, the two networks have not been analysed using the proximity framework. Particularly, in relation to the knowledge of product and process innovation, we do not know yet that how does different dimensions of proximity impact the network of product innovation and the network of process innovation? Here, the contribution of this paper is two folds. First, it aims to contribute to cluster and network studies by attempting to explain the structural properties of product and process innovation networks. Secondly, the paper contributes to the debate on the role of proximity in shaping the formation of innovation networks. Specifically, it attempts to investigate the relationship between different dimensions of proximity and the informal network of product and process innovation.

KEY WORDS:

Proximity, Networks, Inter-firm relations, knowledge exchange, product innovation and process innovation

Introduction:

Innovation is the most important engine for economic growth of firms and regions, however the prerequisite to produce innovation is the capability to learn and create new knowledge (Boschma 2005). New knowledge can be created through trial, error and experimentation process individually or it can be created by joint action of different actors through networking process (Cantner and Graf 2011). Both knowledge and the networks are extremely important for the successful performance of firms and regions (Zaheer and Bell 2005; Arikan 2009). Knowledge is considered as the most valuable source of innovation and hence competitive advantage for the firms (Grant 1996). In order to remain competitive in the market, firms need to regularly update their stock of knowledge by combining the existing knowledge with the new knowledge (Kogut and Zander 1992). Firms can create new knowledge internally, however it is nearly impossible, to produce all components of knowledge required for the development of new products or services internally (Arikan 2009). Secondly, creation of new knowledge through in-house R&D can sometime be more costly than the benefits it may deliver, hence firms may acquire the required knowledge externally (Van Wijk, Jansen et al. 2008). Firms can acquire external knowledge through several mechanisms such as buying required knowledge from the appropriate market, outsourcing research project to other firms, buying license or patent, and hiring people with required knowledge (Cantner and Graf 2011). Over the last two decades, it has been acknowledged across various disciplines that networks play a crucial role in economic activities and acquisition of external knowledge (Granovetter 1985; Powell, White et al. 2005; Jonard, Cowan et al. 2007).

Although, networks are crucial in determining the economic performance of organisations, nevertheless it is equally important to investigate the origin of such relations and to understand the underlying mechanisms of network formation (Boschma, Balland et al. 2015). In doing do, most recent studies in this stream of literature have shifted the focus of inquiry from investigating the structure of network to the underpinning forces that shape the formation and evolution of these informal networks. The first two drivers operates at structural and individual level respectively. The first refer to as the endogenous mechanisms of network formation i.e. future links are dependent on the organisation of existing relationships among networked actors. The second driver focuses on the individual level and analyses the unequal embeddedness of actors in a network i.e. creation of relations are dependent on the characteristics of individual actors (Boschma, Balland et al. 2015). For instance, Giuliani (2013) examined cohesion effect (e.g. reciprocity and transitive closure-'structural level') and threshold effect (e.g. absorptive capacity of firms – 'individual level') in a study on wine cluster in Chile. She found that both the above mentioned effects were key to the formation of new linkages between actors. The author argued that firms are likely to establish knowledge linkages with other firms, which are already connected indirectly with them. Similarly, firms select their partners for knowledge exchange on the

basis of certain level of similarity in their knowledge bases so that new and related knowledge can be transferred or acquired easily.

In addition to the above two levels, authors have recommended a third level of analysis to investigate the formation of network i.e. 'proximity' level (Boschma, Balland et al. 2015). Balland et al. (2014) argue that since firm level attributes and network endogenous effects are important, the notion of proximity plays a central role in explaining the formation and dynamics of informal networks. Notion of proximity refer to as 'being close to something measured on a certain dimension' (Knoben and Oerlemans 2006). The concept of proximity is not new and the studies that uses proximity as a framework to study innovation and knowledge networking has grown tremendously over the past two decades. However, much attention has been paid to the notion of geographic proximity and benefits of co-location or spatial advantages for firms (Molina-Morales, García-Villaverde et al. 2014). The central argument regarding geographic proximity is that establishing knowledge linkages with other partners require close spatial or geographic proximity between the cooperating partners (Ozman 2009).

Although 'geographic proximity' promotes inter-organizational knowledge exchange and it is the decisive factor in the transfer of knowledge (Jaffe, Trajtenberg et al. 1992; Usai, Marrocu et al. 2015), the association of proximity merely with the geographic dimension is not true, because there is growing empirical evidence that has shown that external linkages or the linkages established at far distance are equally important as the linkages that are established at close spatial distance (Shaw and Gilly 2000; Giuliani and Bell 2005; Boschma and Ter Wal 2007; Molina-Morales and Expósito-Langa 2012). Several studies have shown that there are other dimensions of proximity which influence the formation of inter-firm knowledge linkages (Cooke 2011). Boschma (2005) proposed five dimensions of proximity namely geographic, social, cognitive, organizational and institutional. Social proximity between actors is refer to as high embeddedness in terms of social relations (Granovetter 1985) such as friendship and kinship, whereas organizational proximity refer to as the similarity in terms of organizational routines and structures. On the other hand, cognitive proximity refer to as similarity in terms of knowledge bases of partners (Nooteboom 2000), and institutional proximity is defined in terms of similarity in norms and institutions in which actors are embedded (Edquist 1997). Boschma (2005) argued that these five dimensions can influence the inter-firm knowledge exchange and networking activities at large and hence should be studied in an integrated framework.

Till date, the studies on multidimensional aspect of proximity produced huge number of empirical evidence but these studies are not consistent in their findings at large, and a lot of discrimination can be observed in the results among these studies in explaining the impact of proximity dimensions on inter-firm linkage formation (Balland 2012; Geldes, Felzensztein et al. 2015; Molina-Morales, Belso-Martínez et al. 2015; Usai, Marrocu et al. 2015). These conflicting results obviously open new avenues for future research to find out a way to produce more consistent result on impact of proximity

dimensions on knowledge sharing and innovation outcome. Apart from several other factors, one of the important reason for such conflicting findings might be the focus of previous studies on the single knowledge network. Research on multiplex networks can provide useful insight to understand the impact of proximity. Moreover, researcher have also invited scholars to conduct more research on network dynamics and multiplex networks (Ahuja, Soda et al. 2012; Balland, Belso-Martínez et al. 2014).

This research paper highlighted important issues in the research on knowledge networks and inter-firm knowledge exchange linkages particularly in an Industrial cluster and regional context. In doing so, the research paper intends to integrate the literature on management research on networks and the literature on regional studies addressing inter-firm knowledge exchanges.

This study opens doors to a new research agenda for the thorough investigation of the role of multiple dimensions of proximity as a determinant for the formation of inter-firm knowledge exchange linkages among the cooperating firms in regional context (Boschma, 2005; Torre and Rallet, 2005; Usai et al., 2015; Molina-Morale et al., 2015; Geldes et al., 2015). The focus can be given either to developing countries or the developed ones, however the previous research has mostly focused on the developed and advanced countries. We believe this will be unique contribution in literature because application of multidimensional proximity as determinant of informal networks in both developed and developing countries perspective is scarce, particularly, application in case of regional cluster is not yet fully explored.

