Entrepreneurial SMEs and Inter-Organizational Network Embeddedness

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1. Introduction

Globalization leads to increasing interconnection and interdependence between specialized firms located in dispersed geographic boundaries. Fragmented production modules are coordinated by horizontal and vertical production activities in the global value chain, where MNEs obtain their indigenous competitive advantages based on their industrial specialization, technological capacity and country specific factors (Gereffi, *et al.*, 2005; Hagedoorn, 2006; Sturgeon, *et al.*, 2008). Recent research in international business has explained how large MNEs and their subsidiaries orchestrate the formation and evolution of global production networks (Andersson, *et al.*, 2002; Ernst & Kim, 2002; Mudambi & Navarra, 2004; Cantwell & Mudambi, 2005; Dhanaraj & Parkhe, 2006; Meyer, *et al.*, 2011; Rugman, *et al.*, 2011). Nonetheless, it is unclear if the lessons learnt from large MNEs can be generalized to new-born entrepreneurial SMEs with simpler organizational structure and limited access to externally strategic resources and knowledge inflows (Keeble, *et al.*, 1998; Mackinnon, *et al.*, 2004; Cooke, *et al.*, 2005; Meijaard, *et al.*, 2005). As for entrepreneurship research, numerous studies attribute individual personality, leadership of entrepreneurs and personal relationships with each other to their success (Katz, *et al.*, 2000; Knight, 2000; Vecchio, 2003; Cooke, *et al.*, 2005; Thomason, *et al.*, 2013). Though these studies imply the importance of entrepreneurs' social capital acquired in networks, few of them have sufficiently explained how inter-personal informal connections are transferred to formal organizational networks with empirical evidence and how entrepreneurial SMEs obtain their competitiveness through formal inter-organizational business relationships with other types of partners. Miller (1983) argued that personality factors and organizational factors are equivalent determinants of entrepreneurial. In his later work, Miller (2011) further contended that though the capability and personality of the entrepreneurs in smaller “simple firms” where power is centrally controlled at the top play a crucial role in the phase of entrepreneurial SMEs’ incubating phase, market strategies, organic structures and environment challenges overwhelmingly drives their entrepreneurial activities in the progress of corporate development. Hence, focusing only on inter-personal network between entrepreneurial SMEs is not sufficient to understand the life cycle of the growth of entrepreneurial SMEs.

This paper focuses on the sources and measures of competitiveness entrepreneurial SMEs derive from inter-organizational networks. First, this study explains a cornerstone of question – how network embeddedness contributes to entrepreneurial SMEs’ competitiveness. Then, this study explains the concept of network centrality as representations for multifaceted network embeddedness, then identifies size, age and egocentric diversity as the main determinants of entrepreneurial SMEs’ network embeddedness. Finally, an empirical network analysis will be conducted to measure the relationship between these determinants and different aspects of network embeddedness. We find that liability of smallness and latecomer advantages only significantly contribute to proximity of market leader, while the contributions of dyadic partnership diversity also include range of direct resources and knowledge inflows, brokerage control and bargaining power, communication reachability and efficiency.

2. Literature Review

2.1 Network Embeddedness and Competitiveness

The art of entrepreneurship is more than establishing new business. It also engages process opportunity detection and strategic goals achievement. In this progress, entrepreneurial SMEs need to analyze heterogeneous external environmental dynamisms and inter-organizational relationships configured by hierarchical mechanisms (Miller & Friesen, 1983; Stevenson & Jarillo, 1990; Shane & Venkataraman, 2000). Though entrepreneurial SMEs constantly compete against each other, technological innovation and globalized production entail them to cooperate with diverse business partners and coordinate their collaboration (Teece, 1992). The rivalry and pluralism in global competition do not lead to isolation, but accelerate the interconnection and interdependence between entrepreneurial SMEs and other business embedded in complex inter-organizational networks, where well-connected firms obtain high degree of competitiveness in the global market (Eisenhardt & Schoonhoven, 1996; Khanna, *et al.*, 1998; Becker & Dietz, 2004; Narula, 2014). Achieving competitive success requires the capacity of selective sourcing specialized capability inside and outside the boundary of the firm (Ernst & Kim, 2002). In this sense, entrepreneurial SMEs need to optimize the relational structure of their network access and further search for effective approaches to balance the costs and benefits (Baum, *et al.*, 2000). Network embeddedness represents the effect of hierarchical structure of the whole network as well as actors' dyadic relations with other counterparts on its action, performance and institution (Granovetter, 1985; Hagedoorn, 2006; Cantwell, *et al.*, 2010). It incorporates multifaceted aspects and betokens firm's competitiveness in the inter-organizational network. Concerning the differentiated demand for strategic resources, knowledge absorption, and governance mechanisms, prior studies suggested the contribution of network embeddedness to firms' competitiveness in following aspects:

(1) Strategic Resources Acquisition

Strategic resources are those scarce and valuable assets and competencies within the firms sustaining their competitive advantages that cannot be simultaneously implemented or duplicated by its competitors (Barney, 1991). In the era of globalization, firms need to integrate their specialized value-added activities in the Global Value Chain, where they capture the strategic resources in demand throughout input-and-output streams embedded in inter-organizational network. (Porter, 1985; Sturgeon, 2007). Meanwhile, the hierarchical structure of Global Value Chain determines that the power distribution over different layers of value-added activities, where firms specialized in high value-added activities are better positioned than those specialized in low value-added activities (Gereffi, *et al.*, 2005) Moreover, as the inter-organizational network is created through an idiosyncratic path-dependent process that is difficult to imitate, channels directing to market leaders that possess scarce physical assets, competent human capital and insider information become strategic resources themselves (Barney, 1991; Gulati & Gargiulo, 1999; Gupta & Govindarajan, 2000). Resource-based view of social network suggests that inter-organizational network conveys complementary strategic resources to endogenous rent derived from a firm's own resource (Lavie, 2006). Establishing inter-organizational linkages with competent partners alleviate entrepreneurial SMEs from bounded assets and capabilities. In the same progress, inter-organizational network extends entrepreneurial SMEs' boundaries of organizational conducts that are otherwise limited due to relatively small organism (Larson, 1992; Almeida & Kogut, 1997; Dyer & Singh, 1998). Consequently, high degree of network embeddedness strengthens entrepreneurial SMEs' competitiveness in strategic resources acquisition.

(2) Absorptive Capacity Enhancement

Resource-based view remarks foremost the necessity of network embeddedness in acquiring strategic resources but does not explicitly answer the question of sufficiency. As next step, we need to understand how network embeddedness contribute to the transition of exogenous resources acquired to entrepreneurial SMEs' indigenous competitive advantages in inter-organizational networks.

