Paper no. 2011/07

Regional Institutional Environment and Its Impact on Intra-firm and Inter-organisational Innovation Networks: A Comparative Case Study in China and Switzerland

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This is a pre-print version of a paper that has been submitted for publication to a journal

This version: September 2011

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ABSTRACT

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Keywords:

Innovation networks, Regional institutional environment, Intra-firm, Inter-organisational, China, Switzerland

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Abstract

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INTRODUCTION

It has been emphasized that innovation networks are embedded in certain context of regional institutions (Asheim, 2005). Networking for innovation is both an economic process and a social-cultural-process which are shaped by economic, social, cultural, and political, or in short, institutional environment (Thrift and Olds, 1996; Crang, 1997; Lundvall and Christensen, 2004). Regional institutional environment (RIE) is central to the construction of the economy (Martin, 2000). It provides a "wider settings" (Lundvall, 2007) for the interaction among actors in the innovation networks. For all these reasons, RIE is firmly on the research agenda of innovation network studies.

Despite the increasing literatures and growing interest in this field, the understanding of RIE and its impact on innovation network remains rather limited. First, most of the researches just look at one or two specific aspect of RIE, such as education system, or labour market, or IPR regime, etc., instead of taking RIE as a comprehensive combination of many factors. One possible reason of such simplification is that RIE is a macrocosm with complicated structure so that it is difficult to summarize and in particular to measure it. Nevertheless, this oversimplified approach may lead to the problem of taking a part for the whole. It is particularly improper for making generic public policy. Second, it is known that RIE matters to innovation network but it remains unclear as to which part of the networks it matters or matters more --- the intra-firm innovation networks (IntraINs), or the inter-organisational innovation networks (InterINs). Innovation network research has

long been divided into two separate parts, namely the IntraIN research at individual level and the InterIN research at organisational level. One can hardly find literature that integrated these two parts together. The separation of research on IntraIN and InterIN may blur the boundary of the effectiveness of public policy for innovation. In summary, it is necessary to study RIE as a comprehensive combination of multiple factors and the IntraINs together with InterINs so as to better understand the mechanism of the impact of RIE on innovation networks and to generate policy implications for innovation in the firms of the region.

This paper sets out to address these research gaps by taking the RIE as a comprehensive mixture and combining the research on both IntraIN and InterIN. It develops a set of quantitative and qualitative measures to assess the RIEs in the relevant regions. It studies the structure of firms' IntraINs and InterINs by identifying the relationships among internal departments of the firms, the connections between the focal firms and the external organisations, as well as the linkages among the external organisations for the innovation in the focal firm. It explores the differences between the impact of RIE on IntraIN and on InterIN so as to understand the role of RIE as well as the role of firms in constructing innovation networks. This will help to identify the areas where the firms can do it themselves and where they cannot do it, or in other words, to identify the areas where the public policy should play a role and where the government should not interfere.

This paper is a comparative case study between firms' innovation networks in the Great Zurich Area in Switzerland and the Sichuan province in China. It addresses the

following questions:

1) How are the RIEs of these two regions configured?

2) How connectedness differs between firms' IntraINs/InterINs in these two different RIEs?

3) How do RIEs influence the connectedness of firms' IntraINs and InterINs?

4) What are the policy implications?

The rest of the paper is presented in four sections. The first is the theoretical background in which the institutional and organisational dimension of innovation network research is discussed. The second is the analytical framework for analysing and assessing RIE, as well as for mapping and studying innovation network. The third is the research methods including design of case study, selection of regions and firms, and collection of data. The fourth is case analysis and main findings. The fifth is discussions and conclusions.

THEORETICAL BACKGROUND

The institutional dimension of innovation network research

Institutional environment has been highlighted in innovation network research by scholars in the field of economic geography, business administration, and in particular the interdisciplinary innovation studies with innovation system approach (Freeman, 1987; Cooke, 1992; Lundvall, 1992, Nelson, 1993; Malerba, 2002). The characteristic of innovation system approach is the acknowledgement that innovations are carried out through a network of various actors underpinned by an institutional framework

(Asheim and Coenen, 2006). Institutional environment is defined as the "wider settings" (Lundvall, 2007) in innovation system literature. It refers to education systems, labour markets, financial markets, intellectual property rights, competition in product markets and welfare regimes. The wider settings shape people and the way how people relate to each other within and across organisational borders. The institutional environment debate comes from the literature on socio-economic networks and geographical embeddedness. This strands of literature highly emphasis the factors underpinning instances of sustained economic success (Amin and Thrift, 1994a; 1995; Granovetter and Swedberg, 1992; Cooke and Morgan, 1993; MacLeod, 1997). It appears that even though RIE, a multifaceted complex, does not provide an automatic guarantee of economic dynamism, it does influence firm growth and regional development in one way or the other (Bennett, 1997; Scott, 1998; Yeung, 2000; Henisz, 2000).

Research on RIE and its impact on innovation networking can be seen on the horizon recently. Tseng and Kuo (2009) found that institutional environment has significant influence on the adoption of social network and possesses more explanation power than transaction cost. But their paper does not tell toward which direction that institutional environment influences the adoption of network. Chaminade (2011) found that an institution which is not too thick or too thin is the most favourable to boost global innovation network. Todtling et al. (2011) found that the density, structure and size of the regional innovation system, which provides different RIE, influence the nature and geography of knowledge sourcing and the use

of knowledge transfer mechanisms in the innovation networks in ICT industry. However, these literatures mainly studied InterIN instead of IntraIN or both.

The organisational dimension of innovation network research

The organisational dimension of innovation network research experienced a transition from focusing on the user-producer linkage (Lundvall, 1985) to viewing the bigger picture with all the other organisations in the innovation system. This transition echoes the evolution of innovation system approach from the technology system to a more comprehensive system combining economic, social, cultural, political incentives and determinants, and organisations. Lundvall (2007) suggested the core of an innovation system is actually a network of actors including firms, organisations who interact with firms (i.e. customers, suppliers, and competitors), and knowledge infrastructure (i.e. universities, research institutes). OECD (1999) identified five groups of actors in an innovation system. They are government (i.e. local, regional, national government, and international official organisations), intermediaries (i.e. service agencies, associations), firms and firm-financed research institutes, universities, and other public and private organisations (i.e. public laboratories, technology transfer organisations, patent offices, and training organisations). Lundvall's taxonomy is more focused and clear but with government out of view. OECD's taxonomy seems to be overlapping but emphasises the important role of government.