On the other hand, so far little is known, whether the impact of proximity dimensions remain the same over multiplex networks or it varies across the different types of networks. Therefore, the second issue deals with the impact of proximity dimensions on multiplex informal network. We suggest to test the impact on informal network of product innovation and informal network of process innovation. The main assumption is to understand which type of proximity favours the inter-firm linkage formation for product innovation and which type of proximity favour the linkages of process innovation. So far there is no empirical evidence on this topic, however there is evidence that the configuration of both product and process innovation networks are different from each other (Gemünden, Ritter et al. 1996). Secondly, the firms access different sources of knowledge for both product and process innovation and the structure of external knowledge absorption for product innovation is different from that of the process innovation (Bogers and Lhuillery 2011). Hence, we assume that the different dimensions of proximity will influence the two networks in a different way. The second specific research objective of this paper is to investigate the relationship between multiple dimensions of proximity as determinant of 'multiplexity of inter-firm knowledge exchange linkages' (Shipilov 2012; Ranganathan and Rosenkopf 2014; Rogan 2014; Shipilov, Gulati et al. 2014; Sytch and Tatarynowicz 2014), because there is also room for research in this area.

The overall objective of this paper is to combine the two notions i.e. 'multidimensional proximity' and 'multiplexity of inter-firm linkages' in an integrated conceptual framework to explain the informal network formation. In doing so, the main argument is that different proximity dimensions influence the formation of inter-firm linkages (Broekel and Boschma 2012; Balland, De Vaan et al. 2013) particularly informal network (Balland, De Vaan et al. 2013; Balland, Belso-Martínez et al. 2014) therefore their influence will be differentiated in case of multiple kind of linkages and hence on the structural properties of the subsequent multiple type of knowledge networks.

Therefore, we finally proceed with the recent research agenda under the multidimensional proximity and multiplexity paradox and suggest the following research questions in next section.

Research Questions:

In line with the aims and objective discussed in the previous section, the research questions are given below;

- How does the knowledge network of product innovation differ or relate to the knowledge network of process innovation?
- Whether and how does the different dimensions of proximity impact the knowledge network for product innovation? To what extent geographic, social, cognitive, organizational and institutional dimensions of proximity act as determinant for the formation of inter-firm linkages for product innovation?
- Whether and how does the different dimensions of proximity impact the knowledge network for process innovation? To what extent geographic, social, cognitive, organizational and institutional dimensions of proximity act as determinant for the formation of inter-firm linkages for process innovation?
- Whether the impact of different dimensions of proximity on product innovation network is different from the impact on process innovation network or it is same in both network?
- If the impact is different in both networks, then which dimension of proximity is more relevant for product innovation network and why is it so? And which dimension of proximity is more relevant for process innovation network and why is it so?

Literature Review/ Theoretical Framework:

1.1 Proximity and its dimensions

Proximity refer to as the closeness to something. However in analytical terms it is divided into five generally accepted categories namely geographic, cognitive, social, organizational and institutional proximity (Boschma, 2005). Researchers often use spatial and geographic terms alternatively, and non-

spatial and other four dimensions as an alternative. I will also use both the terms interchangeable in this report. The next section will discuss the theoretical framework of this paper.

2.2 Multiple Dimensions of Proximity:

It is now generally acknowledged in the literature that the notion of proximity is no longer limited to the spatial or geographic boundaries, and there are several non-spatial dimensions of proximity that play a key role in the formation of inter-firm knowledge linkages (Boschma 2005; Torre and Rallet 2005; Knoben and Oerlemans 2006). Generally, five dimensions of proximity appear in the literature, which are discussed as follows;

2.2.1 Cognitive Proximity:

'Cognitive proximity' is defined in terms of shared knowledge base and shared skills (Aguiléra, Lethiais et al. 2012). However, there is wide contrast present in the literature on the conceptualization of cognitive dimension of proximity in regional studies. This concept has been introduced by Noteboom (2000) in a learning perspective. Later it is adopted by vast academic field. For instance, Giuliani and Bell (2005) and Ter Wal and Boschma (2007) have operationalized it as the knowledge base or absorptive capacity of the firm in a regional context. On the other hand, it is often replaced by the term technological proximity (Nooteboom, Van Haverbeke et al. 2007; Usai, Marrocu et al. 2015) and industrial relatedness (Boschma, Marrocu et al. 2015; Ellwanger and Boschma 2015) based on similarity in the knowledge bases at technological or sectoral level. In an inter-firm dyadic relationship, (Heringa, Horlings et al. 2014) measured the cognitive proximity by developing several indicators based on the shared specific expertise between ego and it's alter on a Likert scale. Overall, the concept is mostly used in terms of the knowledge base and shared technological skills at different level of analysis. The main argument is that the firms share knowledge with each other when there is certain amount of overlap in the knowledge bases of both partners (Boschma 2005). Some scholars suggest, partners are cognitively close if they show some similarity in terms of technological or industrial relatedness to each other (Ellwanger and Boschma 2015). The research also shows that too much of the cognitive proximity is detrimental to inter-firm cooperation, because partners may not be able to exchange any useful knowledge with each other. On the other hand, too much cognitive distance also hinder inter-firm cooperation because partners may not be able to understand each other's offered knowledge. Hence, an intermediate level of cognitive proximity is ideal for inter-form cooperation (Wuyts, Colombo et al. 2005).

2.2.2 Geographic Proximity:

Geographical proximity or spatial proximity is generally associated with the notion of space, territory, locality and physical closeness (Knoben and Oerlemans, 2006). In other words, it is the spatial distance between two agents and usually operationalized in terms either physical distance or belonging to a

certain geographic location (Anguilera et al., 2012). Spatial proximity is the highly investigated dimension in the literature on knowledge flows and spill over (Jaffe, Trajtenberg, and Hendersen, 1993; Usai, 2015). Although, the theoretical importance of spatial dimension of proximity in knowledge exchange is questioned in the recent past (Breschi and Lissoni 2001; Boschma 2005; Giuliani and Bell 2005; Torre and Rallet 2005) among others), and scholars have reported both positive (Paci, Marrocu et al. 2014) and negative influence (Geldes et al., 2015) of spatial proximity on the formation of knowledge linkages, however it is still considered as important dimension of proximity in influencing the formation of inter-firm knowledge linkages. Geographic proximity facilitates face to face interaction between the actors, however firms may prefer to interact with only those firms which are similar is organizational structure and procedure, as it is easy to coordinate activities and understand each other rules and regulations (Boschma, 2005). Hence, organizational proximity appears to play a useful role in such circumstances.

2.2.3 Organizational Proximity:

There is no consensus among the researchers for single definition of organizational proximity and it is defined in a variety of ways (Knoben and Oerlemans, 2006). However, one can notice a commonality in a way that researchers conceptualize it in relation to the similarity in rules, procedures, practices, routines, structural equivalence, mechanism of coordination, set of interdependencies (Boschma, 2005; Anguilera et al., 2012). In terms of dyadic relationships, it is defined as the similarity between the routine and incentives of the ego and alter (Heringa et al., 2014). Molina-Morales et al. (2015) argues that autonomy and control are the basis of organizational proximity and it is usually operationalize by measuring long term collaboration in the past. Further, belonging to same corporate group (Balland, 2012) or same parent company (Usai et al., 2015). Likert scale based on the literature on organizational culture has also been used to measure the organizational proximity in an inter-firm relationship at dyadic level (Heringa et al., 2014). Too much organizational proximity increases the chance of lock-in and lack of flexibility in learning from each other, therefore (Noteboom, 2000) suggest that organizational structure that facilitate coordination among cognitively proximate and cognitively distant people may be helpful in avoiding the issue of too much organizational proximity.

