Institutions and Economies
Vol. 8, Issue 1, January 2016, pp. 102-129

Regional Institutions and Their Impact on the Connectedness of Firm's Innovation Networks

Ju Liu

Abstract: *This article is an in-depth comparative case study of six leading manufacturing firms in the Great Zurich region of Switzerland and the Sichuan province of China. It employs innovation system approach, institutional thickness framework and social network analysis to investigate the regional institutions of the two regions and their impact on the connectedness of the case firms' internal and external innovation networks. Findings show the impact of regional institutions on the connectedness of the case firms' innovation networks is mainly manifested in the connections among the case firms' outside collaborators rather than the direct relations of and within the case firms. The paper opens the black box of firm's innovation networks and compares different dynamics of firms' internal and external networks. It argues that firms can build up dense direct network relations for innovation by leveraging their endogenous capabilities even in a thin regional institutional environment. As for promoting collaboration among outsiders for the focal firm's innovation, regional institutions play a bigger role than the firm's endogenous capabilities. The paper provides regional policy implications particularly for developing and emerging countries with transitional institutional environment.*

Keywords: Innovation Networks, Regional Institutions, Institutional Thickness, Intra-firm, Inter-organisational, Social Network Analysis
JEL Classification: O31, R11, L23, D22

Article Received: 18 March 2015; Article Accepted: 19 November 2015

1. Introduction

Innovation networks are often embedded in certain context of regional (or national) institution[1] (Thrift & Olds, 1996; Crang, 1997; Lundvall & Christensen, 2004; Asheim and Coenen 2005). Institutions provide a "wider setting" which shapes the interaction among actors in the innovation networks (Lundvall, 2007) and regional institutional support has strong influence on a firm's technological capabilities (Rasiah, Kimura et al. 2014). Despite growing interest and studies in this field, the understanding of regional institutions and their impact on innovation networks remain limited.

Centre for Innovation, Research and Competence in the Learning Economy, Lund University.
Email: ju.liu@circle.lu.se

First, even though regional institutions are a comprehensive combination of many factors, most of the researches highlight only one or two specific aspects of it, such as universities and research institutes (i.e. Motohashi 2005; Mowery & Sampat 2005; Youtie & Shapira 2008; Ponds, Van Oort et al. 2010; Freitas, Geuna et al. 2013), or government (see Mahmood & Rufin 2005; Walker 2006; Beerepoot & Beerepoot 2007; Razak & Saad 2007; Dodgson, Mathews et al. 2008; Etzkowitz 2008; Kang & Park 2012), or labour market (see for example Lam 2007; Alnuaimi, Opsahl et al. 2012; Boudreau 2012), or IPR regime (see for example Bekkers, Duysters et al. 2002; Blind & Thumm 2004; Dolfsma & Leydesdorff 2011), etc.. No doubt that these studies provide rich knowledge and insightful understanding about the role of a single or two aspects of regional institutions in a firm's innovation process. Nevertheless, focusing on one aspect of institutions may lead to the ignorance of the complexity of regional institutions and the neglect of the interplay between different elements. It is particularly not useful for making coherent public policy.

Second, it is known that regional institutions matter to innovation network but it is not clearly known to which part of the networks it matters or matters more - the internal or intra-firm innovation networks (IntraINs), or the external or 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 the organisational level (Liu & Chaminade 2010; Liu, Chaminade et al. 2013). The separation of research on IntraIN and InterIN may lead to insufficient understanding of networking as a process with both internal and external aspects to result in an incomplete understanding of network dynamics.

Employing an in-depth comparative case study method, this paper sets out to address the aforementioned two research gaps by investigating regional institutions as a comprehensive mixture based on the institutional thickness framework, measuring the connectedness of firms' IntraIN and InterIN by social network analysis, and assessing the impact of regional institutions on the different part of firms' innovation network via the innovation system approach. It addresses the following research questions:

1) What is the thickness of the regional institutions of these two case regions (Great Zurich and Sichuan)?
2) How does connectedness differ between case firms' IntraINs/InterINs in these two case regions?
3) How do regional institutions influence the connectedness of case firms' IntraINs and InterINs?
4) What are the policy implications?