Entrepreneurial SMEs are radial innovators in globalization and their entrepreneurial orientation sustain their competitiveness in technological innovation, which involves complex knowledge exchange and social relationships (Schumpeter, 1951; Acs, *et al.*, 2001; Knight, 2001). Innovative activities do not take place in an black box of a closed system. To overcome information asymmetries in opportunity discovery and exploitation, "born-global" entrepreneurial SMEs have strongly incentive to pursue the value of diffusing knowledge and form new means-ends relationships and subsequently extend their technological innovation ground. (Shane & Venkataraman, 2000; Acs, *et al.*, 2009). They open up their innovation process and actively absorb non-rival and non-excludable knowledge spillovers by sharing ideas and knowledge, capital and specialized human capital in an open innovation system. (Grossman & Helpman, 1991; Stuart & Sorenson, 2003; Chesbrough, 2006; Gassmann & Keupp, 2007; Lee, *et al.*, 2010). To facilitate this progress, they need to acquire and enhance their "ability to recognize the value of new external information, assimilate it and apply it to commercial ends", that is, absorptive capacity (Cohen & Levinthal, 1990). By interactive learning and knowledge sharing, entrepreneurial SMEs could transfer new knowledge acquired to economic opportunities. Network embeddedness substantially enhances entrepreneurial SMEs' absorptive capacity and helps to transfer new knowledge acquired to economic opportunities (Podolny & Page, 1998; Gupta & Govindarajan, 2000). On individual level, broad access to high quality human capital and miscellaneous information, as well as frequent interaction with diverse players in inter-organizational networks reduce the entrepreneurial SMEs' "cognitive distance" to understand and exchange new knowledge (Nooteboom, 2000; Lavie, 2006; Acs, *et al.*, 2007; Acs, *et al.*, 2009). On spatial level, entrepreneurial SMEs replenish their R&D capital stocks by through establishing intra-and-inter-regional linkages and benefit from knowledge spillover co-locating in industrial clusters and knowledge exchange across geographic boundaries (Coe & Helpman, 1995; Stuart & Sorenson, 2003).

(3) Behavioral Influence on Partners

In addition to accessibility to strategic resources and enhancing absorptive capacity, the behavioral influence an entrepreneurial SME exerts on its direct and indirect partners also contribute to its competitiveness in inter-organizational networks.

Podolny (2001) claimed that linkages embedded in inter-organizational network not only serve as "pipe" for information and resources, but also "prism" that detects and infer qualities of potential partners. The interactive behavioral patterns of firms in inter-organizational networks imply how they achieve their competitiveness in long-term. The construction and the quality of inter-organizational linkage in various types of network, as well as shared goals and culture, trust, norms and identification all determine the heterogeneity of individual firms, their influence on the others and behavioral logic (Uzzi, 1997; Inkpen & Tsang, 2005).

Next, we discuss how entrepreneurial SMEs exert their behavioral over both its direct and indirect partners embedded in the inter-organizational network as competitiveness.

Due to information asymmetry, entrepreneurial SMEs encounter moral hazard of their direct partners' opportunistic conducts incurring high transaction costs in detecting and monitoring partners' unpredictable behavior (Williamson, 1979; Gulati & Gargiulo, 1999). To overcome the shortcomings of behavioral uncertainty of partners, firms of form "embedded ties" characterized by holistic repeated interaction (Uzzi, 1997). On the one hand, the formation and evolution of dyadic “embedded ties” are based on mutual trust, which compasses the interrelationship of ability to impose influence, benevolence of cooperation and integrity of principle adherence (Mayer, *et al.*, 1995). On the other hand, long-term dyadic partnership strengthens the interdependence between partners in terms of knowledge sharing and behavioral imitation, which lead to organizational isomorphism (Meyer & Rowan, 1977). High degree of dyadic ties with direct partners indicates the reliability and capabilities of the focal firms cooperating with current and potential partners, which in turn, contribute to their market performance. (Ring & Van de Ven, 1992; Gulati, 1995; Andersson, *et al.*, 2002; Hagedoorn, 2006).

Apart from the interactive approach with direct partners, a firm can also establish its own status, legitimacy and reputation, which signal the social evaluation on the firm’s behavior through the referral mechanisms embedded in network (Podolny & Page, 1998; Bitektine, 2011). Through long-term interaction, direct partners provide their judgement of the capacity and trustworthiness propensity of the focal firms, while the assessment is further diffused through the medium of brokers to the focal firms’ indirect partners in the network. These intermediary brokers combine information flows from multiple directions and mitigates mutual perceptions of partners who do not have direct connections with each other. Consequently, a well-connected broker can take the informational advantage to detect high quality partners through network referral mechanism and have high propensity to engage in new partnership (Burt, 1992; Freeman, 1979).

In sum, network embeddedness encompasses the dynamic process of interaction with direct partner and status referral mechanisms leading to indirect partners in long term. For entrepreneurial SMEs, connecting to inter-organizational networks increases their possibility to form long-term partnership with high trustworthy and capable direct partners that possess scarce strategic resources and specialized knowledge. Through the reference of key brokers, which usually turn out to be “flagship MNEs”, entrepreneurial SMEs can extend the access of knowledge pool and accelerate reputation establishment among broader range of potential competitors. As result, well-connected entrepreneurial SMEs become more efficient in opportunity exploration and exploitation, in turn, have higher possibility to reach better competitive position in the global market.

Gulati (1998) suggested two types of network embeddedness that contribute to competitiveness: (1) Relational embeddedness: the cohesiveness and retention of direct ties a firm has to obtain “finely grained information” (Uzzi, 1997) and (2) Structural embeddedness: the systematic control of information diffusion path over directly connected partners as well as the brokerage propensity the whole network relies on to maintain connectedness. Hagedoorn (2006) further addressed both approaches affect firm’s behavior differently, as relational embeddedness influences the learning process of absorption, while structural embeddedness affects companies’ imitation behaviors in the process of organizational homogeneity. As for the entrepreneurial SMEs, the contributions of network embeddedness are reflected in following aspects: (1) Content of network relationship – how actors obtain access to resources in the network; (2) Governance – how network exchange is controlled and coordinated; (3) Structure – the hierarchical pattern of direct and indirect linkages between actors (Hoang & Antoncic, 2003). A well positioned entrepreneurial SME possess broader range of resources, more competitive technological capacity, and higher capacity to influence the others, hence, high network embeddedness substantially contributes their competitiveness over partners and competitors connected to the same inter-organizational network (Wilkinson, *et al.*, 2000). Moreover, studying the network embeddedness of entrepreneurial SMEs not only help to explain the behaviors of entrepreneurs and entrepreneurial firms in react to social changes, but also provide policy-makers practical implications of regional industrial dynamics and cross-regional collaboration (Miller, 2011).

2.2 Measurements for Network Embeddedness

In network science, the individual actor's network embeddedness is measured by a set of centrality measures. High level of centrality signifies an actor's prominent position to take control of resources and information flows and influence the behavior of other players. (Freeman, 1978; Wasserman & Faust., 1994). The dichotomy of network embeddedness introduced by Gulati (1998) suggested the local and global context that network centrality measures encompass. At local level, how well a node is connected can be measured by the number of direct connections with its neighbourhood, that is, **(1) degree centrality** (Nieminen, 1974). High level of degree centrality represents the range of direct sources of resources and information inflows, and signifies the trustworthiness and cohesive relationships the actor possesses (Tsai & Ghoshal, 1998; Luo, 2005). The main limitation of degree centrality is that it ignores the transaction costs incurred by establishing and maintaining redundant ties that lead to the same sources of resources and information (Burt, 1987; Gomes-Casseres, 1994; Reagans & Zuckerman, 2008).   argued that there exists a trade-off between absorbing broad range of resource and knowledge exploitation and bearing high transaction cost of maintaining redundant ties that channel to the same source. Vanhaverbeke, *et al.* (2009) studied the relationship ego network structure and innovation output in local inter-firm alliance network in high-tech sectors. They found that direct tie redundancy has a positive linear impact on exploiting core technologies, while there is an inverted U-shape reaction in exploring non-core technologies. Moreover, Meuleman, *et al.* (2010) explained the paradox of relational embeddedness from an agency-theory based view that, the leading position and reputation of an actor's partner also alter the effect of direct ties, as relational embeddedness plays a crucial role in partner selection if there exists vertical agency problems between investors and investees while impacts less if the partner already establish in a good reputation in the overall network. Hence, it cannot be generalized that an actor has more direct connections possesses absolute competitive advantages over competitors with fewer direct connections.