The analytical level of innovation network literature can be mainly summarized into two categories, the IntraIN research and the InterIN research. Researches on

IntraIN usually take individual employees of the firm as the actors so as to see how the organisational culture, atmosphere, and structure stimulate or inhibit individual employees' creativity and consequently influence the innovation outcome of the firm (Amabile, 1988; Ibarra, 1993; Perry-Smith and Shalley, 2003). Researches on InterIN usually focus on the role of InterIN shaping innovation (DeBresson and Amesse, 1991, Freeman, 1991, Hagerdoorn, 1990, 1993, Nooteboom, 2004, Powell et al, 1996, Soh and Roberts, 2003) and innovation systems (Giuliani and Bell, 2005, Kastelle et al, 2009). There is yet a limited amount of empirical studies on the role of intra-firm networks on innovation and organisational learning (Dantas, 2006, Jensen et al, 2007). There are few researches that integrated both IntraIN and InterIN.

Linking the institution with the organisation

The network perspective offers a meso-level compromise to link the RIE at macro-level with the firms at micro level (Araujo and Easton, 1996).

In recent years, the institutional school has become a major theoretical approach to study organizational structure and behaviour, but mainly towards individual firms. RIEs are characterized by the elaboration of rules and requirements to which individual organisations must conform in order to receive legitimacy and support (Scott and Meyer, 1983). Nevertheless, at the same time, RIE also provides a background condition in which organisations set up networks to get access to new personnel, new knowledge, new marketing channel, etc. which they do not have within the organisations. RIE shapes, constrains, facilitates and allows actions and interactions including those of an economic nature in such networks (Granovetter,

1985 and 1992). Hence, it is believed that RIE influence both individual organisations and their relationship with the others. But to whom that RIE matters more, the internal part of the organisation, or their connection with the outsiders, or the connection among the outsiders for the innovation of the focal organisation, remains understudied. Thanks to the insufficiency of the research on this matter, we do not have clear understanding of where policy should focus on.

This paper links the institutional dimension with the organisational dimension by exploring the structure of the innovation networks of firms (both IntraIN and InterIN) and analysing the RIE so as to detect the mechanism of how and where the former influences the later.

ANALYTICAL FRAMEWORK

The analytical framework of this paper (see Figure 1) is based on regional innovation system approach and social network analytical tool.

Innovation system approach is the theoretical perspective of this paper. It provides the "tool of inquiry" (Nelson and Winter, 1982) to focus the research on the most important issue of innovation, namely the innovation networks and the RIE they are embedded in. The components in RIE and the actors of the innovation networks are identified based on the literature of innovation system.

Social network analysis (SNA) is adopted to map the innovation networks of the case companies and to measure the networks' connectedness. The connectedness of the innovation networks reflects the intensity of the interaction among them.

Except the RIE, other important influential factors of the innovation networks, such as firm's innovation capabilities, firm size, and technological regime are controlled. It will be explained later in the section of methods.

The following section will explain the operational definition of the important indicators of RIE in the paper and how they are measured and analysed.

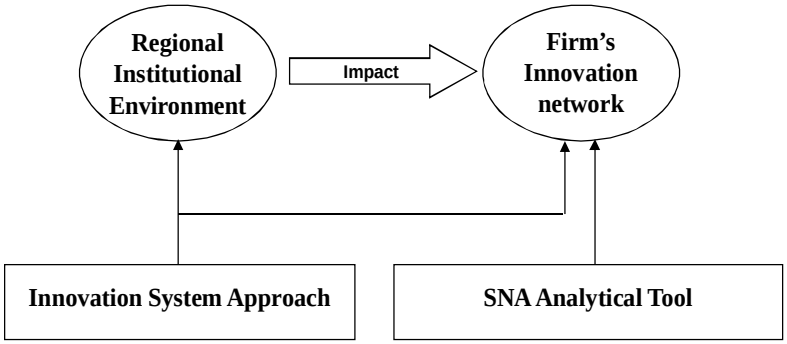

Figure 1. Analytical Framework

Analysing and assessing RIE

In this paper, RIE consists of two elements. One is the software, which is the informal conventions, customs, norms, and social routines, as well as the formal rules, regulations, and laws (Johnson, 1992; Edquist, 2004). The other is the hardware, which are the organisations whose constitution and operation are governed by the former elements (Neilson and Rosenberg, 1993).

The analytical framework of RIE is based on the concept of institutional thickness which is proposed by Amin and Thrift (1995) as a multifaceted concept to sum up the institutional factors in a relevant region. This paper adopts the framework of institutional thickness because of its strong relevance to innovation and its great

potential to explain the RIE as a comprehensive complex. According to Amin and Thrift, institutional thickness depends on four determinants. First, a strong organisational presence that is a plethora of organisations of various kinds including universities, research institutes, government agencies, innovation centres, consultant companies, development agencies, industrial associations, training agencies, etc. Second, there is high level of interaction among these organisations in the region including contact, exchange information, and cooperation. Third, there is development of structures of domination and/or patterns of coalition-building in order to minimize sectionalism and rogue behaviour. Fourth, there is the development of mutual awareness and common agenda. These four factors reflect the most important elements for innovation, such as inter-organisational interaction and synergy, collective representation by different bodies in the regional innovation system, common purpose and shared cultural norms and values which nourishes relations of trust, stimulates entrepreneurship, and consolidates the local embeddedness of industry.

There is no doubt that institutional thickness provides relevant insights for innovation research. Nevertheless, this theoretical framework has not been significantly developed despite its great potential in explaining the geographic difference of innovation and development. The concept of institutional thickness was introduced 15 years ago but since then it has not received enough exposure in contemporary discourse. The reason is that this framework does not provide any reference to a methodology for an empirical application of the concept to analyse

regional economic development (Coulson and Ferrario, 2007). In other words there is a lack of systematic observable or measurable indicators to demonstrate or to assess the thickness of the institutional environment.

In consideration of the lack of development on methodology as aforementioned, this paper develops a set of observable or assessable indicators to measure, or at least, to assess the four determinants of the thickness of RIE (see Table1).