The study found the regional institutions of Great Zurich are thick while that of Sichuan are uneven which reflects the transitional characteristics of the regional institutions of an emerging economy. It also found that the connectedness of the IntraINs of case firms in both thick and thin regional institutions is convergent. The same outcome was noticed in the connectedness between the case firms and their outside collaborators. But apparent discrepancy was noted in the connectedness of the relations among the outsiders in the case firms' innovation networks. The findings suggest that regional institutions matter more to the connectedness of the relations among outsiders rather than the direct relations within the focal firm and between the focal firm and outside collaborators. They also suggest that firms can build up dense direct network relations for innovation by leveraging their endogenous capabilities even in thin regional institutions. But for promoting collaboration among outsiders for the focal firm's innovation, regional institutions mater more than firm's endogenous capabilities and this is where public policy can play an influential role.

Despite efforts to collect data, the small number of case firms and regions constrains the extent to which the observed patterns can be generalised to other companies, and thus, this study can be considered explorative.

The contribution of this paper is twofold. First, it provides evidences based on primary data to show the different impact of regional institutions of the case regions on the connectedness of the case firms' innovation networks. Second, it opens the black box of the firm and compares the different dynamics of firms' IntraINs and InterINs. Such findings help illuminate regional policy for promoting innovationparticularly for developing or emerging countries with transitional institutional environment.

The rest of the paper is presented in four sections. The second section is the theoretical background and literature review in which the concept of institutions is discussed and defined. Studies on the impact of regional institutions on the connectedness of firms' innovation networks are investigated and summarised. The third is the analytical framework for analysing and assessing regional institution, as well as for mapping and studying firms' innovation networks. The fourth is research methods including design of case study, selection of case regions and firms, and collection of data. The fifth is case analysis and main findings. The final section summarises, discusses and concludes the paper.

2. Theoretical Background and Literature Review

2.1 The Definition of Institutions and Institutional Thickness

There is no unanimous definition of institutions in innovation studies (Doloreux & Parto 2005). The debate is mainly about the separating or conflating the

'Northian' typology of institution-as-rules-of-the-game and institution-as-players-of-the-game (North 1990). The institution-as-rules-of-the-game strand (Johnson 1992; Edquist 2004; Asheim & Gertler 2005; Lundvall 2010) defines institutions as formal rules (constitutions, laws, regulations and standards among others) and informal norms (such as convention, custom, values and beliefs) that enable and constrain social interactions. The institution-as-players-of-the-game analogy (Cooke 1996; Storper 2002) defines institutions as particular organisational forms (firms, universities, government agencies, unions, etc.) whose constitution and operation are governed by the former elements (Nelson & Rosenberg, 1993). The challenge of such duality of definitions is not identifying which definition is better than the other but choosing the one that is relevant to the research question.

For studying innovation process, Hollingsworth (2000) as well as Gertler and Wolfe (2002) suggest that both rules and organisations should be taken into account in the definition of institutions. The reason is that rules, norms and conventions unfold in tandem with organisational structures (Powell 1991; Hollingsworth 2000). At the same time, a firm's networking behaviour is influenced both by the rules of the normative environment it is embedded in (Owen-Smith & Powell 2008) and the behaviour of the other actors in the network (Gulati & Singh, 1998). Thus, the definition of regional institutions in this paper includes both formal rules and informal norms (such as laws, regulations, standards, conventions, shared values and believes.) as well as organisations (such as universities, research institutes, government agencies, etc.) in the regional milieu.

The suggestion to combine rules and organisations to define institutions was endorsed by Amin and Thrift (1995) who developed 'institutional thickness' concept and emphasised the importance of regional institutional thickness in the formation of inter-organisational network for innovation. The institutional thickness concept not only involves the presence of rules and organisations, but also goes one step further to include the synergies of interaction, collective representation and common purpose.

According to Amin and Thrift, institutional thickness depends on four determinants. Determinant 1: organisational presence which is a plethora of organisations of various kinds including universities, research institutes, government agencies, innovation centres, consultant companies, development agencies, industrial associations and training agencies among others. Determinant 2: interaction among these organisations in the region including contact, exchange information, and cooperation. Determinant 3: the structures of domination and/or patterns of coalition-building in order to minimise sectionalism and rogue behaviour. Determinant 4: mutual awareness and common agenda.