Freeman (1978) suggested that an actor's network centrality is not only determined by its direct neighbourhood, but also dependent on the impact of its allocation in overall network structure. He proposed that an actor's "global centrality" can be measured by

(2) betweenness centrality: how frequent an actor appears between other nodes' geodesics. This measurements implies an actor's bargaining power of the over its partners, as it serves as the medium broker over "structural holes"(Burt, 1992). The overall connectedness of the network, or network robustness, is also dependent on a few "hubs" (Albert, *et al.*, 2000; Callaway, *et al.*, 2000), whose brokerage positions are large indispensable. Removal of these "hubs" could result in the scattering of overall network connection, reduce in number of linkage and increase in average network path length. Hence, an actor with high degree of betweenness centrality has stronger brokerage control over the flows in the whole network and high bargaining power over other actors in the network.

(3) closeness centrality: the steps an actor follows to reach all other actors in the connected network through the geodesics. In comparison to betweenness centrality, closeness centrality excludes the impact of tie redundancy in actor's neighbourhood. An actor with high closeness centrality is more reachable and efficient in communication with its directly and indirectly connected partners, since fewer steps in between reduce the decay of information diffusion as well as transaction cost incurred during resources transfer. In this study, we calculate the multiplicative inverse of the sums of steps of all geodesics ("nearness") as measurement for closeness centrality.

Additionally, Katz (1953) and Bonacich (1972) suggested that calculation of centrality should take both the brokerage position and degree centrality of an actors' adjacent partners into consideration. They introduced a set of weighted centrality algorithms of **(4) eigenvector centrality** based on individual actors' eigenvector of the adjacent network matrix, measuring an actor's access to other well-connected actors in terms of neighbourhood degree and whole network reachability within the same network. Firms with high eigenvector centrality has high proximity centrally located well-connected market leaders in the whole inter-organizational network, who, in turn, provide better access to the information for its directly connected partners and exert influence on other members in the same network (Scott, 1991; Wasserman & Faust., 1994; Mehra, *et al.*, 2006; Jackson, 2008).

In sum, the listed four measurements for network centrality encompass the multiple aspects of relational embeddedness and structural embeddedness an entrepreneurial SMEs derive from the inter-organizational network. Degree centrality measures the range of direct sources of resources and information in the neighbourhood; betweenness centrality represents the brokerage control in the network and the actor's bargaining power; closeness centrality embodies the an actor's reachability and efficiency in intra-network communication; eigenvector centrality combines both local and global properties of network embeddedness, thus evaluates a firm's proximity to central located market leaders with large number of direct and indirect connections.

2.3 Determinants of entrepreneurial SMEs' Network Embeddedness

2.3.1 Size and Age

After explaining how network embeddedness is perceived as competitive advantages, we continue to explore the constraining and contributing factors for entrepreneurial SMEs' network embeddedness. Entrepreneurial SMEs are often characterized by their small firm size, young age and specialization in highly dynamic technological sectors. The effect of size and age on entrepreneurial SMEs' competitiveness in comparison to large globally presented MNEs are disputed, and we suggest to take both views into considering in analyzing how size and age affect entrepreneurial SMEs' network embeddedness

It is widely agreed that entrepreneurial SMEs are exposed to higher degree of market risks for survival and development in comparison to globally presented large SMEs due to liability of newness and smallness (Aldrich & Auster, 1986; Baum, *et al.*, 2000). In terms of age, entrepreneurial SMEs as latecomers are often less acquainted with the order of competition and incline to highly depend on alliances with suppliers, distributers and joint-venture partners. Inexperience dealing with changes in the market competition often lead to high risk aversion that "resist against change", thus entrepreneurial SMEs are less capable to promptly respond to exogenous radical innovation and technological discontinuities effectively (Freeman, *et al.*, 1983; Brüderl & Schüssler, 1990; Zahra, *et al.*, 2000; Minguzzi & Passaro, 2001; Mitra, 2012). In terms of size, Drucker (1985) addressed "smallness does not represent entrepreneurship, while bigness is not always an obstacle to entrepreneurship and innovation." Small size inhibits entrepreneurial SMEs to achieve economies of scale due to lack of access to financial funding, human capital and knowledge inflows. Finally, the disadvantages of small size and young age lead to entrepreneurial SMEs' low legitimacy to influence their partners and competitors and less advantageous position in inter-organizational network. (Rogers, 2004; Freeman, *et al.*, 2006).

Hypothesis 1.1 Younger entrepreneurial SMEs are less well-connected in inter-organizational network

Hypothesis 1.2 Smaller entrepreneurial SMEs are less well-connected in inter-organizational network

On the other hand, more recent studies challenge the long-holding new on liability of smallness and newness of entrepreneurial SMEs.

Although early market entrants enjoy first-mover advantages, such as low level market complexity and leadership in marketing and technology, younger entrepreneurial SMEs could also achieve latecomer advantages by imitating early movers' success and learning from their mistakes. They could avoid high level sunk costs that early comers bear in technological and managerial development, and benefit from knowledge spillovers in technological exploration as well as the scale of economies brought by market exploitation that early consume comers high level of sunk costs (Kerin, *et al.*, 1992; Cho, *et al.*, 1998). Based on the experience in high-tech firms from emerging economies, it turns out that successful newly founded entrepreneurial SMEs adapt Linkage-Leverage-Learning (LLL) strategy in the process of catch-up, which involves wide linkage to incumbent firms in inter-firm network. (Mathews, 2007; Yiu, *et al.*, 2007; Guillén & García-Canal, 2009). Hence, regardless of liability of newness, newly founded entrepreneurial SMEs could still better connection to the inter-organizational network thanks to high flexibility in partnership search though resource leveraging and organizational learning in comparison to older firms in their mature phase experiencing organizational lock-in in react to exogenous changes (Sydow, *et al.*, 2009).

In terms of size, Teece (1992) argued that globalization knowledge diffusion blurs the boundaries of the firms whereas firm's competence is more of a matter of their role international collaboration and coordination. The formation and evolution of inter-organizational network is a synergy of path-dependent reproduction and alternation of network structure. Such progress embodies the social resources of embedded actors where entrepreneurial SMEs could seize opportunities bridging up "structural holes" and shift to more advantageous position in the competition (Walker, *et al.*, 1997). The small size is not an incurable obstacle for high competence, since the business scope of entrepreneurial SMEs could be further extended through long-term external alliances with partners of various sizes and specializations. Moreover, small size often facilitates simpler organizational structure and less bureaucracy in decision making. When the potential of high competent partners is detected (Mitra, 2012), SMEs are more quick in action to transfer it to formal partnership in comparison to large established MNEs. Thus, it is suggested that SMEs should concentrate on establishing and maintaining ties with partners that enhance their capability of innovation. (Døving & Gooderham, 2008; Gronum, *et al.*, 2012).