2.2.4 Social Proximity:

Social proximity is referred to as the social embeddedness in relation between agents (Knoben and Oerlemans, 2006) and its origin is generally considered as the embeddedness literature (Granovetter 1985). It is mainly related to the notion of trust, based on kinship, friendship and past collaborations (Boschma, 2005; Broekel and Boschma, 2012). It is measured as an inverse of geodesic distance (Usai et al., 2015) or otherwise through asking questions based on trust and nature of relationship between the exchange partners (Heringa et al., 2014) and social interaction and trust (Molina-Morales and Martinez-Fernandez, 2009). In a cooperation based on informal linkages, it is not market contracts that

favour knowledge exchange rather it is trust that facilitates smooth flow of knowledge among partners, especially when the knowledge is in tacit form (Boschma, 2005). Therefore, social proximity is important for knowledge exchange and interactive learning. On the contrary, Uzzi (1997) argued that too much social proximity is detrimental for innovation because it may lock the actors into too much social network that they may not look for valuable sources of knowledge outside their social circle. The author shows an inverted U-shape relationship between social embeddedness and innovative performance of firm and argue that, positive impact of social embeddedness remain to a certain threshold after which the positive impact turns into negative influence. Boschma (2005) argue that social proximity operates at micro-level and firms are also affected by the factors at macro-level i.e. rules and regulations at national level. Hence institutional proximity is also an important factor in the inter-firm cooperation.

2.2.5 Institutional Proximity:

Institutional proximity is usually related to the same institutional framework shared by the agents (Usai et al., 2015). (Edquist) (1997: p46)define institution as 'sets of common habits, routines, established new ideas and innovations practices, rules, or laws that regulate the relations interactions between *individuals and groups'*. Boschma (2005) argued that researchers should carefully use the concept of institutional proximity because of its interconnected with the concepts of organizational and social proximity (Boschma, 2005). Knoben and Oerlemans (2006) recommended to merge it under the heading of organizational proximity. Researchers have operationalized based on the status of the partners, such as legal status of firm (Molina-Morales et al., 2015) or in other words same institutional status such as private, government, or subsidiary (Balland, 2012; Usai et al., 2015). Research points out that too much institutional proximity is unfavourable for new ideas and innovation due to institutional lock in, and on the other hand too little institutional proximity is detrimental for collective learning process (Boschma, 2005).

Having discussed the different types of proximity dimensions, it is important to understand its interaction with inter-firm cooperation. The next section will shed light on the existing literature.

2.3 Multidimensional Proximity and inter-firm linkage formation:

There is a growing recognition that multiple dimensions of proximity can influence the formation of inter-firm knowledge linkage, however the impact varies along the dimensions of proximity. Several studies have found evidence that multiple dimensions of proximity shows significant influence on the inter-organizational collaborative partnerships (Balland, 2012; Usai et al., 2015; Molina-Morale et al., 2015; Geldes et al., 2015). However, the researchers obtained contradictory results regarding the influence of multidimensional proximity in explaining inter-firm knowledge linkages. For instance, Balland (2012) in his study on collaborative papers on Global Positioning Satellite Systems (GPSS) under EU 6th Framework program found that geographic, organizational and institutional proximity

favour collaborations, whereas social and cognitive proximity do not play a significant role. In another study on foodstuff cluster in Valencia region (Spain), Molina-Morale et al., (2015) after controlling network endogenous forces and firm characteristics, found that cognitive and institutional proximity negatively affect the formation of technological knowledge linkages among the actors where as social and geographic proximity promotes knowledge linkages over time and organizational proximity fosters learning and knowledge sharing among partners. In a different context, Geldes et al., (2015) found that in the agribusiness cluster, geographic proximity is not a relevant factor whereas non-spatial proximities are more relevant, and especially in agribusiness cluster social proximity plays highly important role in promoting inter-firm market linkages among the partners. Because of such contradictory effects of proximity dimensions, some authors attempted to find out the complementary/overlapping and substituting effect for proximity dimensions. Paci et al. (2014) found that all proximity dimensions have the positive effect on linkage formation and hence complement each other. On the contrary, Hansen (2014) in a study on Danish clean-tech industry found that geographic and social dimensions of proximity can have both overlapping and substituting effect, whereas cognitive and organizational dimensions play the substituting role against geographic dimension. Finally, geographic and institutional dimension only overlap.

There are few studies that have found positive influence of all dimensions of proximity on the knowledge sharing, however authors have reported significant difference in the level of influence among all the dimensions (Paci et al., 2014; Usai et al., 2015). For instance, (Usai et al. 2015) found positive influence of all five proximity dimensions on the formation of inter-firm knowledge linkages in their longitudinal study, using data form Standard Platinum Databased (Thomson Financial) on joint ventures and alliance formation. However, authors highlighted that all the dimensions of proximity have shown heterogeneous affect i.e. technological proximity has the highest impact followed by organizational, geographic and institutional proximity and social proximity was reported to have the lowest effect on inter-firm collaboration. Likewise, Broekel and Boschma (2012) found significant positive influence of social, organizational, cognitive and geographic proximity on the establishment of knowledge linkages, however authors also suggested that too much of the cognitive proximity reduces the firm innovation performance. Heringa et al. (2014) in their study on Dutch water sector found interesting results on the four proximity dimensions on the organizational outcome. They divided organizational outcomes into three soft (shared knowledge, collaborative programs and support for ideas) and three hard (innovation, financial turnover and publications) categories. The authors found that geographic and organizational proximity have negative influence on hard outcome and have no effect on soft outcomes, whereas social and cognitive proximity have a positive effect on all six outcomes.

Despite, large amount of empirical evidence based on variety of methodological tools and data sets used by researchers to study the influence of multidimensional proximity on the formation of knowledge

linkages among the actors, there are still contradictions among the scholars regarding the positive or negative impact of all proximity dimensions. Secondly very little evidence is reported from the developing country's perspective. Scholars have called for more research in the proximity and network studies based on different research settings. The two main short comings in the previous research are reported as either static in nature or it is based on single network study. For instance, Balland et al. (2015) argued that the previous studies have adopted a static approach that is why there is conflicting results found by the researcher. Authors further suggest that a dynamic perspective to study proximity might be useful to overcome this issue (Balland et al., 2015). Similarly, Balland et al. (2014) argued that multiple dimensions of proximity should be studied in a multiplexity framework. In this regard, our argument is that studying the influence of multidimensional proximity on multiple networks or multiplexity of linkages in an integrated theoretical framework provides a dynamic perspective and that might provide us insight for the contradictory role played by the proximity paradox.