This paper adopts the framework of institutional thickness to investigate the case regions' institutions. This is because of the framework's strong

relevance to innovation and its great potential to explain the regional institutions as comprehensive and complex. There is no doubt that institutional thickness provides relevant insights for innovation research. The four factors aforementioned 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 nourish of trust, stimulates entrepreneurship, and consolidates the local embeddedness of industry (MacLeod, 1997). Nevertheless, this theoretical framework has not been significantly developed despite its great potential as it does not provide any reference to a methodology for an empirical application of the concept to analyse regional economic development (Coulson & Ferrario, 2007). In other words, there is a lack of systematic observable or measurable indicators to demonstrate or to assess the thickness of the institutions. But this shortcoming also provides space for further developing methods and indicators to investigate the institutional thickness of a region. A set of observable or assessable indicators are developed in this paper with the purpose of assessing, if not measuring, the four determinants of the thickness of regional institutions. They will be explained in Section 4 (Methods).

2.2 The Impact of Institutions on The Connectedness of Firms' Innovation Networks

The impact of regional institutions on a firm's innovation networks has been widely discussed in the literature on innovation studies.

The impact of organisational presence (determinant 1) on the connectedness of innovation networks can be explained using a resource-based view (Arora & Gambardella 1994; Gulati & Singh 1998; Miotti & Sachwald 2003; Schilling & Phelps 2007). A firm's network formation is based on the complementarities in heterogeneous resources of different organisations (Wernerfelt, 1984). Such resources include knowledge and skills, human resources, financial resources that are needed but not available within the firm. This is particularly true in technologically intensive industries (Hagedoorn 1993; Becker and Dietz 2004). The organisational presence is the basic requirement of network. Nevertheless, a strong presence of organisation in the region does not necessarily guarantee effective and efficient collaboration among the organisations. It needs other elements to protect and promote the interaction. Such elements include formal and informal governance mechanisms. The formal governance mechanism, such as IPR regime, is a structure to minimise sectionalism and rogue behaviour (determinant 3). The IPR regime provides a structure of domination and patterns of coalition which result in the gain of collective presentation and inhibit rogue behaviour. Stronger IPR regimes are associated with a higher reliance on external actors (Gallini 2002; Laursen and Salter 2006) and a higher connectedness in innovation networks. The

informal governance mechanism, such as trust, reciprocity norms, shared value and common culture, can smooth and enhance interaction among the organisations (determinant 2) (Coleman 1988; Granovetter 1992; Dyer & Singh 1998). Repetitive network interaction nourishes trust and shape shared value and common culture which helps to form mutual awareness and common agenda (determinant 4) (Coleman 1988; Granovetter 1992). It has been found that high networks connectedness is associated with high level of trust, reciprocity norms and common culture (Uzzi 1997; Hagedoorn & Duysters 2002; Gilsing & Nooteboom 2005; Edelenbos & Klijn 2007). Trust and mutual understanding is an important precondition for any collaborative network (Gertler & Wolfe 2004; Gössling 2004).

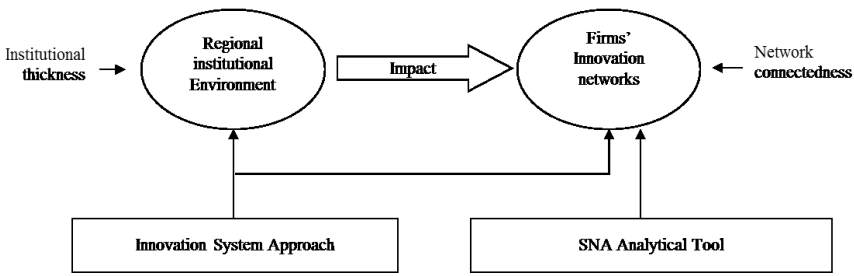
Based on the above literature, one can assume that in a strong region with 1) strong organisational presence, 2) intense interaction among the organisations, 3) effective structure to minimise sectionalism and rogue behaviour, and 4) mutual awareness and common agenda for innovation, firms' innovation networks are highly connected or dense. In a weak region with weak performance on these four determinants, firms' innovation networks are supposed to be less connected or sparse. Nevertheless, thanks to the lack of research investigating all the four aspects of regional institutions as a whole, such assumptions have not been empirically proven. Because of the segmentation of the research on IntraINs and InterINs, it is also not clear which part of the innovation network, the IntraIN or InterIN, the regional institutions matter or matter more.