Hypothesis 2.1 Younger entrepreneurial SMEs are better connected in inter-organizational network

Hypothesis 2.2 Smaller entrepreneurial SMEs are better connected in inter-organizational network

2.3.2 Egocentric Diversity and Network Embeddedness

Getting connected is the first step for SMEs to extend their organizational boundary and compensate inexperience for small and young entrepreneurial SMEs. A subsequent strategic concern is how to establish and manage complex connections in inter-organizational networks. In inter-organizational networks, entrepreneurial SMEs collaborate with diversified partners including suppliers, customers, third parties, science partners and venture finance partners. In this progress, focal entrepreneurial SMEs form various types of linkages and exchange knowledge from both horizontal and vertical direction in the value chain. Hitherto, the first-order neighbourhood including direct partners and ties construct the egocentric network of focal entrepreneurial SME (Marsden, 2002).

In inter-organizational networks, firms' egocentric diversity is mainly reflected in (1) intensity of reciprocal interactions between direct partners, or tie strength (Granovetter, 1973), (2) the heterogeneous composition of alliance, or partner diversity (Goerzen & Beamish, 2005) and (3) contextual difference business relationships, or tie multiplexity (Shipilov, 2012; Shipilov, *et al.*, 2014; Shipilov & Li, 2014). They determine egocentric network cohesion that robustly affects firm's absorptive capacity and knowledge transfer process (Tsai, 2001; Reagans & McEvily, 2003; Inkpen & Tsang, 2005), in turn, diversity of dyadic partner selection and forms of linkages enhance entrepreneurial SMEs' innovation capacity and market competitiveness (Pittaway, *et al.*, 2004; Macpherson & Holt, 2007; Roper, *et al.*, 2008).

In entrepreneurship research, several studies have emphasised the importance of network diversity on innovation output and competitiveness. From micro perspective, Guimera, *et al.* (2005) argued that size of organization, proportion of newcomers and propensity of incumbents to repeat collaboration affect the innovation output in creative teams. Eagle, *et al.* (2010) studied the inter-regional communication and found that spatial and social network diversity connected by telecommunication positively contribute to regional economic development. Nonetheless, neither of these individual-level studies emphasised how organizational-level diversity contribute to the network embeddedness of entrepreneurial SMEs, thus enhance their embedded competitiveness. As Chen and Tan (2009) suggested, though relational diversity play an evident role in entrepreneurship, empirical research in how diversity affect the egocentric network of entrepreneurial SMEs is very limited. In this this study, we examine if the general contributions of diversity in egocentric network also apply to inter-organizational network where entrepreneurial SMEs are embedded in. To answer this question, we take 5 major types of organizations including (1) domestic entrepreneurial SME; (2) large domestic firms; (3) foreign firms; (4) universities and research institutes; (5) governmental institutions into account for entrepreneurial SMEs' dyadic partner diversity in their egocentric network. We calculate the Index of Qualitative Variation (IQV) (Blau, *et al.*, 1982) representing the diversity of dyadic partners, and test how diversity of dyadic partners contribute to entrepreneurial SMEs' network embeddedness. Additionally, we include several tie diversity measures as control for geographic and industrial heterogeneity.

Hypothesis 3: An entrepreneurial SME with high degree of dyadic partner diversity are better connected in inter-organizational network.

3. Methods

3.1 Data Collection

In this study, we focus on the roles of domestic entrepreneurial SMEs embedded in the industrial networks of Chinese aerospace industry. The primary reasons to select this one-industry-one-country dataset are as follows

(1) On demand side, aerospace industry maintains long-term above-average growth driven by global economic growth and technological innovation. Increasing frequency of passengers and air cargo traffic, establishment of new air routes and supportive infrastructures, and diversification of aerospace services boost market demand and create new market niche for entrepreneurial SMEs to enter.

(2) On supply side, the complexity of products, manufacturing process, and relationships among various business units in aerospace industry strongly affect the formation production networks of aerospace industry. Demand for tailor-made products and services require high degree of specialized technological input and coordinated knowledge exchange and partnership between firms, universities, research institutes and government. Entrepreneurial SMEs benefit from

competitive advantages facilitated by the specialized technological competence of entrepreneurs embedded in wide range of networks. Additionally, the flexibility of organizational configuration and partnership selection of entrepreneurial SMEs contribute to the dynamisms of the aerospace networks.

(3) As one of world's large civil aviation market, after six decades of trials and errors, China has established independent aerospace industrial system. Although large State-Owned Enterprises (SOE) still hold the dominant market influence supported by the government, Chinese government incrementally reforms the industrial institution and implements preferential policies for entrepreneurial SMEs to solve the long-existing problem of inefficiency and low competence of SOEs. Eradication of entry barriers and perfection of regulations and policies accelerate entry of entrepreneurial SMEs in the Chinese aerospace industry.

In this study, a set of production networks are constructed based on horizontal and vertical relationship, and integrated to a multiplex business network. First of all, a list of 140 commercial aviation enterprises above designated size included in *Civil Aviation Industrial Yearbook 2014* are selected as focal nodes (egos). Then, we approach their first-degree formal business contacts at home and abroad including strategic alliance, joint-venture and R&D programs, letter of intent for cooperation and supplier-buyer agreement as their alter nodes. These contacts include not only incorporated firms, but also non-incorporated institutions such as governmental institutions, research institutes, universities and vocational colleges. At this stage, we create a list of 920 business units of Chinese aerospace industry connected by in total 5098 non-redundant ties together.

In a second step, we identified the geographic and industrial attributes of nodes and categorize the types of linkages in accordance to the business activity they represent. Based on the ego-alter list, we further exploited the business relationships between the alters, and integrated all these linkages into a comprehensive production network. For domestic business units, we refer to their registration information in the National Enterprise Credit Information Disclosure System (NECIDS) updated by the end of 2015 including their official name in Chinese, address of registration, type of incorporation and ownership, year of foundation and registration, major business specialization and registered capital. Since number of employees is not disclosed in the NECIDS, registered capital, that is, the limited liability of capital contributions from all shareholders on account, serves as the measurement for size. It measures the initial capability of liquidation in terms of capital and represents the credit and trustworthiness of shareholders. In this study, we define incorporated domestic firms with registered capital less than 1000 million RMB (approximately 150 million US dollars) as domestic entrepreneurial SMEs, and those with registered capital greater than this threshold as large domestic firms.

For foreign units, we mainly obtain these data based on the information disclosure on their web portals and publicly available financial reports. In addition, secondary data such as business news on aerospace industry and market research reports are also important reference to determine the existence of linkages.

Based on the information available, we categorize these 920 units on the list to five types: (1) domestic entrepreneurial SMEs; (2) domestic large firms; (3) foreign firms; (4) university and research institutes; (5) governmental institutions.