The indicators of “organisational presence” are density indicators. They are the number of relevant organisations involved in the regional economic development. The identification of different groups of organisations is based on the six-element taxonomy of the “wider settings” of innovation system by Lundvall (2007), namely education system, labour market, financial market, IPR regime, production market competition, and social welfare system. In terms of the structure of the markets in which the case companies operate they are all oligopoly, and market competition is considered to be constant when comparing the different cases in the two regions of Great Zurich and Sichuan. So that the production market competition is not included in the indicators of organizational presence. This set of indicators also excludes the organisational presence in social welfare sector because of its weak relevance to interaction for technological innovation. The impact of social welfare system on innovation is more related to the willingness and readiness of the society to accept innovation even though it might entail unemployment.

The indicators of “interaction among these organisations” mainly focus on the interaction between universities and industry. The university-industry relationships

and their impact on innovation process has been highly recognized and intensively studied by scholars from different academic communities. It is considered to be the key relationship for technological innovation compared to other links with lower relational involvement (Perkmann, 2007). The set of indicators includes history of cooperation, exchange of personnel, and mutual trust between university and industry which was estimated by the interviewees in this research. It also includes the university-industry-cooperation index by the Global Competitiveness Report (World Economic Forum, WEF) which reflect to what extent that the R&D collaboration has been established between the business community and local universities.

The indicators of “development of structures to minimize sectionalism and rogue behaviour” are related to IPR regime and competition legislation which are the two key legal areas for technological innovation. The IPR regime is assessed by the history of IPR legal system construction and the IPR protection index by the Global Competitiveness Report (WEF) which reflects the effectiveness of IPR protection and the enforcement of IPR law. The competition legislation is estimated by the anti-monopoly policy effectiveness index by the Global Competitiveness Report (WEF).

The indicator of “development of mutual awareness and common agenda” is the year of the initiation of the regional innovation strategy. It is supposed that as the common agenda of regional innovation, the longer the regional innovation strategy was formulated and implemented the better mutual awareness the region should have developed.

Table 1 Regional institutional environment determinants breakdown

Determinants	Indicators	
Organisational presence	Higher education system	Number of researchers at tertiary level per million population Number of students at tertiary level per million population
	Labour market	Number of engineers and scientists per million population
	Financial market	Number of employees of banks and investment institutes per million population
	IPR regime	Number of patent attorneys per million population
Interaction among these organisations	Interaction between university and industry	History of cooperation Exchange of personnel Mutual trust University-industry cooperation index
Development of structures to minimize sectionalism and rogue behaviour	IPR regime	Legal system construction IPR protection index
	Competition legislation	Anti-monopoly policy effectiveness index
Development of mutual awareness and common agenda	The history of regional innovation strategy	The year of the initiation of first regional innovation strategy

Mapping and studying innovation network

Innovation network in this paper refers to a set of relationships in and of the case company aiming at technological innovation including both product and process innovation. The case companies' IntraINs and their InterINs are weighted and undirected whole networks

Actors of an intra-firm network were identified as different functional departments or groups who serve as function of marketing, financial, R&D, and human resources (HR) etc. within the firm. This taxonomy follows the value chain analysis by Porter (1985). In the InterIN of this paper, the actors include the case company itself and other organisations outside the case company, such as universities, research institutes, investment institutions, customers, suppliers, competitors, government agencies and so on. This category follows the taxonomy of OECD (1999) and Lundvall (2007). The names and abbreviations of the IntraIN actors and the InterIN actors are shown in Table 2.

Table2. Name and abbreviation of actors of IntraINs and InterINs

IntraIN's Actors		InterIN's Actors (excluding the focal company)	
R&D	R&D Department	CST	Customers
PRD	Production Department	SPL	Suppliers
HR	Human Resource Department	CPT	Competitors
MKT	Marketing Department	INV	Investment institutions
FIN	Financial Department	IA	Industrial Associations
LOG	Logistic Department	GOV	Government
I M	Innovation Management Department/group	UNI	Universities
		RI	Research Institutes
		CSL	Consulting Companies

The ties of the innovation network are both formal and informal relationships for:

1) Access to openly available information without the need to pay for or with marginal fee for the access, such as membership in trade associations, attendance at conferences, and subscriptions of journals;

2) Acquisition of technology and knowledge without active cooperation with the source, such as purchasing machinery, equipment, hiring people, or using contract research and consultant service; and

3) Active participation in joint innovation projects.

The relational data of the ties were collected through a roster recall method (Wasserman and Faust, 1994). Each case company was presented with a complete list (roster) of the actors in the network and was asked the following questions:

Q1: Do the following actors contact each other for your company's technological innovation activities?

Q2: If do, how is the strength of these connections in terms of the intensity they contact each other, the frequency they contact each other, and the trust between each other? Please give a score to represent the strength of the connections:

Strength	Very strong	Strong	Normal	Weak	Very weak
Score	5	4	3	2	1

The connectedness of the IntraIN and InterIN was measured by the network density and actor's Freeman degree.

Network density is a measure of the connectedness of the network as a whole. The density of the IntraINs and InterINs were calculated and compared within and between the Great Zurich Area in Switzerland and Sichuan in China. Then one can see if there are differences within each region and between two regions. Specifically, this paper took away the case companies from the InterINs and analyzed the density of the "alter InterINs", which refers to the set of nodes that has ties with the focal firm but not including the focal firm itself. The purpose is to further explore the impact of RIE on the direct connections between the case companies and their outside collaborators in their InterINs as well as the indirect connections among outside organisations (the alters) for the case company's technological innovation.

Freeman degree is a measure of the connectedness of a specific actor in a local environment. It measures the centrality of the node in the network and shows the potential of the node's positional power. It is used to identify who are the most well connected actors in the innovation networks.

METHODS

Design of case study

This research is a concrete research. Concrete research as defined by Sayer (1992) studies actual events and objects as unities of diverse determinations. It involves theoretical research which deals with the mechanisms and structures of the RIE which

conditions firm's networking. It also involves study on actual networking activities which are dealt with as possible outcomes of the regional innovation system. This concrete research has a certain extent of generalisation. It seeks regularities and common properties of the specific networking activities. However, it has no intention to involve all the networking activities at the practical level and has no intention to study all the mechanisms and structures of the RIE at the theoretical level either. It just tries to provide interpretive understanding on how RIE influences the connectedness of firms' innovation networks.

With the intensions aforementioned, this research chose the research method of comparative case study with multi-case embedded design. The reason why I used multiple cases is that multiple case studies are likely to yield more convincing, robust, and tenable findings. The embedded design uses several units of analysis, such as connection with in firms, connection between firms and other organisations, as well as and RIE determinants.