2.3.1 Multidimensional Proximity and Multiplex Networks-an integrated framework

The research on proximity is scarce on the relationship between multiple dimensions of proximity and multiplex networks. However, ample of research has been done on the single dimension of proximity and multiplex networks. Particularly, in the recent literature the notion of business networks and technical networks in the clusters has been explored by number of scholars to test the cognitive proximity between the actors (Boschma and Ter Wal 2007; Giuliani 2007; Morrison and Rabellotti 2009). The authors argue that the structure of the network of business interaction is different from the structure of the technical network. However, this stream of empirical studies are limited to the single dimension of proximity. Whereas the studies those have analysed multiple type of proximity dimensions, do not consider the multiplex networks. There is only one study conducted by Balland et al. (2014), who have attempted to capture the both concepts in an integrated network on the study on toys cluster in Spain. The authors studied different factors such as structural embeddedness, status and proximity that can affect the formation of ties in both business and technical network. They authors found some factors such as structural and social embeddedness imparting similar impact on both of the network. On the other hand authors argue that other factors have totally different impact on both networks. They further argue that technical networks are more stable over the period of time, whereas business networks change as the time passes. Regarding the impact of proximity, authors have found proximity has limited impact on the business network formation. On the impact on technical network, they found that geographic and cognitive proximity are insignificant, however they argue that this discrepancy might be because of the selection of the case. This is the only study available on the impact of multiple dimensions of proximity on the multiplex networks, therefore authors have invited other researchers to conduct further studies in a similar way, because it is difficult to generalize from a single study.

Therefore, the current study will follow the same methodology however, the focus of current study is not on the business and technical network comparison, and rather it will study the impact of multiple dimensions of proximity on the multiple type of informal technical networks based on product and process knowledge. Why we have chosen product and process innovation network and what will be our research hypothesis is discussed in the next section.

2.3.2 Proximity Dimensions and Network for Product and Process Innovation: Suggested Research Hypothesis

There is empirical evidence that differences exist between characteristics of product and process innovation and the knowledge required for both have different characteristics (Casanueva, Castro et al. 2013). Process innovation require more tacit, complex and systematic knowledge which is not easy to acquire from the external sources, hence process innovation rely more on internal knowledge (Peters, Pressey et al. 2010). Moreover, Capello (1999) argues that process innovation mostly require internal knowledge, however some technological proximity is required with customers and suppliers. Similarly, Gemunden et al. (1996) argue that process innovation requires multiple dimensions of cooperation with multiple actors to successfully produce process innovation. On the other hand, firms rely more on external sources of knowledge for product innovation (Gopalakrishnan, Bierly et al. 1999) and therefore external collaborations are more common in product innovation as compared to process innovation (Westerlund and Rajala 2010).

Regarding the acquisition of external knowledge, Bogers and Luihilery (2011) argue that structure of external knowledge absorption for product innovation is different form process innovation, and both use different channels for the acquisition of knowledge. Authors further suggest that horizontal linkages matter more for product innovation as compared to process innovation, and the knowledge coming from different sources influence the product innovation more than the process innovation. Similarly, the magnitude of absorptive capacity to acquire external knowledge for product innovation is different from the magnitude of process innovation. Competitors are dominant source of knowledge for process innovation and less dominant for product innovation (Bogers and Lhuillery 2011). Moreover, Gemunden et al. (1996) also found that the network configuration of product innovation is different from the network configuration of process innovation, and the pattern of external knowledge acquisition for product innovation is different form the pattern of process innovation.

Although, there is very little empirical studies that have considered both product and process innovation for analysis and most of the studies focus only on the analysis of product innovation and ignores the process innovation in their analysis. However, from the above literature review we can summarise the following points. Firstly, the product and process innovation require different sources of knowledge. Secondly, the pattern of external knowledge acquisition is different for product innovation and process innovation. Third, the network configuration of product innovation network is different from the

network configuration of process innovation network and finally, process innovation require more internal knowledge and product innovation mainly rely on external knowledge.

Based on the above literature review and the key argument that magnitude of absorptive capacity for product innovation and process innovation is different from each other, hence we can assume that the forces that shape the formation of product innovation network and process innovation network could have differentiated impact. Since, we know that multiple dimensions of proximity are one of the most important factors that drives the formation of knowledge networks, hence we can formulate the below hypothesis;

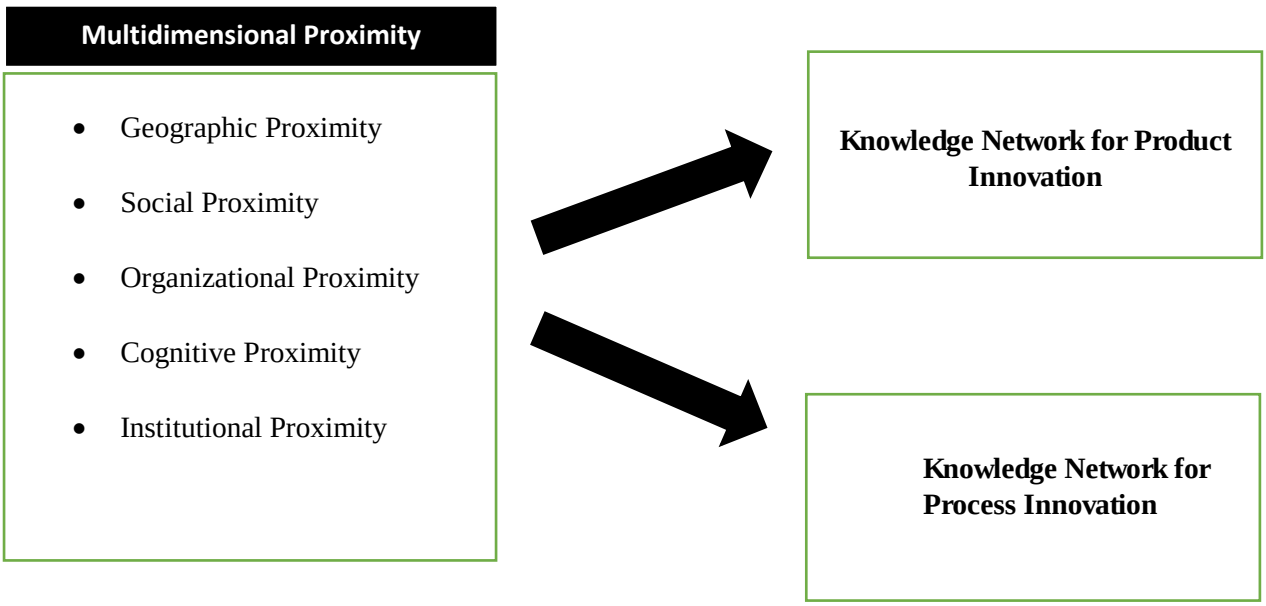
H1. The multiple dimensions of proximity has influence on product innovation network.

H2. The multiple dimensions of proximity has influence on process innovation network.

H3. The impact of different dimensions of proximity on product innovation network is different from their impact on process innovation network.

H4. The density of product innovation network and process innovation network is different and process
H5. The level of importance of various external sources are different in case of product innovation and process innovation

3. Conceptual Framework



4. Research Methodology

4.2 Nested Research Design:

This research is based on a network level research which includes the manufacturing firms based in a textile cluster in Faisalabad-Pakistan. Hakim (2000) argues that case study is the most flexible method providing a richly detailed portrait and in depth view of a social phenomenon. However, my purpose is to study the impact of proximity dimensions on the formation of networks. In my study the case is about the phenomena of network formation. Gerring (2004) define case study as "an intensive study of a single unit for the purpose of understanding a larger class of (similar) units. A unit connotes a spatially bounded phenomenon—e.g., a nation-state, revolution, political party, election, or person—observed *at a single point in time or over some delimited period of time"*.