Table 1: Proportion of Business Units by Region and Type

	Number	**Percentage**
By Region		
Domestic	543	59.02%
Foreign	377	40.98%
By Type		
Domestic Entrepreneurial SMEs	299	32.50%
Large Domestic Firms	97	10.54%
Foreign Firms	335	36.41%
Universities and Research Institutes	132	14.35%

Governmental Institutions	57	6.20%
Total	920	100.00%

The descriptive statistics illustrate that the number of domestic business units overwhelms their foreign counterparts, and domestic entrepreneurial SMEs constitute more than 30 percent of total number of business units appear in the complex business networks.

Next, we categorized the multiple inter-unit linkages into two groups based on the motive and status of dyadic relations among business units. Strategic alliances, joint-venture and R&D program, tentative cooperation are categorized as horizontal linkages, while arm's length supplier-buyer relationships are characterized as vertical linkages. These linkages and nodes are joined as two separate production networks, namely, horizontal partnership network and vertical supply chain network. Based on the category of business activities the linkages represent, these two networks are named as horizontal network and vertical network accordingly.

As the last stage, these two networks are overlapped to two synthesized network: a multiplex network that combines all types of linkages and a double-embedded network that only counts for linkages that appear in both network. All these network inputs are proceeded with UCINET 6 network analysis software package and following whole network measures (Freeman, 1978; Hanneman & Riddle, 2005) are calculated including

(1) Number of nodes and ties: Total number of active actors and linkages that appear in each network. They measure the size of each networks respectively.

(2) Degree Centralization: Ratio of the actual sum of differences of ego degree to the maximum possible sum of differences of ego degree. It measures the general tendency of concentration of the whole network.

(3) Density: Total number of ties divided by the total number of possible ties.

(4) Average Degree and Distance: The average level of the number of linkages ego nodes are connected to and the length of path they procced to reach their direct and indirect partners.

(5) Triplet Transitivity: Number of triples that are transitive divided by the number of triples which have the potential to be transitive by the addition of a single edge. This measures the transitivity of direct ties of a structural hole (Burt, 1992).

Table 2: Network statistics of Chinese Aerospace Industrial Networks

	Multiplex Network	**Horizontal Network**	**Vertical Network**	**Double embedded Network**
Number of nodes	920	663	593	336
Number of ties	5098	2206	3158	266
Density	0.006	0.003	0.004	0.000
Centralization	0.285	0.100	0.220	0.035
Average Degree	5.541	2.398	3.433	0.289
Average Distance	3.689	4.542	3.292	4.506
Transitivity	0.081	0.107	0.036	0.012

As exhibited in Table 2, we figure out that both horizontal and vertical networks exhibit strong tendency of “small world” property with high cliquishness and short path length (Milgram, 1967; Watts & Strogatz, 1998). They are connected by sparely distributed nodes. They are exceedingly concentrated to major components, while peripheral nodes are bridged to the center within short geodesic path. Comparatively, horizontal network includes larger number of nodes than the vertical network, but due to the lower quantity of linkages, the density of horizontal network is lower than vertical network. In average, ego nodes in vertical network has more direct partners and may reach indirect partners in fewer steps than those in horizontal network. Nonetheless, it appears that in horizontal network, there are more “bridges” than in vertical network, hence the level of transitivity of horizontal network is higher than vertical network.

From the network statistics of the union set (Multiplex Network) and intersection set (Double-embedded Network) of horizontal and vertical network, it turns out that although the impact of linkage redundancy is limited, as only one third business units appear to have both types of linkages and the density and connectivity double embedded network appear to be relatively low. At the same time, the complementary effect of horizontal and vertical linkages contributes to the overall density, concentration and ego nodes' connectivity to their direct and indirect partners. On the other hand, due to the increasing number of structure holes, it turns out that the transitivity of the united multiplex network is lower than that of horizontal network, but higher than vertical network.

3.2 Dependent Variables

Multifaceted network centrality serves as comprehensive measurement for network embeddedness as competitiveness for individual firms. Based on the discussion on network embeddedness and centrality measures, we process the multiple centrality measurements calculation based on the multiplex networks with UCINET 6 for all 920 business units in the network including

(1) Degree centrality

Degree centrality measures the width of resources and information flows from direct partners, and represents the range of ego unit's direct neighbourhood. To reduce the effect of scale, we calculate the logarithm values of the total number of direct ties an ego business unit has as measurement for degree centrality.

(2) Betweenness centrality

Betweenness centrality measures the brokerage power of the ego over the resources and information flows, and represents the bargaining power over other partners and competitors in the network. It counts for the frequency an ego is presented on the geodesic path between two other partners that it possesses direct or indirect connections with.

(3) Closeness centrality

Closeness centrality measures ego units' reachability and efficiency of communication. In this study, we calculate nominalized Freeman Closeness centrality (Freeman, 1978) for this measurement as follows:

$$C_{C^{(i)}} = \frac{\left[\sum_{j=1}^{n} d(i,j)\right]^{-1}}{N-1}$$

, where d(i,j) denotes the geodesic path length of ego i to reach alter j, and N represents the total number of nodes connected in the same network. High degree of closeness centrality represents high reachability of the ego units to its direct and indirect partners as well as high efficiency of resources and information flows the ego emits and receives from its partners.

Since there are no isolated units, all units in the inter-organizational are assigned with valid closeness centrality value.

(4) Eigenvector centrality

Unlike the previous centrality measures that can be directly counted from the display, the eigenvector centrality of an ego unit is computed based on the eigenvalue derived from adjacency matrix rearrangement (Katz, 1953; Bonacich, 1987).

If we denote the eigenvector centrality of node i is x_i and the vector of eigenvector centrality **x** =(x_1, x_2…). The adjacent matrix for given network **A**, where the binary element A_{ij} represents if there is a connection between node i and neighbouring node j. A constant eigenvalue λ meets the criteria that

$$\mathbf{A} \cdot \mathbf{x} = \lambda \mathbf{x}$$

And the relative score of x_i is the eigenvector centrality of node i, so that

$$x_i = \frac{1}{\lambda}\sum_{j=1}^{n} A_{ij}x_j$$

High eigenvector centrality represent proximity to well-connected market leaders that have high influence in the whole network.

3.3 Independent Variables

Based on the three sets of hypotheses, following measures are counted as the independent variables for this study

Age

Since the network dataset this study is based on the integrated networks of 140 large Chinese aerospace enterprises in 2014 and the latest entry of enlisted business units was founded in year 2015, we calculate the age of firms on the base year 2016. For domestic firms that have experienced significant corporate restructure process, the founding year of their main business divisions will be recorded as year of foundation.

Size

The capital structure determines firms' innovation capacity where smaller firms are more dependent on debt liquidation at its founding stage (Acs & Isberg, 1991). Since aerospace industry is a capital-and-technology intensive rather than labor-intensive, and the initial capital available to pay off their liability represent the capability of sustainable business development, in this study we use registered capital as measure for the size and liquidation capacity of the domestic entrepreneurial SMEs.

Dyadic Partner Diversity

Based on the five-way categorization of business units, the diversity of a domestic entrepreneurial SME's direct partners is measured by Index of Qualitative Variation (IQV), the normalized index of Blau's measure of heterogeneity (Blau, *et al.*, 1982) as follows:

$$IQV_r = \frac{1 - \sum_{i=1}^{n} p_i^2}{1 - \frac{1}{n}}$$

, where p_i represents the proportion of each type of alter-partners' presence, and n represents the total number of categorized, in this study, equals 5.