This paper investigates all the four aspects of the regional institutions of the case regions and their impact on the connectedness of both IntraINs and InterINs of the case firms.

3. Analytical Framework

The analytical framework of this paper is based on the innovation system approach, the framework of institutional thickness, and the analytical tool of social network analysis (see Figure 1).

Figure 1: Analytical Framework



The innovation system approach is the theoretical perspective of the paper. It provides the "tool of inquiry" (Nelson & Winter, 1982) to focus the research on the most important issue of innovation, namely the innovation networks and the regional institutions they are embedded in (Lundvall 2004). The components in regional institutions and the actors of the innovation networks are identified based on the literature of innovation system (Freeman, 1982; Nelson, 1993; Lundvall, 1992).

The institutional thickness framework is used to investigate and assess the case region's multi-dimensional regional institutions. The social network analysis is employed to map the case firms' innovation networks and to measure their connectedness.

3.1 Analysing and Assessing Regional Institution

Based on the framework of institutional thickness (Amin & Thrift 1995), the paper develops a set of observable or assessable indicators to investigate the four determinants of the regional institutional thickness (see Table 1).

Table 1: Indicators of regional institutional thickness

Determinants	Aspects of determinants	Indicators
1. 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
2. Interaction among organisations	Interaction between university and industry	History of cooperation
		Exchange of personnel
		Mutual trust
		University-industry cooperation index
3. Structures to minimize sectionalism and rogue behaviour	IPR regime	Legal system construction
		IPR protection index
	Competition legislation	Anti-monopoly policy effectiveness index
4. Mutual awareness and common agenda	Regional innovation strategy	The initiation and implementation of the regional innovation strategy

Organisational presence (determinant 1) is indicted by density. 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 discussed 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. Production market competition is not included in the indicators of organisational 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 society to accept innovation even though it might entail unemployment (Eliasson, 1997).

The indicators of interaction among these organisations (determinant 2) mainly focus on the interaction between universities and industry. The university-industry relationship is considered to be the key relationship for technological innovation compared with 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 reflects to what extent the R&D collaboration has been established between the business community and local universities.

The indicators of development of structures to minimise sectionalism and rogue behaviour (determinant 3) 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 indicators of development of mutual awareness and common agenda (determinant 4) are the initiation and implementation of the regional innovation strategy. It is supposed that as the common agenda of regional innovation, the longer it took the regional innovation strategy had been formulated and implemented, the better mutual awareness the region should have developed

3.2 Mapping and Studying Innovation Networks

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

Actors of an IntraIN were identified as different functional departments or groups who serve as a function of marketing, financial, R&D and human resources (HR) within the firm. This taxonomy follows the value chain analysis by Porter (1985). In an InterIN, the actors include the case firm and other organisations outside the case firm such as universities, research institutes, investment organisation, customers, suppliers, competitors, government agencies and so on. This category follows the taxonomy of OECD (1999) and Lundvall (2007) (see Table 2).

Table 2: Name and abbreviation of actors in IntraINs and InterINs

IntraIN's Actors		**InterIN's Actors (excluding the focal firm)**	
R&D	R&D Department	CST	Customers
PRD	Production Department	SPL	Suppliers
HR	Human Resource Department	CPT	Competitors
MKT	Marketing Department	INV	Investment institution
FIN	Financial Department	IA	Industrial Associations
LOG	Logistic Department	GOV	Government
IM	Innovation Management Department/Group[1]	UNI	Universities
		RI	Research Institutes
		CSL	Consulting Companies

The ties of the innovation networks are identified based on Oslo Manual, the 3rd edition (OECD, 2005). They include both formal and informal relationships for innovation.

The relational data of the ties was collected through a roster recall method (Wasserman & Faust, 1994). Each case firm 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 so, how is the strength of these connections in terms of the intensity of contact, the frequency and the trust? 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 at network level and Freeman degree at actor level.