Selection of regions

Polar sampling approach was used to select the case regions in order to see how RIE influences the construction of IntraINs and InterINs. Polar sampling can make the constructs and theoretical relationships "transparently observable" (Pettigrew, 1990). The two regions I compared in this paper are Sichuan in Southwest China and the Great Zurich Area including Glarus, Grisons, Schaffhausen, Schwyz, Solothurn, Zug and Zürich in Switzerland.

It is expected that Sichuan and Great Zurich are significantly different in terms of

RIE thanks to the economic and social differences between these two regions. First, the economic development levels of these two inland regions are obviously different. Sichuan is one of the least developed regions in a developing country，while the Great Zurich is the economic centre and home of a large number of multinational companies in one of the most developed countries in the world. The GDP per capita of Sichuan in 2005 was 1,048USD ranking 27th among China's 31 provinces and municipalities directly under the central government[1] compared to that of the Great Zurich, which was 74,110 USD ranking 5th among the 25 cantons in Switzerland. Second, the social and cultural norms and conventions are very different. Sichuan is a province traditionally restrained by its disadvantaged geography. Tibetan plateau in the west and other huge range of mountains in other three directions isolate Sichuan from the outside world. Consequently, Sichuan people feel culturally and socially uneasy to cooperate with outsiders. Great Zurich is right in the centre of Europe neighbouring with Germany, Austria, and close to France and Italy. The multi-language speaking people and permanent neutral political status make negotiation and cooperation common activities in the society.

The RIE of these two regions will be further discussed in the section of analysis and main findings.

Selection of firms

Theoretical sampling approach was adopted to select the case firms in order to induce tenable findings from the cases. Six large high-and-medium-tech

[1] Sichuan Statistics 2006

manufacturing companies with strong innovation capabilities were chosen as case companies. In Zurich, they are HVP, LED, and Emhart. In Sichuan they are Grace, DEC, and ERZ[2].

These six firms were selected by four criteria, namely firm's innovation capabilities, firm size, market structure in which the firm operates, and technological regime in which the firm is involved. These four criteria were chosen from the perspective of firm, market, and technology which have fundamental influence on firm's innovation process.

Only companies with strong innovation capabilities were selected as innovation activities in these companies are more active and it is easier to observe their innovation networking behaviour and collect data compared to that of companies with low innovation capabilities. The technological innovation performance which is measured by the percentage of the sale of new products to total sale in the past three years is used to estimate the innovation capabilities of the case companies.

Only large companies were selected as firm size matters when it comes to innovation (Acs and Audretsch, 1987. Cohen and Klepper, 1996; Rogers, 2004). Large firms and small firms behave differently when innovate. I chose large companies because their innovation networks are usually broader than small companies. It is also easier to observe their innovation networking behaviour and to collect data. The number of employees is used to measure the size of the case companies.

[2] The company HVP and LED requested anonymity.

Only companies operating in oligopoly market were selected. Market structure (Kamien and Schwartz, 1982) refers to the state and characteristics of a market with respect to the degree or intensity of competition among buyers and among producers. Scholars with market structure perspective argued that competition urges innovation and monopoly protect the profitability of innovation. Herfindahl-Hirschman-Index is used in this paper to identify the structure of the market in which the case companies are operating. HHI is the measure of market concentration which is the most important indicator of market structure.

$$\text{HHI}=\sum_{i=1}^{n} S_i$$

S is the market share of firm i competing in the market. In this research only the top four companies with biggest market share are considered.

Technological regime of the case companies are all high-and-medium-tech based. Technological regime (Dosi, 1982; Nelson and Winter, 1982; Malerba and Orsenigo, 1996) is characterized by the opportunity, appropriability, and cumulativeness. It is also characterized by the complexity of knowledge base. Scholars with technological regime perspective argued that the specific features of technological regimes affect the specific patterns of innovation process as well as the structure of innovation networks (Malerba and Orsenigo, 1996). In this research I used the R&D cycle, which is related to the changing speed of technology, to indicate the opportunity, appropriability, and cumulativeness of the technology in which the firms are involved. It is measured by the average time period for developing a significant new product in the industry. I also used R&D intensity to specify to what extent the technology of the

firms is knowledge-based. R&D intensity is measured by the ratio of expenditures by a firm on research and development to the firm's sales

The overview of the firms in terms of firm's innovation capabilities, firm size, market structure in which the firms operate, and technological regime in which the firms are involved, is shown in Table 3. It is clearly seen that these six case companies are all strong in terms of innovation capabilities. They are all large companies (number of employee > 1000). They all operate in oligopoly market (HHI > 0.10) where competition is concentrated among several big companies. They are all medium-and-high-tech companies (R&D intensity between 4% and 9%).

Table 3. Overview of the case companies

Region	Firm	Firm size	Innovation performance			Market structure					Technological regime	
		Number of employees	Percentage of the sale of new products to total sale			Market share of the 4 biggest firms in the industry			HHI			
			2007	2006	2005	Case firm	Firm A	Firm B	Firm C		R&D cycle (months)	R&D intensity
Zurich	HVP	33600	50%	50%	50%	20%	15%	15%	5%	0.109	36-60	6% - 8%
	LED	36000	40%	30%	25%	30%	30%	10%	10%	0.204	24-36	6% - 8%
	Emhart	1064	30%	30%	90%	45%	9%	7%	6%	0.219	18-24	7% - 8%
Sichuan	Grace	12000	47.8%	45.8%	51%	29%	28%	13%	11%	0.192	12-24	6% - 9%
	DEC	9000	60%	50%	55%	30%	30%	25%	5%	0.245	20-36	4%-5.5%
	ERZ	12650	72%	69%	67%	45%	25%	n/a	n/a	0.265	12-24	6% - 9%

Data collection

Data sources of this paper includes interviews, questionnaires, follow-up emails and phone conversations, archives, websites, internal reports, internal documents and press news. Multiple data sources provide more accurate information and improve the robustness of the results (Jick, 1979; Anand et al., 2007). One questionnaire was developed and administered to elicit responses from 15 senior managers in these companies. In total, 51 interviews were conducted. I interviewed companies' senior managers (most of them are CEOs and/or VPs of technology) to fill up the questionnaire and interviewed middle level managers (usually R&D managers, innovation managers) to clarify and verify the answers to the questionnaires, and to complement with necessary information. I interviewed government officials, university researchers, and industrial practitioners in other companies for better understanding of the institutional context of these two regions. Each interview lasted from one to three hours. All the interviews in Europe were recorded but some interviews in China were not, as our Chinese interviewees were reluctant to be recorded. The interviews in Sichuan, China were done between 2007 and 2009 while the interviews in Great Zurich were conducted in 2008.