3.4 Control Variables

To control the impact of heterogeneous ties across geographic regions, business sectors and governance structure in entrepreneurial SMEs' egocentric network, in the regression models, we also include following tie diversity measures as control variables, including the number of direct cross-national connections, linkages to non-incorporated organizations (universities, research institutes, and governmental institutions), linkages to non-manufacturing units and number of horizontal linkages as control variables.

Foreign Connections

Total number of an ego domestic entrepreneurial SME's foreign partners including firms, universities, research institutes, and governmental institutions.

Non-incorporated Connections

Total number of an ego domestic entrepreneurial SME's non-incorporated partners, including both domestic and foreign universities, research institutes, and governmental institutions

Non-manufacturing Connections

Based on the dichotomy of business activities in Porter's generic value chain model (Porter, 1985), we labelled business units that are not specialized in manufacturing section as "non-manufacturing connection" and count the total number of ego entrepreneurial SME's direct connections to such units.

Horizontal Linkages

Based on the observation of the whole network property, we can observe the leverage effect on network efficiency of horizontal linkages. Since in comparison to arm's length supply chain linkages, establishment of horizontal linkages requires a higher frequency of repetitive contacts and degree of mutual trust, we count for the number of horizontal linkages of ego entrepreneurial SMEs, as indicator of their long-term orientation.

4. Results

Table 3 presents a summary of the mean, standard deviation and the correlation coefficient of all independent variables. Apart from pair of number of horizontal linkages and linkage diversity (r= 0.50; p=0.000) and the pair of the prior and non-incorporated connections (r=0.35; p=0.000), which share moderate level of positive linear correlation, the linear correlation coefficients of all other pairs of independent variables are either insignificant or remain at low level (<0.30). Later on, when we calculate the mean variance inflation factor (VIF) of the these independent variables based on regression models, it turns out that the mean VIF value remains at a relatively low level (mean VIF= 1.29). Hence, we conclude that the impact of linear collinearity on the regression models are considerably limited.

Table 3: Correlations, means and standard deviations of independent variables

		Mean	S.D.	1		2	3	4	5	6
1	**Age**	22.42	18.79							
2	**Size**	2.04	2.53	0.28	***					

		Mean	SD	1		2		3		4	5		6	
3	**Dyadic Partner Diversity**	0.33	0.33	0.12	**	0.20	***							
4	**Foreign Connections**	2.85	7.83	0.05		0.13	**	0.02						
5	**Non-incorporated Connections**	0.89	2.51	0.05		0.01		0.38	***	0.02				
6	**Non-manufacturing Connections**	0.26	0.44	-0.18	***	0.02		0.20	***	-0.05	0.22	***		
7	**Horizontal Linkages**	2.11	2.96	0.28	***	0.20	***	0.50	***	0.06	0.35	***	-0.12	**

Note: Significance level: **<0.05;***<0.01

Table 4: Multiple Regression Models on Centrality Measures

Dependent Variable	**(1) ln (Degree centrality)**		**(2) Betweeness centrality**		**(3) Closeness centrality**		**(4) Eigenvector centrality**	
Age	0.0012		-1.4554		-0.0002		-0.0001	***
	(0.0016)		(5.5207)		(0.0002)		(0.0000)	
Size	0.0180		16.2281		0.0017		0.0010	***
	(0.0120)		(40.4329)		(0.0013)		(0.0003)	
Dyadic Partner Diversity	1.5508	***	831.3707	*	0.0436	***	0.0097	***
	(0.1058)		(356.9468)		(0.0115)		(0.0027)	
Foreign Connections	0.0020		0.1310		-0.0008	**	-0.0001	
	(0.0036)		(12.2989)		(0.0004)		(0.0001)	
Non-incorporated Connections	0.0838	***	86.4048	*	0.0022		0.0035	***
	(0.0128)		(43.0890)		(0.0014)		(0.0003)	
Non-manufacturing Connections	0.1802	**	-104.7804		0.0056		0.0029	
	(0.0710)		(239.3556)		(0.0077)		(0.0018)	
Horizontal Linkages	0.1127	***	457.4075	***	0.0028	**	0.0007	**
	(0.0121)		(40.8393)		(0.0013)		(0.0003)	
N	299		299		299		299	
F	139.540	***	40.990	***	9.200	***	41.340	***
R-squared	0.771		0.497		0.181		0.499	
Root MSE	0.487		1644.100		0.053		0.013	

Note: Significance level: *<0.1;**<0.05;***<0.01

Next we conduct multiple regression between ln(Degree centrality), Betweeness centrality, Closeness centrality and eigenvector centrality on the seven designated independent variables. All the four models are globally significant (p<0.01), but only in Model 4 detecting the factors affect proximity to well-connected market leaders, all listed 3 sets of hypothesis are universally significantly supported.

The results demonstrate that the impact of age and size is only evident in market leader search for entrepreneurial SMEs.

Due to liability of smallness entrepreneurial SMEs with higher level of registered capital are more proximal to well-connected units than those with lower level of registered capital. In this sense, financial sustainability and relational trustworthiness determine the legitimacy and reputation of entrepreneurial SMEs to access market leaders. (Model 4: $\beta= 0.0010$, $p=0.004$), Hypothesis 1.2 is significantly supported.

An interesting observation regarding the age of entrepreneurial SMEs is that, contradictorily to the argument of "liability of newness", younger entrepreneurial SMEs have higher chance to get in contact with well-connected market leaders (Model 4: $\beta= -0.0001$; $p=0.004$). Possible explanation can be the late-mover advantages of newly-entrepreneurial SMEs that spare the sunk-cost of good quality partner detection and imitate the partnership selection strategies of early movers by linkage, leverage and learning, especially in emerging economies like China (Mathews, 2002; Yiu, 2011), Hypothesis 2.1 is significantly supported.

At the same time, we observe the significant unitary effect of dyadic partner diversity and the leverage effect of horizontal ties. An entrepreneurial SME with high degree of diversification of direct partners tend to have wider range of direct ties, high brokerage power and efficiency in resource and information transmission, and they are better connected to the most well-connected players in the network (Model 1: $\beta=1.5508$, $p=0.000$; Model 2: $\beta= 831.3707$, $p=0.021$; Model 3: $\beta=0.0436$, $p=0.000$; Model4: $\beta=0.0097$, $p=0.000$). Hypothesis 3 is robustly supported in all terms of network centrality.