Network density is a measure of the connectedness of the network as a whole. Freeman degree is a measure of the connectedness of a specific actor in a local environment. The density of the Case firms' IntraINs and InterINs, as well as the Freeman degree of the case firms are calculated and compared within and between the two case regions to see if there are any differences within each region and between two regions whose regional institutional thickness are different.

4. **Methods**

4.1 Design of Case Study

This paper employed comparative case study method with multi-case embedded design. Comparative case study with multiple cases is likely to yield more convincing, robust and tenable findings. Multiple cases are like a series of related laboratory experiments which serve as replications, contrasts and extensions to the emerging theory (Yin, 2003). The embedded design of the case study increases the complexity and accuracy of data (both qualitative and quantitative) thereby improving the robustness of the results (Jick 1979; Anand et al., 2007). It also helps to establish corroboration of critical information and avoid potential problems of data bias. This paper used multiple units/levels of analysis.

4.2 Selection of Regions

Polar sampling approach was used to select the case regions in order to see how regional institutions influence the connectedness of IntraINs and InterINs. Polar sampling can make the constructs and theoretical relationships "transparently observable" (Pettigrew, 1990). The two regions selected in this paper are the Sichuan province in Southwest China and the Great Zurich that includes Glarus, Grisons, Schaffhausen, Schwyz, Solothurn, Zug and Zurich in Switzerland. The selection of these two regions is deliberate, as it is expected that the regional institutions of Great Zurich are thick while that of Sichuan province are thin. Such expectation is built on the significant economic and

social differences between these two regions: Great Zurich is the economic centre and home to a large number of multinational companies in one of the most developed countries while Sichuan is one of the least developed regions in a developing country at the time when the research was conducted.

4.3 Selection of Firms

Based on the principle of comparability when selecting case firms, the study controlled four criteria which have fundamental influence on firm's innovation process according to literature: 1) firm size; 2) firm's innovation capabilities; 3) market structure in which the firm operates; and 4) technological regime in which the firm is involved.

Only large companies (with number of employees > 1000) were selected as firm size matters when it comes to innovation (Acs & Audretsch, 1987; Cohen & Klepper, 1996; Rogers, 2004). Large and small firms have different innovation behaviour. The study chose large firms because their innovation networks are usually broader than small companies (Goerzen 2005; Huggins & Johnston, 2010). It is also easier to observe their innovation networking behaviour and to collect data.

Only firms with strong innovation capabilities were selected because the paper aims to identify the field which is beyond the firms' endogenous capabilities and thus may be the place where the regional institutions can play a role. 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 as the indicator of innovation capabilities of the case companies.

Only firms operating in oligopoly market were selected (HHI > 0.10). It is argued that competition shapes the innovation network and vice versa (Powell et al. 1996; Gruber, 2001). This paper adopted Herfindahl-Hirschman-Index[2] to measure the market structure (Kamien & Schwartz, 1982) which refers to the state and characteristics of a market with respect to the degree or intensity of competition among buyers and among producers.

Only high-and-medium-tech companies (R&D intensity between 4% and 9%), whose main technologies change at a medium speed (R&D cycle between 18-48 months) were selected. Technological regime (Dosi, 1982; Nelson & Winter, 1982; Malerba & Orsenigo, 1996) is characterised by the complexity of knowledge base as well as the opportunity, appropriability, and cumulativeness. It is argued that the specific features of technological regimes affect the specific patterns of innovation process as well as the structure of innovation networks (Malerba & Orsenigo, 1996). This paper uses R&D intensity and R&D cycle[3] to indicate the technological regime the case firms are involved with.

Based on the selection criteria above, the author selected three firms in the Great Zurich region, that is HVP (a high-voltage electric power equipment manufacturer), LED (a low-voltage electric power equipment

manufacturer) and Emhart (a container forming machine manufacturer); three firms were selected in Sichuan province, that is Grace (a chemical and fibber manufacturer), DEC (an electric power equipment manufacturer) and ERZ (a heavy machine manufacturer). They are all large, innovative, high-and-medium-tech manufacturing companies operating in an oligopoly market. The overview of the firms is shown in Table 3.