In this study unit of analysis is two networks which are nested in a textile cluster and hence this study is a nested as well as parallel case study design in which I am interested to compare the formation of two knowledge network for product innovation and process innovation and also in understanding the impact of proximity on these networks. The Faisalabad/Lahore Textile Cluster is taken as a contextual research setting for the quantitative as well as qualitative analysis of the concepts explained in the theoretical framework. The study focuses on the firms based in Lahore region in Pakistan. Yin (2013)suggested to set the criteria in order to enhance the reliability of the research. Moreover, single case study is suitable for a detail and intensive study (Bryman 2012) and parallel case study is good to compare two cases in detail. First of all the cluster which should be studied, must have enough number of firms agglomerated and interlinked to each other. The firms must be involved in improving products and processes.

4.3 Data Collection and Analysis Technique

4.3.1 Data Collection:

Different methods of data collection can be used to collect data in case study design such as survey method (self-administered questionnaire), archival analysis, observations and interviews (Vaus D, 2001; pp.221). The primary data is done through semi-structured questionnaire through face to face interviews. As our purpose was to collect data mainly for social network analysis, and Borgatti et al. (2013) suggested that the best method is to collect data via face-to-face interviews, because it decreases data handling errors and increase response rate.

I have conducted interviews based on semi-structured questionnaire to test my hypothesis. Apart from general information on firm age, production capacity, size etc., the questionnaire seeks information on the proximity variables. The interviews were carried out from the heads of the manufacturing departments who are responsible for the R&D, quality, operations and production of the products and processes. Data on proximity variables were also included in the questionnaire, however secondary

sources were also be consulted to gather information about firm through company websites and industry magazines. For instance, to measure the organizational proximity, data from All Pakistan Textile Mill Association was collected to check the number of firms that are associated with the group of companies.

In addition to the data collection on proximity variables, I collected information on the network data to address the research question, and in accordance with the previous studies I have used the 'roster recall method' (Giuliani and Bell, 2005) to collect information on the advice linkages on both product and process innovation. There are almost 81 textile units which were included in the roster, however firms were also asked to add any name which is not given in the list.

4.3.2 Pilot Study

Baker (1994) suggests to conduct a pilot study before launching a full fledge study and starting a field work is desirable. He argues that the researcher could increase the validity of data. I had conducted a pilot field work for two main reasons. First of all, to test and improve the questionnaire tool and secondly to further improve the strategy for my proper fieldwork. On the basis of pilot study results, I have modified my questionnaire and theoretical framework.

4.3.3 Operationalization of Variables

The following variables were operationalized in this study;

Explanatory Variables:

Geographic proximity:

This variable has been operationalized in the studies by measuring the distance between firms in either kilometres, logarithm kilometre, travel time and from the location of the firm in a similar geographic locality (Balland, 2012; Broekel and Boschma, 2012; Balland et al., 2014; Molina-Morales et al., 2015 among others). I followed Balland et al., (2014) and measuring it in terms of inverse of the distance in kilometres. The data on geographic proximity is not completed yet, hence it is not yet analysed in this paper. However, a separate question was asked by the respondents regarding their preferences on getting advice from the alters. Firms were asked to rank the five statements that represents five dimensions of proximity. For instance, they were asked if they prefer to take advice for product innovation from their friends or past colleagues? Similarly, they were asked to rank the five statements according to their preference. The descriptive results are given in the APPENDIX.

Cognitive proximity:

Cognitive proximity is also measured by scholars in different ways. Mostly, it is measure by using the NACE code (Broekel and Boschma, 2012; Usai, 2015). Some scholars have operationalize it by measuring the similarity in the technological and knowledge base. I measure it through two similarity

measures. If two firms will show a link, I will first of all compare the technical class of the firms to identify the similarity. If the technical classes of two firms match then this shows a cognitive link. Secondly, I have collected information on the machinery and equipment of both partners, if both firms share share the same equipment/ machinery set-up then it is also considered as a cognitive link.

Social proximity:

This variable has also been defined by scholars in different ways. I have operationalised it following (Beoekel and Boschma, 2012) and consider it as a binary variable. Broekel and Boschma (2012) measured it by creating a dummy variable FOKKER, which means if the top management of the firms worked in FOKKER Company in the past then it will be considered a social proximity. I follow the same but a slightly different approach. In my case, I have asked the respondent about their university/college degree affiliation and if both partner share the same university then the variable takes the value 1 and otherwise 0. Secondly, I have also asked information about the last three employers of the respondent, if any of the last three employers be same between the two partners then it shows a sign of social proximity. Finally, I also seek information about the owner's name and tribe. This is particularly important in Pakistani scenario, because the textile business is largely owned by some special clans. For instance, sheikh clan is particularly famous for their investment in textile industry. Therefore, I will see if the owners of the two families are same then it will also be a social link and takes the value 1.

Organizational proximity:

This variable has also been defined by scholars in different ways. I have operationalised it following (Balland et al., 2014) and consider it as a binary variable. It will take the value 1 when both firms are owned by the same group of companies and otherwise 0.

Institutional proximity:

This variable has also been defined by scholars in different ways. I have operationalised it following (Balland et al., 2014) and consider it as a binary variable. It will take the value 1 when both firms share the same legal status and otherwise 0. Legal status means if both firm are registered with the stock exchange then it takes the value 1 otherwise it takes the value 0.

Dependent Variables:

Knowledge Network for Product Innovation (formation of tie)

This variable is operationalize on the basis of links between actors established to share knowledge for product innovation. We follow Broekel and Boschma (2012) in the operationalization of this variable, because our main purpose is to estimate the importance of different dimension of proximity on the likelihood that two actors are connected for the purpose to share the product innovation knowledge.

Although the question seeks information on the importance and quality of information from 0-3 (0=no importance, 3= high importance), however for the purpose of analysis, this variable will be dichotomous and mention whether there is a link exist between the two actors. It takes the value 0 when there is no link and the value 1, when there is a link. The question seek information for directed graph but for the purpose of analysis, we will consider the graph as undirected and like Broekel and Boschma (2012) assumes presence of link when one of the partner identifies a link.

Knowledge Network for Process Innovation (formation of tie)

This variable is operationalize on the basis of links just like the product network, but this link is based on the knowledge related to process innovation. We follow Broekel and Boschma (2012) in the operationalization of this variable, because our main purpose is to estimate the importance of different dimension of proximity on the likelihood that two actors are connected for the purpose to share the process innovation knowledge. Although the question seeks information on the importance and quality of information from 0-3 (0=no importance, 3= high importance), however for the purpose of analysis, this variable will be dichotomous and mention whether there is a link exist between the two actors. It takes the value 0 when there is no link and the value 1, when there is a link. The question seek information for directed graph but for the purpose of analysis, we will consider the graph as undirected and like Broekel and Boschma (2012) assumes presence of link when one of the partner identifies a link.

Control Variables

I will control several variables so that the effect of proximity can be fairly understood. The common variables that can affect the results are size of firm and age of firm etc.

4.3.4 Data Analysis

The variables operationalized in the above section will be analysed by using the social network analysis.