For the control variables for tie diversity, their impact on network embedded are not as coherent as dyadic partner diversity. Unexpectedly, connections to foreign units only have marginally significant effect on the closeness centrality of entrepreneurial SMEs, and it turns out to be negative. This may be explained by the fact that although multinational enterprises (MNEs) act as "boundary spanners" that bridge locally embedded clusters and direct them to a broader knowledge pool in the global market (Aldrich & Herker, 1977; Tushman, 1977). The Chinese aerospace industry was historically dominated by a handful number of large State-Owned Enterprises with high degree of local protection (Nolan, 2002; Bai, *et al.*, 2004) and foreign business units still encounter "liability of foreignness". As result, connection to foreign units reduces the reachability and efficiency of communication in the network. (Model 3: β=-0.0008, p=0.044). Contrarily, the positive effects of linkages to non-incorporated units such as universities, research institutes, and governmental institutions are evident in improving the width or direct linkages, brokerage and bargaining power as well as partnership with well-connected players. Nevertheless, their contribution to global communication reachability and efficiency of entrepreneurial SMEs are not significant (Model 1: β=0.084, p=0.000; Model 2: β=86.405, p=0.046; Model 4: β=0.004, p=0.000). Although as Porter (1985) argued, support activities are the crucial coordinating forces that connecting manufacturing sectors, it turns out that specialization in non-manufacturing sectors only significantly contribute to the number of direct partners, while its influence on entrepreneurial SMEs' connection to indirect partners is not evident. (Model 1: β=0.1802, p=0.012). Finally, we can also observe that entrepreneurial SMEs that establish long-term oriented horizontal linkages, such as strategic partnership, joint-venture and joint R&D programs with direct partners are better positioned in complex business network in all four aspects of network embeddedness. (Model 1: β=0.113, p=0.000; Model 2: β= 457.4075, p=0.000; Model 3: β=0.0028, p=0.0034; Model4: β=0.001, p=0.019). These results go along with our arguments on the important of mutual trust in knowledge transfer.

5. Conclusion and Discussion

This study adapts an inter-disciplinary approach based on recent studies on entrepreneurship, strategy, sociology and network science to answer the question, why network embeddedness of entrepreneurial SMEs has become competitiveness in the global market and how to measure it. First of all, this study emphasises on the organizational context of entrepreneurship reflected in the network embeddedness. The innovation activities of entrepreneurial SMEs are not merely dependent on the individual talent of entrepreneurs or their inter-personal relationships. In the opportunity exploration and exploitation progress, entrepreneurs and entrepreneurial SMEs are embedded in a complex inter-organizational nexus comprised of firms sparsely distributed with various specialization and capacity that are interconnected by diverse types of inter-organizational relationships.

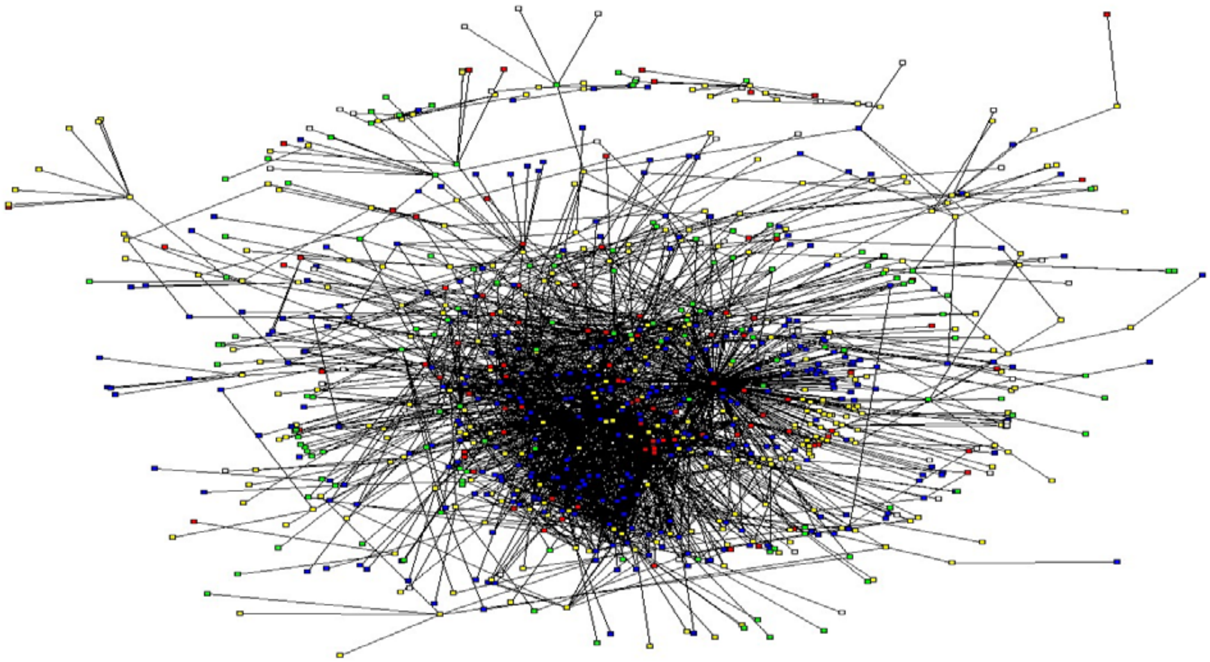
Secondly, this study addresses the contribution of network embeddedness to entrepreneurial SMEs' competitiveness and different dimensions that represent multifaceted local and global embeddedness properties. Inter-organizational linkages channel entrepreneurial SMEs to strategic resources and enhance their absorptive capacity to capture specialized knowledge spillovers. Long-term partnership with direct partners based on mutual trust reduces the risk of moral hazard and designates the reliability of the behavioral patterns of embedded firms. At the same time, a firm that acts as broker over structural is capable of leveraging network resource and knowledge flows through the inter-organizational networks, thus obtains stronger bargaining power over their indirect partners.

Finally, based on empirical studies on the multiplex business networks of Chinese aerospace industry, we can conclude that the impact of size, age and egocentric diversity affect entrepreneurial SMEs' multifaceted network embeddedness vary. Dyadic partner diversity and number of horizontal linkages have the universal positive contribution to all four aspects of entrepreneurial SMEs' network embeddedness. On the other hand, the influence of other factors varies. Liability of smallness only significantly restrain entrepreneurial SMEs’ proximity to well-connected market leaders, but newly-founded entrepreneurial SMEs are more likely to benefit from latecomer advantage in partnership selection. Connection to foreign business units downgrades the reachability and efficiency of SMEs’ communication. Contradictorily, connections to non-incorporated units, such as universities, research institutes and governmental institutions can expand entrepreneurial SMEs’ neighbouring range of direct partners, brokerage and bargaining power and proximity to well-connected market leaders. Finally, the impact of industrial heterogeneity is marginal, as entrepreneurial SMEs specialized in non-manufacturing sectors hold the advantage of more direct partners, but do not necessarily have effective reach to indirect partners and influencing power in the whole network.