Table 3: Overview of the selected 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%	0.11	36-60	6% - 8%
	LED	36000	40%	30%	25%	30%	30%	10%	10%	0.20	24-36	6% - 8%
	Emhart	1064	30%	30%	90%	45%	9%	7%	6%	0.22	18-24	7% - 8%
Sichuan	Grace	12000	48%	46%	51%	29%	28%	13%	11%	0.19	12-24	6% - 9%
	DEC	9000	60%	50%	55%	30%	30%	25%	5%	0.25	20-36	4% - 5.5%
	ERZ	12650	72%	69%	67%	45%	25%	n/a	n/a	0.27	12-24	6% - 9%

4.4 Collection of Data

Data sources of this paper includes interviews, questionnaires, follow-up emails and phone conversations, archives, websites, internal reports, internal documents and press news. In total, 63 interviews were conducted with top level senior managers, middle level managers, city mayors, head of innovation funding agencies, chairman of the board of science park, university researchers and inventors as well as engineers and managers in other companies. Each interview lasted between one and three hours. All the interviews in Switzerland were recorded but some interviews in China were not because the interviewees were reluctant to be recorded. The interviews in Sichuan China were conducted between 2007 and 2009 while the interviews in Switzerland were mainly conducted in 2008 with follow-ups in 2010.

Potential informant bias is addressed in three ways. First, highly knowledgeable informants were selected from both different hierarchical levels of the firms and different organisations outside of the firms. Second, "courtroom questioning" technique was used to focus on factual accounts (Lipton, 1977; Huber & Power, 1985). The informants was asked 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. Third, anonymity was given to the informants and their firms on request to encourage candour.

5. Analysis and Main Findings

5.1 Assessing the Regional Institutions of Great Zurich and Sichuan[4]

The assessment of the regional institutions of Great Zurich and Sichuan is shown in Table 4 and the findings will be presented and discussed in this section.

Table 4 : Overview of regional institutions in Sichuan and Great Zurich

Determinants	Indicators	Sichuan	Great Zurich[2]
Organisational presence	Number of researchers at tertiary level per million population	430	1972
	Number of students at tertiar level per million population	10,556	29,718
	Number of engineers and scientists per million population	1,583	13,180
	Number of employees of banks and investment institutes per million population	2000	15,000
	Number of patent attorney per million population	4.6	31.5
Interaction among organizations	Interaction between universit and industry	• Short history of cooperation • Few personnel exchange • Lack of mutual trust	• Long history of cooperation • Frequent personnel exchange
	University-industry cooperation index[1]	5.6	4.5
Structures to minimize sectionalism and rogue behaviour	IPR Legal system construction	• Patent law issued in 1984 • Legal system in shaping	• Patent law issued in 1888 • Legal system compatible with European IPR system
	IPR law enforcement (IPR protection index[2])	6.3	3.9
	Competition legislation (Anti-monopoly policy effectiveness index [3])	5.3	4.0

Table 4 : (Continued)

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

Sources: 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 .

Note:

[1] 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)

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

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

5.1.1 The Regional Institutions of Great Zurich are Thick

Great Zurich has strong organisational presence in the region. This can be seen from the statistics in four aspects, namely higher education system, labour market, financial market and IPR regime as shown in Table 4.

Great Zurich also has intensive interaction between different organisations in the region, particularly between the universities and industries. For example, in Great Zurich, the applied science universities are specifically established and successfully enhanced the collaboration between university and industry. The R&D in applied universities is all related to the demands in market instead of pure basic research. 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. In reference to 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 be partially attributed 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 cooperation on the basis of mutual trust'.*

Great Zurich has strong legal system to minimise infringement and rogue behaviour for innovation. Taking IPR regime as an example, in Switzerland the first patent law was issued in 1888 and the Federal IPR Association was established in the same year. After more than a hundred years of development, the importance of IPR has been highly recognised by the whole society.

Switzerland is the member of the European IPR system. The Swiss patents and European patents are mutually recognised. The recent amendments to IPR law further enhanced the right of inventors and improved the financial incentives for university researchers. IPR negotiation is a common practice when collaborating for innovation.