To test the hypothesis for the research questions that are based on relational data, we follow Broekel and Boschma (2012) and will use the network regression techniques. These techniques allow to test the hypothesis on relational matrix data. Borgatti et al. (2013) argue that Multiple Regression Quadratic Assignment Procedure (MRQAP) regression technique allow us to test model with multiple independent variables in matrix form and relational matrix as a dependent variable. Network statistics is used for the analysis of product knowledge network and process knowledge network. Bootstrap paired sample t-test was used to measure the differences between the densities of the two networks.

The software used for the analysis of data is UCINET VI (Borgatti 2002) because it is widely accepted software that perform all relevant functions for the analysis of social network data.

Findings:

Tables and graphs are presented in the Appendix, however the analysis of data is under progress.

……. (See APPENDIX)…….

Conclusion:

Preliminary results suggest that the density of knowledge network of product and process innovation slightly differ. The intensity of interaction is higher among firms when they seek advice for the development of process innovation and the interaction among firms is low in case of product innovation. The possible reason might be that the product market is same for all competitors and to avoid opportunistic behaviour they prefer to take advice from their customers and suppliers rather than competitors. Second, possible reason is that textile cluster is a traditional sector and the rate of introduction of new product is very slow and hence firms do not feel the need to interact with each other on frequent basis. On the other hand, knowledge network for process innovation is dense, and interaction among firms is higher as compared to product advice network. The possible reason for that might be the presence of community of technical engineering personnel who belong to the same national university and prefer to share technical knowledge with each other on regular basis. Regarding the impact of proximity, four dimensions significantly influence the formation of both product and process innovation. However, social and cognitive proximity favours the formation of process innovation more than product innovation. Institutional proximity does not prevail in the local network, as none of the respondents interact with university or government research institute.

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APPENDIX

Table 1:

Characteristics of Firms by		**N=81 (%age)**
Size (No. of Employees)	- More than 2500	- 9 (11%)
	- 1000-2499	- 18 (22%)
	- 500-999	- 40 (49%)
	- 250-499	- 12 (15%)
	- Less than 250	- 2 (2%)
Year of Establishment	-	-
Ownership	- Domestic	- 100 %
	- Foreign	- 0%
Technological Class	- Spinning/Fibre Yarn	- 30 (37%)
	- Weaving/ Knitting	- 22 (27%)
	- Textile Processing	- 13 (16%)
	- Garments/ Made-ups	- 16 (20%)

Export %age in Total Sales	- Less than 25% - 25-50% - 50-75% - 75-100% - Do not Export	- 17 (21%) - 18 (22%) - 12 (15%) - 32 (40%) - 2 (2%)
Organisational Structure	- Independent Unit - Part of Textile Group - Part of Multi-Group	-

Table 2: Composition of External Knowledge for Product & Process Innovation

Descriptive Statistics		**Product Innovation**	**Process Innovation**
External Knowledge %	- Mean	38%	25%
	- Max	80%	70%
	- Min	0%	0%
	- Median	40%	18%
	- S.D	24%	25%
	- S.E	3%	2%

Table 3: Importance of 10 Sources of External Knowledge for Product and Process Innovation

Descriptive Statistics		**Product Innovation**	**Process Innovation**
Customers	- Mean	4.43	3.65
	- Max	5	5
	- Min	2	1
	- Median	5	4
	- S.D	0.87	1.45
	- S.E	.009	0.161 (N=81)
Machine Suppliers	- Mean	3.07	4.01
	- Max	5	5
	- Min	1	2
	- Median	3	4
	- S.D	1.31	0.96
	- S.E	.146	0.106 (N=81)
Raw Material Supplier	- Mean	3.40	2.78
	- Max	5	5

	- Min	1	1
	- Median	3	2
	- S.D	1.52	1.47
	- S.E	0.169	0.162
			(N=81)
Intermediary Material Supplier	- Mean	3.36	3.01
	- Max	5	5
	- Min	1	2
	- Median	3	3
	- S.D	1.32	1.36
	- S.E	0.146	0.151
			(N=81)
Competitors	- Mean	3.84	4.07
	- Max	5	5
	- Min	1	2
	- Median	4	4
	- S.D	1.09	1.03
	- S.E	0.121	0.115
			(N=81)
University/ Research Institutes	- Mean	1.46	1.35
	- Max	3	3
	- Min	1	1
	- Median	1	1
	- S.D	0.69	0.57
	- S.E	0.076	0.064
			(N=81)

Table 3…Continued

Consultants	- Mean	1.58	1.74
	- Max	5	5
	- Min	1	1
	- Median	1	1
	- S.D	1.13	1.18
	- S.E	0.125	0.131
			(N=81)
Government Departments	- Mean	1.26	1.31
	- Max	3	4
	- Min	1	1
	- Median	1	1
	- S.D	0.57	0.74
	- S.E	0.062	0.082
			(N=81)

Internet/ Web Sources	-	Mean	4.10	3.40
	-	Max	5	5
	-	Min	2	1
	-	Median	4	4
	-	S.D	0.80	1.13
	-	S.E	0.088	0.125
				(N=81)
International Exhibitions	-	Mean	4.14	4.62
	-	Max	5	5
	-	Min	2	3
	-	Median	5	5
	-	S.D	1.07	0.62
	-	S.E	0.118	0.069
				(N=81)

Table 4: Ranked Data for Different Dimensions of Proximity for Product Innovation

Descriptive Statistics	**Social**	**Cognitive**	**Organisational**	**Geographic**	**Institutional (N=81)**
Rank					(%age)
1st	33%	37%	28%	1%	0%
2nd	53%	28%	12%	6%	0%
3rd	14%	25%	23%	38%	0%
4th	0%	10%	36%	52%	2%
5th	0%	0%	0%	2%	98%
Total	100%	100%	100%	100%	100%
Mean					
Max					
Min					
Median					
S.D					

S.E	

Table 5: Ranked Data for Different Dimensions of Proximity for Process Innovation

Descriptive Statistics	**Social**	**Cognitive**	**Organisational**	**Geographic**	**Institutional (N=81)**
					(%age)
Ranking					
1st	27%	46%	28%	0%	0%
2nd	46%	36%	12%	7%	0%
3rd	27%	16%	23%	42%	0%
4th	0%	2%	36%	51%	0%
5th	0%	0%	0%	0%	100%
Total	100%	100%	100%	100%	100%
Mean					
Max					
Min					
Median					
S.D					
S.E					

Table 6. Bootstrap paired sample t-test

Bootstrap Statistics		**Product Innovation**	**Process Innovation**
Variance of Ties	(10,000 boot samples)	0.0289 0.0032	0.0392
Classical S.E of difference		0.0032	
Classical t-test		3.4267	
bootstrap t-statistic		1.7028	
Estimated bootstrap standard error for density		0.0040	0.0052
t2 (p –value)		0.0057*	
t1 (p-value)		0.0033*	

*Significance level 95%

Table 7. Kolmogorov-Smirnov Test of Normality

Actor's Normalised Degree Centrality		**Product Innovation Network**	**Process Innovation Network**
Max values	(Critical Value of 0.05 alpha is 0.151)	0.923	0.7402
The two values are not significant, hence we conclude that both the networks' have unequal distribution of linkages			

Figure 1a.