The interview started by asking informants background questions about their company and the industry, such as the history of the company, the organisational structure of the company, their strategy of innovation, the technology nature and competition in the industry, etc. Then the questions went to the relationship between the inside functional departments or groups, the relationships between the inside

functional departments/groups and the outside organisations, and the relationships among the outside organisations. The informants were reminded constantly that all the relationships should be relevant to the technological innovation activities of the specific company they work for. At the end of the interview, open-ended questions were asked to identify the hindrances and facilitators in the region for the construction and development of the firms' innovation networks.

Potential informant bias is addressed in four ways. First, I selected highly knowledgeable informants from multiple hierarchical levels of the firms. Both top management team members that are CEO and/or VP of technology, and middle level managers such as R&D managers or innovation managers, were interviewed. The CEOs and/or VPs of technology usually know the whole picture of the innovation activities in the company but they may ignore some details of the innovation process. The R&D managers or innovation managers' answers were used as complementary material to improve the accuracy of the data collected from the CEOs and/or VPs of technology. Second, I used "courtroom questioning" technique to focus on factual accounts (Lipton, 1977; Humber and Power, 1985). I asked the informants to specify what kind of activities have been carrying on in each specific relationship so as to ensure that the informant did not mix the relationship for innovation with those for routine work, such as production. It was also helpful for informants to avoid the confusion between what had happened and what should happen. Third, I gave anonymity to the informants and their firms on request to encourage candour. Fourth, I showed the potential benefit of the research to the informants to increase their

interest of participating. Strong interest of informants ensures the accuracy of their accounts (Miller et al., 1997). The informants were very motivated to give accurate information because they knew that networking is critical to the companies' innovation but they did not know the very precise picture of the IntraIN and InterIN of their companies.

ANALYSIS AND MAIN FINDINGS

Following the multiple case study procedure (Eisenhardt, 1989b; Yin, 2003), I used within-case and cross-case analyses with propositions as follows

Proposition 1: RIE has no apparent impact onto the case firms' IntraINs.

Proposition 2: in the thick RIE, the case firm's InterINs are dense

Proposition 3: in the thin RIE, the case firm's InterINs are sparse

Triangulating all the data I collected, I began with studying each single case by analysing the thickness of the RIEs and explaining its impact on the construction of the case company's IntraIN and InterIN. Then I conducted a cross-case analysis using replication logic across the cases, treating each company as a case. Using replication logic, I developed preliminary findings from some cases and then tested them on others to validate and refine the prior findings (Eisenhardt, 1989b; Yin, 2003). Some propositions were confirmed and others were revised when they did not replicate across the cases. The findings of this multiple case study are as follows.

The RIE of the Great Zurich Area is thick while that of the Sichuan province is thin

The evaluation of the RIE of Great Zurich and Sichuan is shown in Table 4.

Great Zurich has strong organisational presence while Sichuan has a weak one. This can be seen from the statistics in four aspects, namely higher education system, labour market, financial market and IPR regime as shown in Table4.

Great Zurich has more intensive interaction between different organisations in the region than Sichuan.

Table4. Overview of RIE in Sichuan and Great Zurich

Determinants	Measures	Sichuan	Great Zurich[3]
Organisational presence	Number of researchers at tertiary level per million population	430	1972
	Number of students at tertiary level per million population	10,556	29,718
	Number of engineers and scientists per million population	1,583	13,180
	Number of employees of	2000	15,000

[3] Note: There are two occasions that the national level data is used to substitute for the regional level data. One is when the data of Great Zurich Area (GZA) is not available. As GZA is one of the economic, financial, and education centre of Switzerland, one can expect the data of GZA shows more advantage than the average data of Switzerland. In this sense it will not change the result of the analysis. The other occasion is when the national level data can represent the regional level data. This happens to the data about IPR regime and the competition legislation. The reason is that such legislation is arranged at the national level more than the regional level. This reflects the reality that RIE is a combination of both the regional and national factors. It is more proper and clearer to name it as the institutional environment within the region instead of the regional institutional environment.

	banks and investment institutes per million population		
	Number of patent attorney per million population	4.6	31.5
Interaction among organizations	Interaction between university and industry	• Short history of cooperation • Few personnel exchange • Lack of mutual trust	• Long history of cooperation • Frequent personnel exchange • Generally trust each other
	University-industry cooperation index[4]	• 5.6	• 4.5
Development of structures to minimize sectionalism and rogue behaviour	IPR Legal system construction	• Patent law in 1984 • Legal system in shaping	• Patent law in 1888 • Legal system compatible with European IPR system
	IPR law enforcement (IPR protection index[5])	• 6.3	• 3.9
	Competition legislation (Anti-monopoly policy effectiveness index [6])	• 5.3	• 4.0

[4] In the area of R&D, collaboration between the business community and local universities is (1 = minimal or non-existent, 7 = intensive and on-going)

[5] Intellectual property protection and anti-counterfeiting measures in the country are (1 = weak and not enforced, 7 = strong and enforced)

[6] Anti-monopoly policy in the country is (1 = lax and not effective at promoting competition, 7 = effective and promotes competition)

Development of mutual awareness and common agenda	The history of regional innovation strategy	• Regional innovation strategy launched in 2006	• Regional innovation strategy launched in 1990s

Source: Sichuan Statistics 2008

Sichuan Fiscal Report 2008

China Banking Regulatory Commission Yearbook 2008

Higher Education in Switzerland 2008 by State Secretariat for Education and Research SER and Federal Office for Professional Education and Technology OPET

Statistical Yearbook 2008 (Switzerland)

China Banking Regulatory Commission Yearbook 2008

The Global Competitiveness Report 2008-2009 (World Economic Forum)

Swiss Federal Institute of Intellectual Property website https://www.ige.ch/en/service/patent-attorneys.html

Development Plan for Patent Agencies (2009-2015), State Intellectual Property Office of People's Republic of China

In Great Zurich, university and industry has a long history of cooperation. One famous case is the cooperation between Swiss Federal Institute of Technology, Zurich and Roche group in 1935 on the patent of Vitamin C which resulted in the rapid growth of Roche making the company one of the leading pharmaceutical companies in the world. The applied science universities are the very special institutions in the Swiss higher education system. The original intention of establishing applied science universities is to enhance the connection between university and industry. R&D in applied universities is all related to the demands in market instead of pure basic research. The establishment of applied science universities successfully improved innovation via cooperation between university and industry. Personnel exchange between universities and industry is very common in Switzerland. Half of the rectors

of applied science universities have been industrial practitioners. Many engineers and managers have formal position in universities. Talking about the relationship between university and industry, a former applied science university rector said:

> Generally speaking, universities and industry trust each other. Switzerland is a small society where everybody knows everybody. Not only people in the same field know each other, those from different fields know each other too. This can partially attribute to the Swiss compulsory military service system. If we don't meet in the school or at work, we meet in the military. Once we set up personal relationship, it is much easier for further develop cooperation for innovation on the basis of mutual trust.