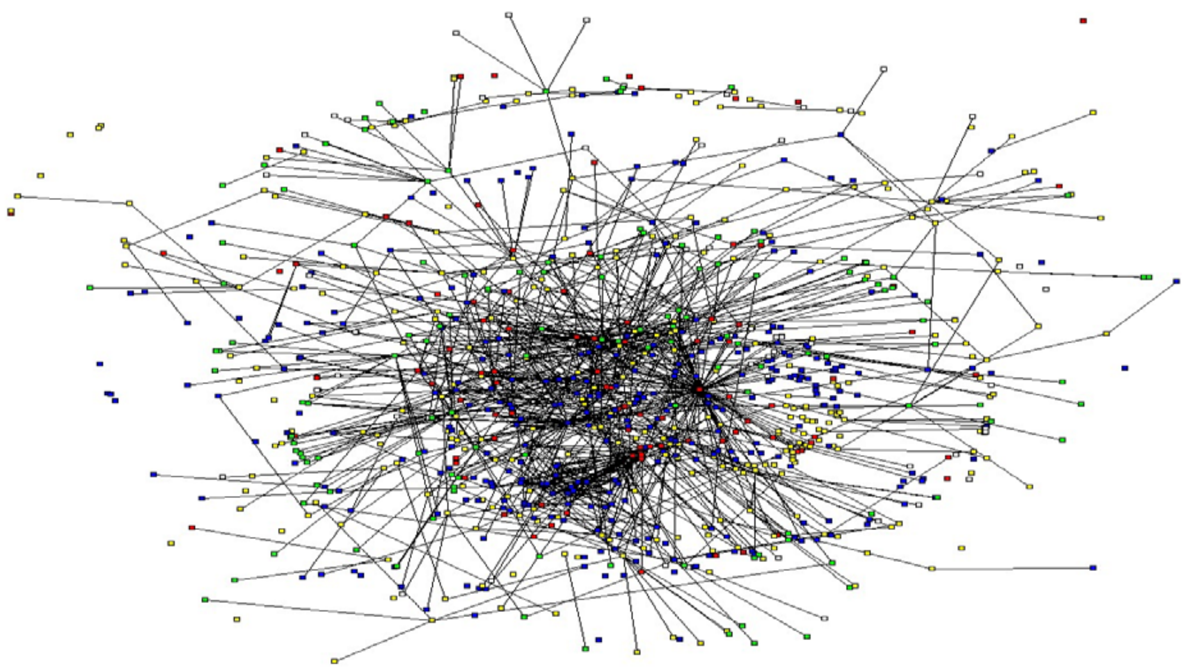
For further research, we suggest to bridge the gap figuring to what degree different aspects of network embeddedness contribute to strategic resources acquisition, absorptive capacity enhancement, and behavioral influence over other partners. In addition, the scope of research can be extended to multinational and cross-industry level. We suggest to further explore how cross-national and cross-sector ties contribute to entrepreneurial SMEs’ competitiveness. In addition, longitudinal studies on the shift of linkages among diverse partners over time could also help to understand the dynamics inter-organizational network evolution and how the changing network contributes to entrepreneurial SMEs’ competitiveness.

Appendix

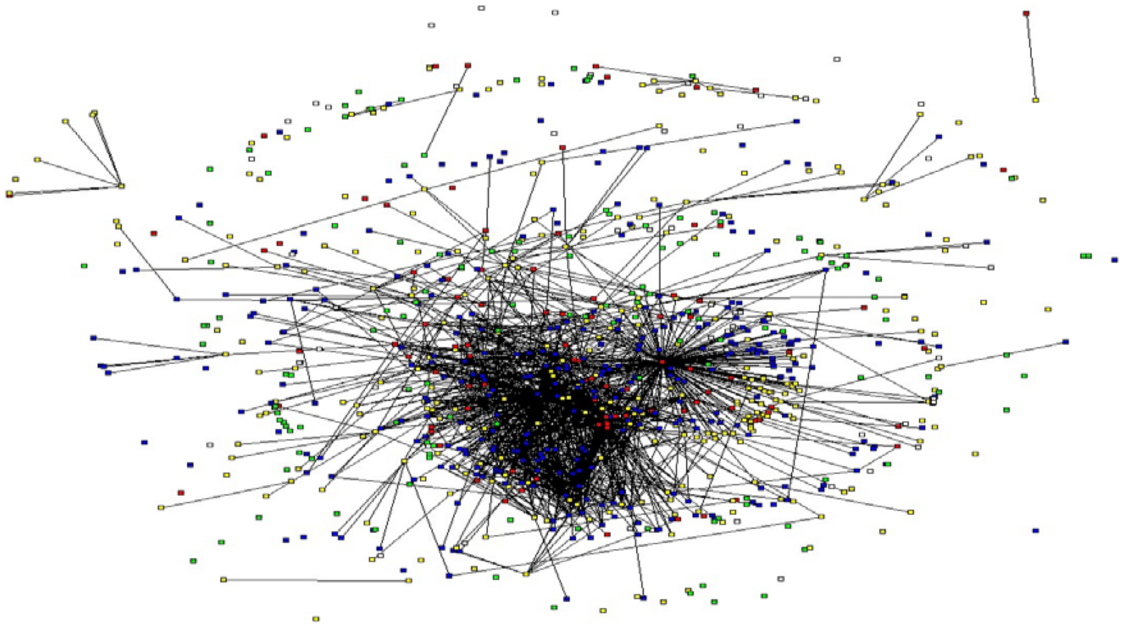
Graph 1: Multiplex Network of Chinese Aerospace Industry



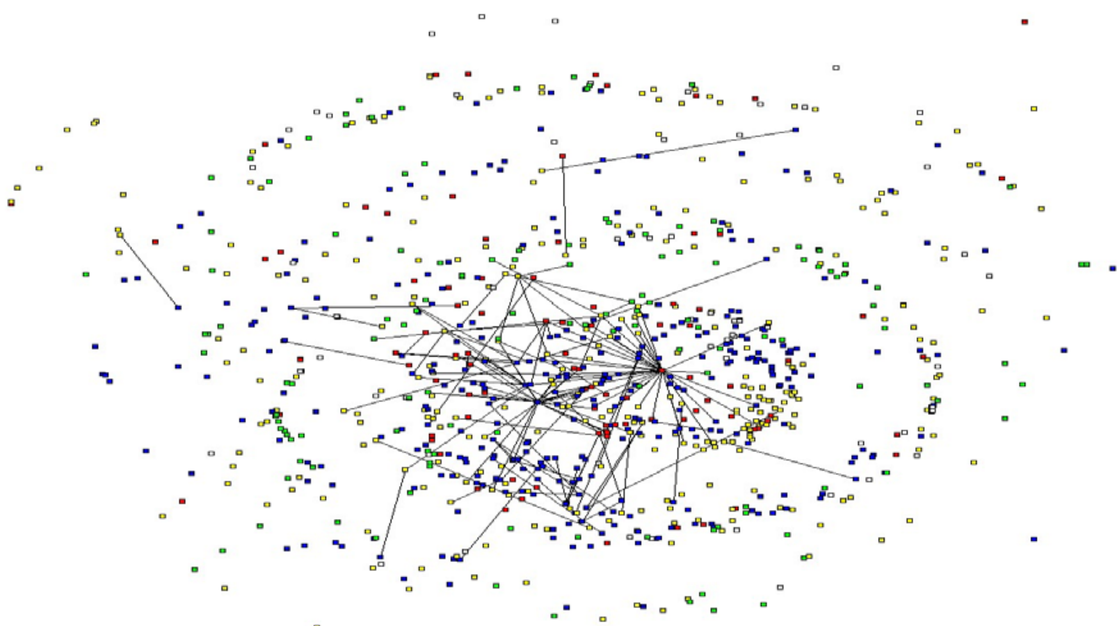
Graph 2: Horizontal Network of Chinese Aerospace Industry



Graph 3: Vertical Network of Chinese Aerospace Industry



Graph 4: Double Embedded Network of Chinese Aerospace Industry



Note: The colors of vertices represent different types of business units: (1) Domestic entrepreneurial SMEs (yellow); (2) Domestic large firms (red); (3) Foreign firms (blue); (4) University and research institutes (green) (5) Governmental institutions (white).

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