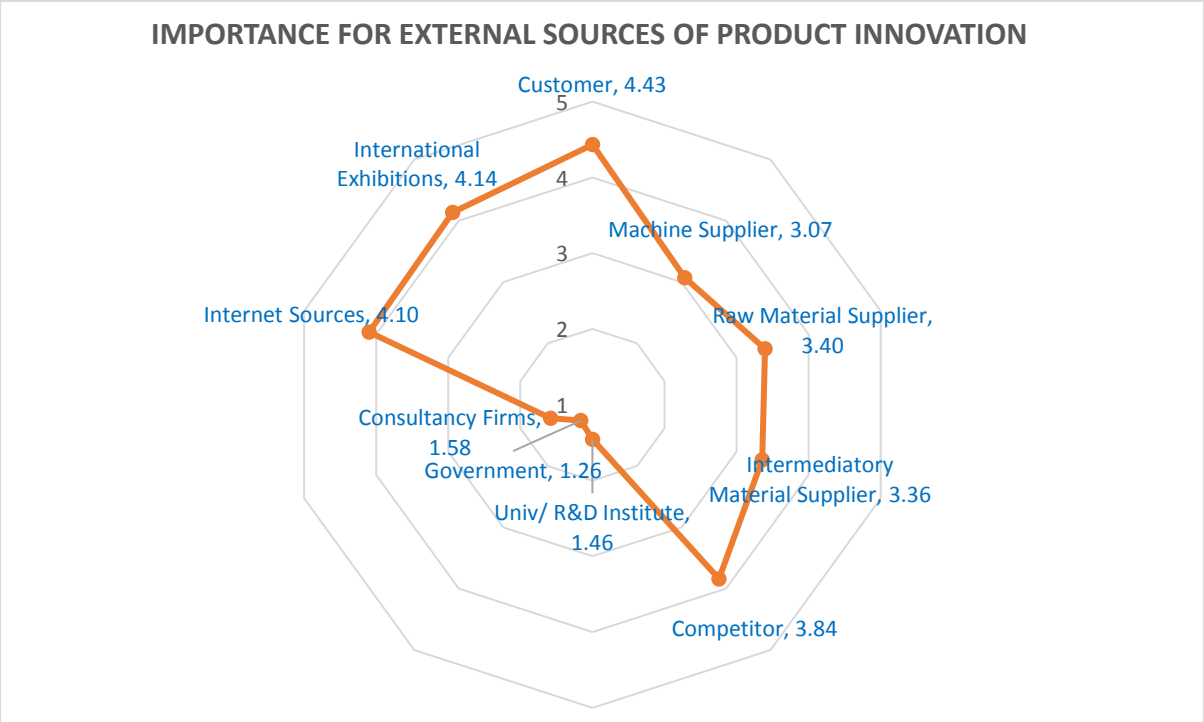

Figure 1a. Radar/ Spider Web Diagram Shows Importance of Sources for Product Innovation

Figure 1b.

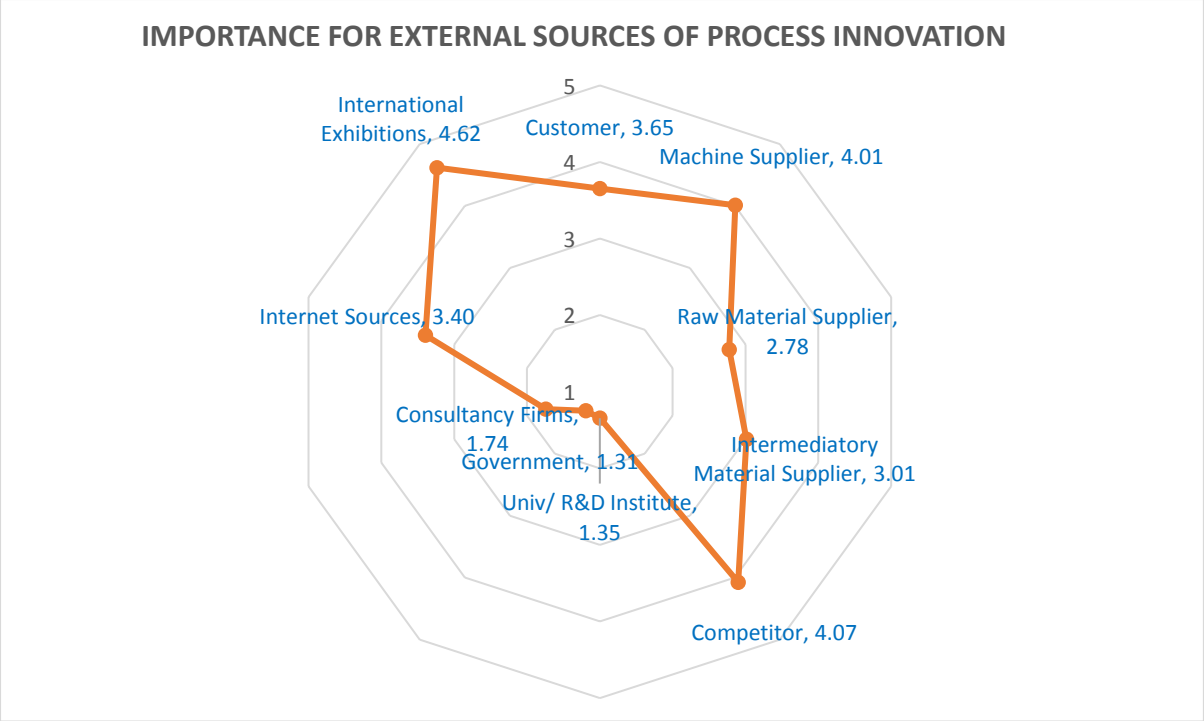

Figure 1b. Radar/ Spider Web Diagram Shows Importance of Sources for Process Innovation

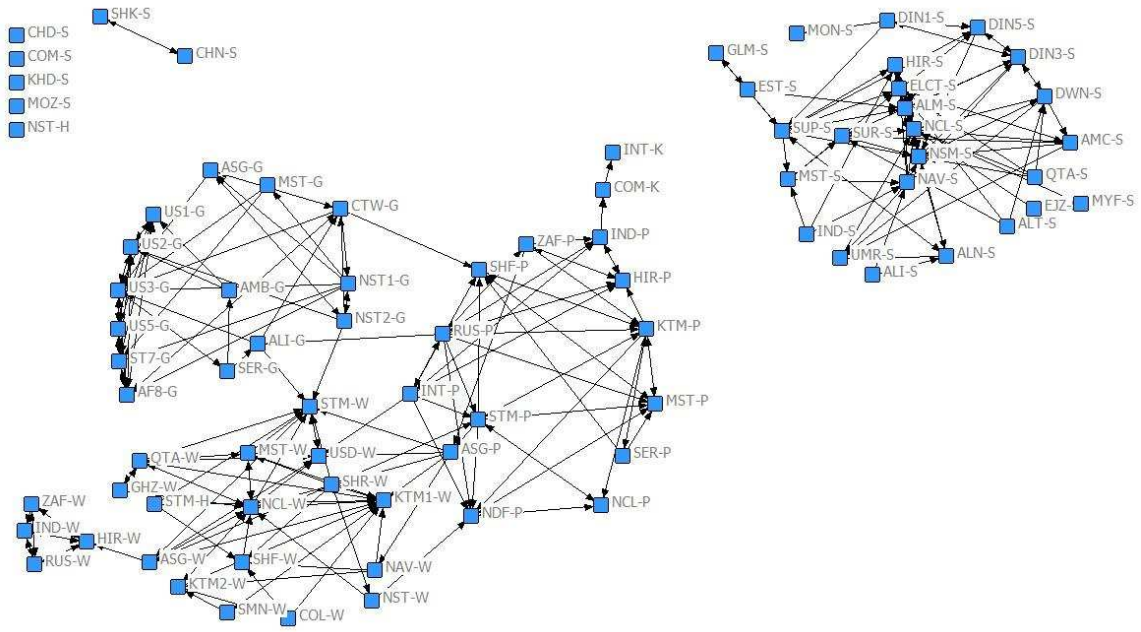

Figure 2a. Process Innovation Network:

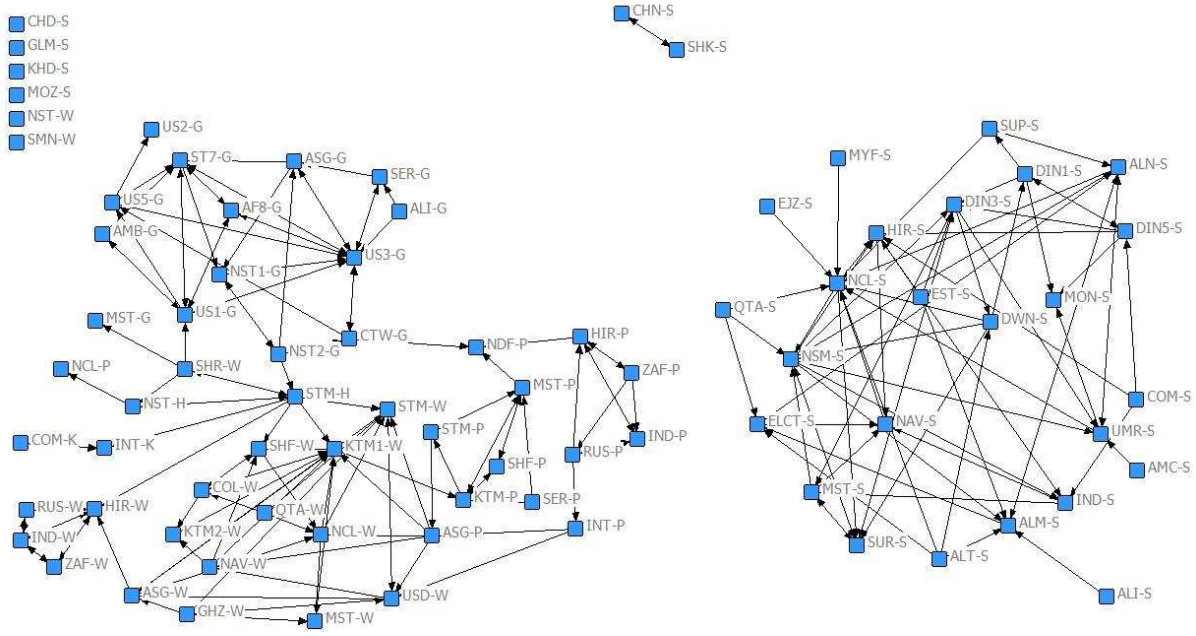

Figure 2b. Product Innovation Network

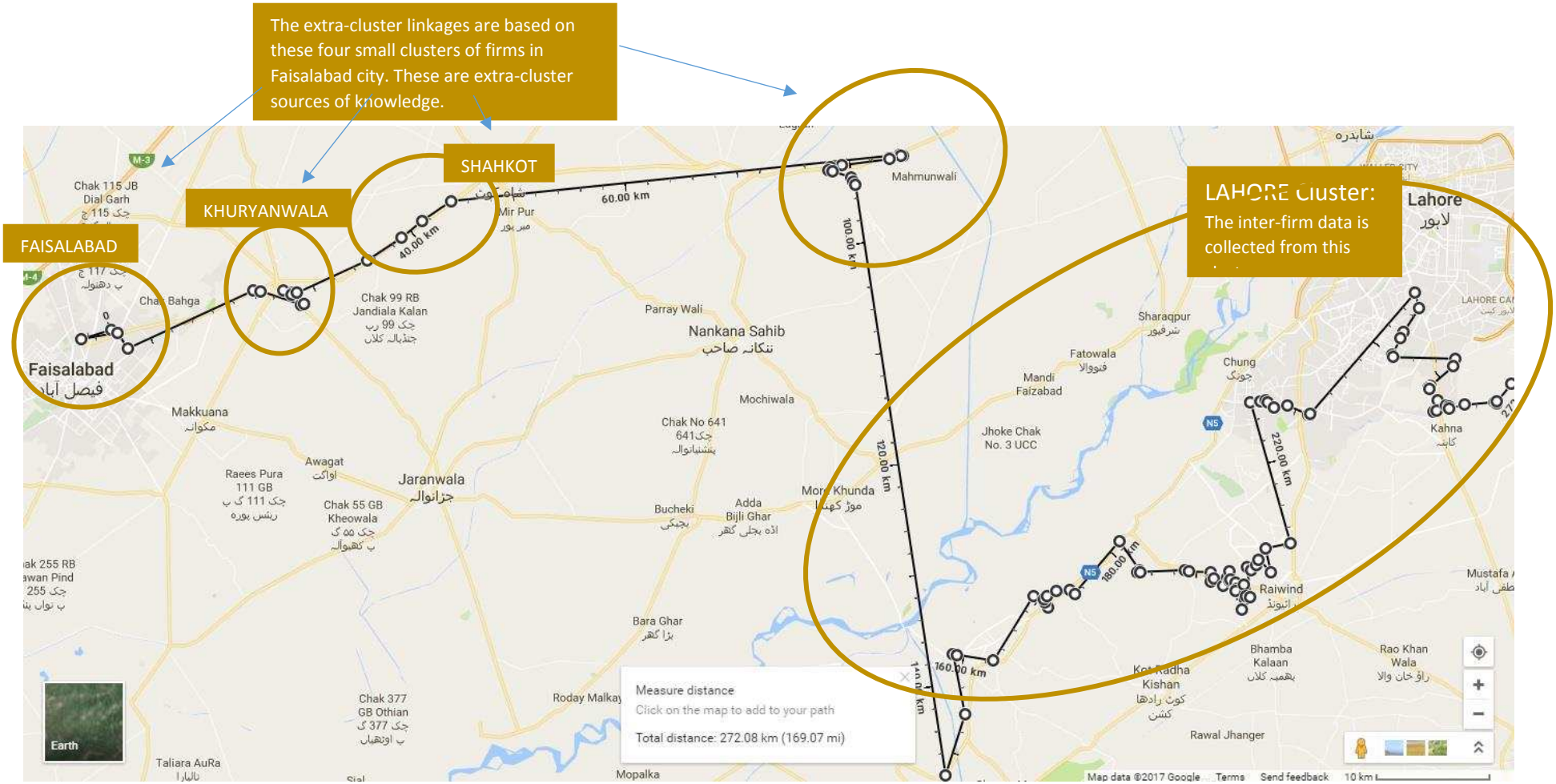

Figure 2 Map of Lahore Cluster