In Sichuan, universities have been historically considered as ivory towers which are to some extent isolated from the industry. Recently, four of the main universities in Sichuan province pledged to build themselves as the (pure) research-based universities. The evaluation criteria for professors are mainly the number of publications and patents. Not many researchers and professors in the universities are really interested in developing products for the market. Personnel exchange, especially those from industry to universities, is very rare. Usually the highly achieved engineers or managers can only be invited as part time guest lecturers. It is almost impossible for them to have formal position in universities thanks to the bureaucratic regulation. The director of Department of Science and Technology in Grace said:

> We had tried very hard to cooperate with one of the universities in our province. We

invested heavily but failed badly. The reason is that our company and university professors had different goals and interests. We wanted new product which is profitable in the market. They wanted papers and patents. We tried several other universities, but few were successful. Usually the professors together with their students came to pay a two-day visit. Then they took the project back and worked in their laboratory. Three months later they came back with blueprints and technical drawings which usually ended up on the shelf.

Great Zurich has stronger legal system to minimize infringing and rogue behaviour in innovation than Sichuan. Taking IPR regime as an example one can see the apparent difference between these two regions.

In Switzerland the first patent law was issued in 1888 and the Federal IPR Association was established in the same year. After a hundred years of development, the importance of IPR has been aware by companies, universities, and individuals. Switzerland is the member of the European IPR system. The Swiss patents and European patents are mutually recognized. The recent amendments to IPR law further enhanced the right of inventors and improved the financial incentives for university researchers. As the VP of technology of HVP said:

Usually at the beginning of the cooperation, we made an agreement on IPR issue. There is actually a regulation on IPR for the cooperation between companies and universities in Zurich. Once we reach the agreement, everybody abides by it. The IPR law here is very strict. You can hardly find loopholes to manipulate. We try our best not to infringe other's IPR by accident. We definitely will not infringe on purpose. There is no space for the pirates in the Swiss society.

In China, the first patent law was issued in 1984. The importance of IPR and the awareness of IPR protection have not yet been widely recognized. The legal system is still in transition. Local protectionism remains serious problem when enforcing the IPR law. To some extent it costs relatively less to break the IPR law than to abide by it. The director of Sichuan Patent Office said:

> Things have been improved a lot since the Patent Law was put into practice in the 1980s. There is still a large space to improve. We are now confronted with two important issues. The first is the weak awareness of IPR among the entrepreneurs, individual customers, even the government officials. The second is the serious problems in terms of enforcement of the IPR law. The Central government has kept emphasizing the importance of IPR law, but when it comes to enforcement, there is still a long way to go.

Great Zurich developed more mutual awareness and common agenda on innovation than Sichuan. Looking into the history of the initiation and implementation of regional innovation strategy, one can tell the difference between these two regions.

Great Zurich started the region's innovation strategy in the 1990s. The then mayor of Zurich said:

> Zurich's innovation strategy started in early 1990s when the economy went down with annual GDP growth rate at 0% which was the weakest among the Western European countries. One of the symbolic events was the closure of a Sulzter factory in Zurich. Sulzter is one of the top three biggest Swiss companies. The picture of the smokeless chimney of Sulzter's factory and the empty workshops on the newspaper was totally astonishing to all the citizens in

Zurich. It was at that moment when people started to realize the importance of innovation to revive the economy and to strengthen the competence of our companies. New strategies, tools, ideas and ventures have been formulated and put into practice with the focus on transferring research into market success. Since then the industry of Zurich has been upgraded from mass manufacturing to knowledge-based high-value-added industries. Now many citizens, including the municipal government, are keenly aware that they will have to continue and boost innovation activities because the innovation capabilities are more critical these days when global competition is much more intensive than in the 1990s.

Sichuan just introduced the concept of innovation very recently. Only from 2006 the word “innovation” began to be frequently used in public media in Sichuan and the rest of China. In that year the central government issued a 15-year-long plan for science and technology development. The president of China Hu Jintao made an important speech calling for building an innovation-oriented country. But till now “innovation” has never become the key word neither in the regional strategic planning nor in the government annual report. Instead, there were “ecology strategy” in 2005, “industrialization strategy” in 2006, “brand strategy” in 2007, and recently the “quality strategy” in 2009. As one of the government official in Sichuan Economic Committee said:

The importance of innovation has been recognized more and more widely in our province. But not many people has deep understanding about it, say nothing about implementing it. It is more a political slogan than an economic and societal practice. We need to do more to educate people to realize that innovation is the only way to make economic

growth sustainable. Strategies and polices should also put innovation in the centre.

In both thick and thin RIE firms' IntraINs are similarly dense

No significant difference is found in the densities of IntraINs within and between the thick RIE of Great Zurich Area and the thin one of Sichuan. The densities of all the six case companies' IntraINs are similar (see Figure 2). This means all the different functional departments or groups closely work together for the innovation activities in each case company.

Proposition 1, RIE has no apparent impact on the case firm's IntraINs, is therefore validated.

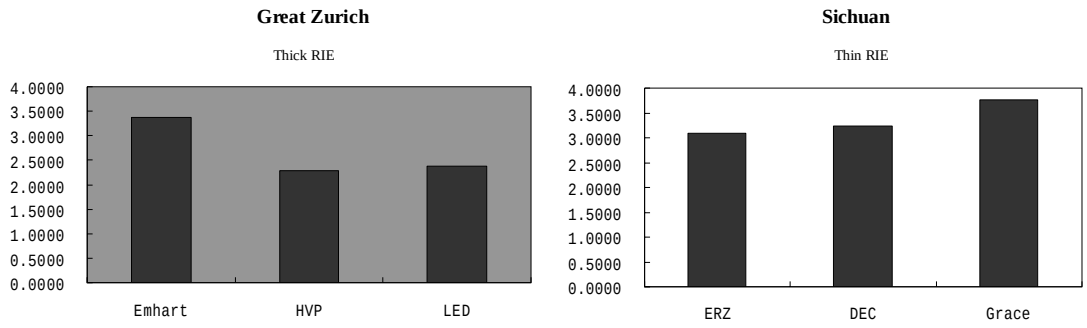

Figure 2. Comparison of IntraINs' density in the thick RIE of Great Zurich and the thin RIE of Sichuan

In the thick RIE the case firm's InterINs are dense

As seen in Figure 3, the densities of case companies' InterIN in the thick RIE of Great Zurich Area are all high. It means in a thick RIE firms and outside organisations closely work with each other for the innovation of the firms in question.