Great Zurich has a long history of developing mutual awareness and common agenda of innovation. Great Zurich started the region's innovation strategy in early 1990s when the economy slowed down with annual GDP growth rate dropping to 0% which was the weakest among the Western European countries at. The then Mayor of Zurich Thomas Wagner observed:

> '*Since then new strategies, tools, ideas and ventures have been formulated and put into practice with the focus on transferring research into market success. Now many citizens, including the municipal government, are aware of the necessity of continuing and boosting innovation because the innovation capabilities are more critical nowadays when global competition is much more intensive than in the 1990s'.*

Based on the high performance in all the four determinant of regional institutions, the paper argues that Great Zurich has a thick regional institution, or in other words, Great Zurich is a 'thick region' in terms of its regional institutions.

5.1.2 The Regional Institutions of Sichuan are Uneven

In general, Sichuan has a weak organisational presence in the region. This can be seen from the statistics in higher education system, labour market, financial market, and IPR regime as shown in Table 4.

Sichuan also has insufficient interaction between different organisations in the region, in particular, the interaction between universities and industries. Here, universities have been historically considered as ivory towers which are to some extent isolated from the industry. Four of the key universities in Sichuan province have targeted to building up research-oriented universities while none has been interested in becoming an innovative or entrepreneurial university. The evaluation criteria for professors are mainly based the number of publications and patents. Not many researchers and professors in the universities are really keen on developing products for the market. 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 solutions which usually ended up on the shelf*.'

Personnel exchange, especially those from industry to universities, is very rare. Engineers or managers can only be invited for seminar or as guest lecturers. It is almost impossible for them to have formal position in universities thanks to the bureaucratic regulations.

Sichuan has a weak legal system to minimise infringing and rogue behaviour for innovation. In China, the first patent law was issued in 1984 which is 96 years later than in Switzerland. The importance of IPR has not yet been widely recognised. Local protectionism remains a serious problem when enforcing the IPR law. To an extent, it costs relatively less to break the IPR law than to abide by it.

Sichuan has a very short history of developing mutual awareness and common agenda on innovation. The region did not pay attention to the concept of innovation until 2006 when the central government highlighted it during and after the National Science and Technology Convention. In the same year, the Chinese central government issued a 15-year plan for science and technological development. The Chinese President Hu Jintao made an important speech calling for building an innovation-oriented nation. But until the time of the present study, innovation had never been the key word in any government document, such as the provincial annual report and the regional strategic plan. Instead, there were "ecology strategy" in 2005, "industrialisation strategy" in 2006, "brand strategy" in 2007, and the "quality strategy" in 2009, and "strategic emerging industry strategy" in 2010.

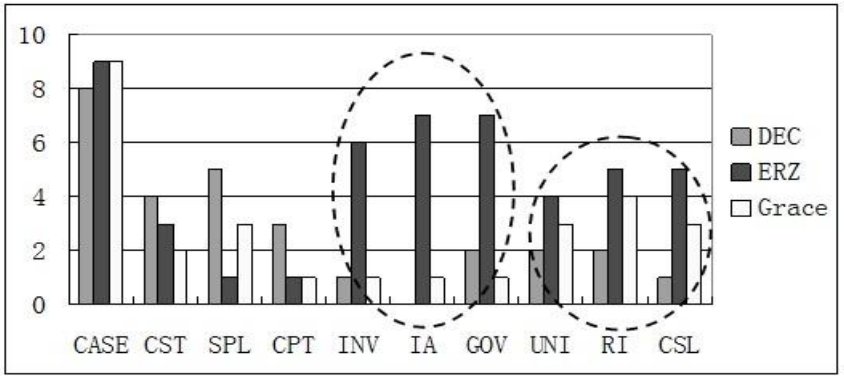
Although in general, the regional institutions of Sichuan are thin, it is found that there are still industrial differences. The heavy machine industry in which ERZ operates enjoys particularly stronger regional institutions compared with the rest.

Analysing Freeman degree of the actors in the InterINs of the three case firms in the region of Sichuan (see Figure 2), it is found that in the case of ERZ there are two groups of outside organisations whose Freeman degree are significantly higher than that of DEC and Grace.