Hence, proposition 2, in the thick RIE the firm's InterINs are dense, is validated.

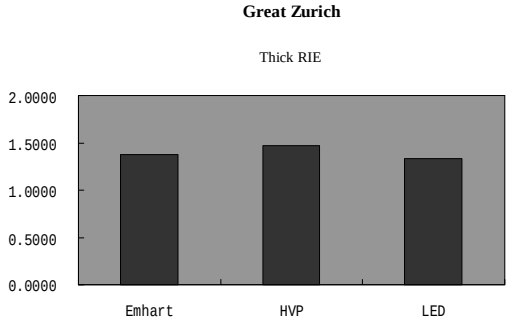

Figure 3. Comparison of InterINs' density in the thick RIE of Great Zurich

However, proposition 3, in the thin RIE the firm's InterINs are sparse, is not validated.

As shown in Figure 4, the density of ERZ's InterIN is high while those of DEC and Grace are both low.

The invalidation of proposition 3 provided a chance to further explore the reason behind the uneven distribution of density among the three case companies' InterINs in the region of Sichuan. Further analysis on the RIE of this underdeveloped region shed light on the causation. The paper comes up with the following findings.

When the thickness of RIE is unevenly distributed to the industries within the region, for the firm in the thick part of the RIE, its InterIN is dense; for those in the thin part of the RIE, their InterINs are sparse.

Analyzing freeman degree of the actors in the InterINs of these three case companies in the region of Sichuan (see Figure 4), I found that in the case of ERZ there are two groups of outside organisations whose Freeman degree are much higher than that of DEC and Grace.

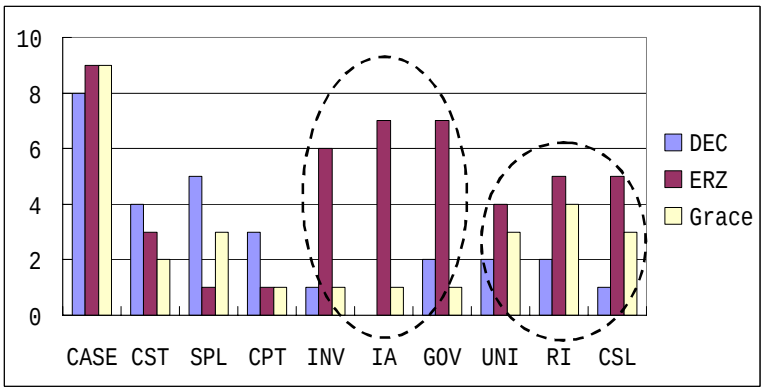

Figure 4. Freeman degree of actors in the InterINs of three case companies in Sichuan[7]

One group of actors is the knowledge-based organisations, namely universities (UNI), research institutes (RI) and consultant companies (CSL). In the case of ERZ, there is a university and several research institutes in the region that have strong R&D competence in machinery and material science for ERZ's innovation. They also have good relationship with ERZ. The strong presence of knowledge-based organisations in the machinery industry in Sichuan is because this region had been the target area of Three-tier-construction (San-xian-jian-she) Project since the 1950s when China moved all the heavy industries to inland provinces to avoid possible attack from the former Soviet Union. Knowledge infrastructure in the industry of ERZ has become strong since then. But in the case of DEC and Grace, they are not as lucky as ERZ as the knowledge infrastructure in their technology field is still weak in Sichuan. In short, the strong organisational presence in the technology field of ERZ increased the thickness of RIE only for ERZ.

The other group of actors is government-based organisations, namely investment

[7] Note: in the graph, CASE means the case company, namely DEC, ERZ, and Grace

institute (INV), industrial association (IA), government agency (GOV). ERZ is a state-owned company which is recognized by the central government as an enterprise with “significant importance to national economy and people’s livelihood”. The investment institute in the case of ERZ is actually the government. The industrial association is also an organisation with strong government background. In this sense, all of them are government agencies in different forms. The similar governmental background of these three organisations naturally provides a structure where sectionalism and rogue behaviour is constrained, mutual awareness and common agenda is encouraged and interaction among each other is guaranteed. But the thickness of RIE increased only in the case of ERZ. It did not happen in the case of DEC and Grace

To summarize, for ERZ, the only company that has high density of InterIN, it is found that the presence of knowledge-based organisations in the specific technology field of ERZ in Sichuan is stronger than that of DEC and Grace. The interaction among several key actors, the structures to minimize sectionalism and rogue behaviour, and the mutual awareness and common agenda are all better developed than the other two cases -- DEC and Grace. In other words, the RIE for ERZ is thicker than that for DEC and Grace. As shown in Figure 5, the left dark part of the background represents the thick part of the RIE for ERZ while the right lighter part represents the thin part of the RIE for DEC and Grace. It is very obvious that for the firm in the thick part of the RIE, its InterIN is dense; for those in the thin part of the RIE, their InterINs are sparse.

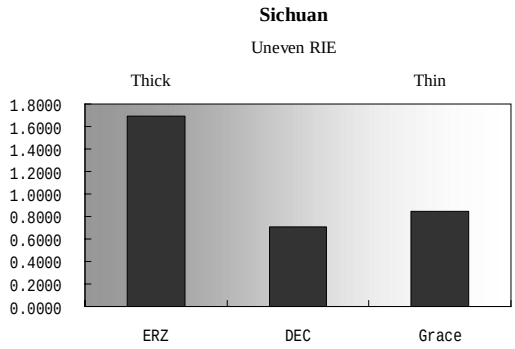

Figure 5. Comparison of InterINs' density in the uneven RIE of Sichuan

The impact of RIE on the InterINs is mainly manifested through its impact on the connection among the outside organisations rather than the direct connection between the focal firm and their outside collaborators

Comparing the focal firm degree of all the six case companies within and between these two regions, no apparent differences are found (see Figure 6). If we dichotomize the weighted InterINs, the density of all the case companies' degree in the InterINs is quite similar. ERZ and Grace have connection with all the 9 outside organisations while Emhart, HVP, LED, and DEC have 8 connections instead.

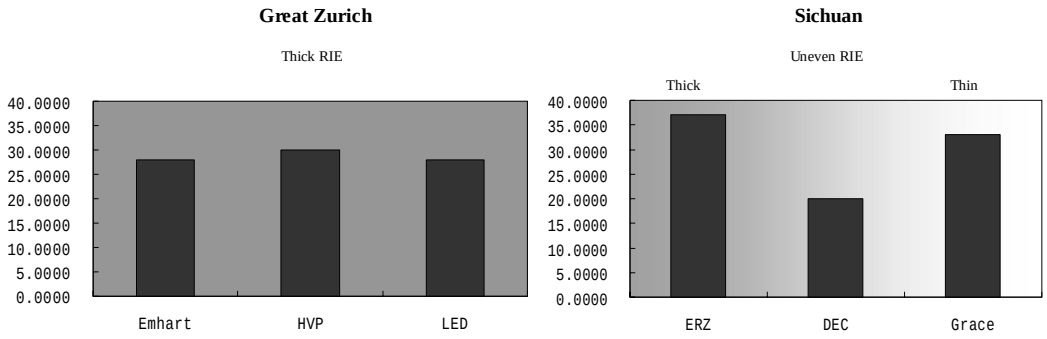

Figure 6. Comparison of focal firm degree in the two regions

Comparing the density of the alter-InterIN (the set of nodes that has ties with the focal firm but not including the focal firm itself) in thick and thin RIE respectively (see Figure 7), I found that there is a similar distributive pattern of density as that of the density of InterINs in thick RIE (see Figure 3) and thin RIE (see Figure 5).

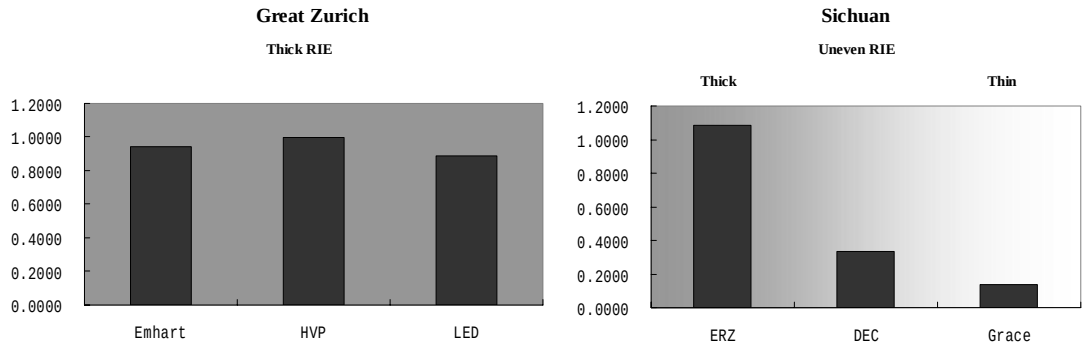

Figure 7. Comparison of alter InterINs' density in the two regions

This finding suggests that RIE influences InterIN's density through the influence on the connection among outside organisations instead of direct connection between focal firm and outside organisations.

DISCUSSIONS AND CONCLUSIONS

This paper is a comparative case study which explores the impact of RIE on the connectedness of firms' IntraINs and InterINs. The selected cases are six large high-and-medium-tech manufacturing companies with strong innovation capabilities in two different regions --- the Great Zurich Area with thick RIE in Switzerland and

the Sichuan province with thin RIE in China.

The evidence uncovered through the case studies shows that RIE has not apparent impact on the IntraINs but on the InterINs. Furthermore, the impact of RIE on the InterINs is mainly manifested through its impact on the connection among the outside organisations rather than the direct connection between the focal firm and their outside collaborators.

The reasons behind these findings lie in the inherent capabilities of the firms and the boundary of utilising such capabilities.

The construction of IntraIN depends on firm's networking capabilities within the organisational boundary. The establishment of direct connections with outside organisations depends on firm's networking capabilities across the organisational boundary. If a firm has strong networking capabilities, its IntraIN and direct connections with outside organisations should be well established. This is actually what happened in the six case companies in both thick and thin RIEs of Great Zurich and Sichuan. All the six case companies are big leading companies with excellent innovation performance. They are all strong in terms of networking capabilities for technological innovation. No matter they are in thick or thin RIE, they all created strong connections among the internal departments within the company, and they all built up collaborative relationships with key outside organisations for their technological innovation. For a big company, building up IntraIN and setting up direct relationships with outside organisations depends more on inherent networking capabilities of the firm than on RIE of the region.

Nevertheless, there is still a boundary of utilising networking capabilities of the firms. A firm is an entity with high extent of autonomy within the organisation as well as some extent of initiative outside of it. It is possible for firms to utilize their networking capabilities to build up internal innovation network and to reach out for setting up relationships with outside organisations. But it is naturally difficult for the firms to help the outside organisations to team up with each other, or in other words, to build up the alter-InterIN by themselves. The establishment of the relationships among the outside organisations for the innovation in the focal firm depends more on how strong that organisational presence (universities, research institutes, banks, IPR services, etc.) is in the region. It also depends on how much these organisations interact with each other, how well the legal structure can minimize sectionalism and rogue behaviour, and how well the mutual awareness and common agenda are developed in the region. Hence, the construction of alter InterINs of large companies depends more on the RIE of the region than the networking capabilities of the firms.

To generalize, for large firms, their networking capabilities are more relevant than RIE to the construction of IntraINs and direct relationships with outside organisations for technological innovation, while RIE is more relevant than firms' networking capabilities to the construction of alter-InterINs. To help big companies to build up technological innovation network, public policy should be designed to improve the RIE by increasing the organisational presence in the education system, labour market, IPR regime, and financial market, enhancing the legal structures to minimize sectionalism and rogue behaviour, and developing mutual awareness and

common agenda for innovation. It would be less efficient and less effective if the government tries to directly bridge big firms with outside organisations. The big firms can do it well by themselves.

The conclusions and implications of this paper are drawn from the cases of big firms in mature industries. Hence they should neither be extended to small-and-middle-sized enterprises (SMEs) nor to emerging industries that have different patterns of innovation networks and dynamics, and consequently need different policy support.

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