One group of actors is the knowledge infrastructure, namely universities (UNI), research institutes (RI) and consultant companies (CSL). It was found that in the case of ERZ, a university and several research institutes recently started to collaborate with ERZ based on their strong R&D competence in heavy machine and material science. The strong presence of knowledge infrastructure in the heavy machine industry in Sichuan is because this region had been the target area of the Three-tier-construction Project since the 1950s when China moved the whole heavy machine industries together with several

science and technology universities to inland provinces to avoid possible attack from the former Soviet Union. Knowledge infrastructure in the heavy machine industry of ERZ has become strong since then. But active collaboration with firms on innovation is a recent phenomenon after the transition in Sichuan's science and technology system in the 1990s[5]. Hence, the strong organisational presence in the technology field of ERZ increased the thickness of regional institutions for ERZ. But this did not happen in the case of DEC and Grace. There has not been enough knowledge infrastructure in the sub-industries they operate in. Such a situation is in line with the concept of 'organisational thinness' (Tödtling and Trippl 2005) which refers to a lack of critical mass of organisations, particularly firms and knowledge providers, in the region.

Figure 2: Freeman degree of actors in the InterINs of three case firms in Sichuan



The other group of actors is government-based organisations, namely investment institutes (INV), industrial associations (IA), government agencies (GOV). The ERZ is a state-owned company whose investor is actually the government. The industrial association is also an organisation with strong government background. In other words, all of them are government agencies in different forms. The similar governmental background of these three organisations naturally provide a structure where sectionalism and rogue behaviour are constrained, mutual awareness and common agenda is encouraged and interaction among each other is facilitated. Under this condition, the regional institutions are thicker for ERZ than for DEC and Grace.

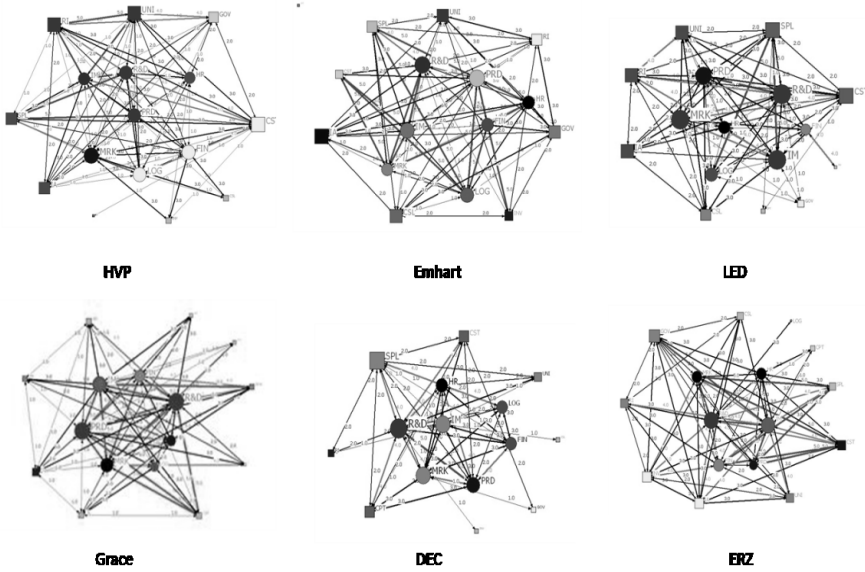
Thus, the paper argues that Sichuan is an 'uneven region' with both thick and thin institutions co-existing.

5.2 Mapping the Innovation Networks of the Case Firms

To visualise the innovation networks of the case firms, the social network analysis software NetDraw was employed. The socialgrams of all the cases are presented in Figure 3. The circle nodes represent IntraIN actors which are the different functional department and groups of the focal firm. The

square nodes refer to InterIN actors which are the outside organisations, such as universities, research institutes, investment organisation, customers, suppliers, competitors, government agencies and so on. The size of the node reflects the number of connections of the actors. The bigger the node is the more direct connections the actor has. One can clearly see that the case firms in Great Zurich have more connections compared with those in Sichuan. Particularly, the square shaped InterIN actors or the external actors of the Great Zurich case firms' innovation networks have more connections than that of the Sichuan case firms'. Whether and how such comparison reflects the impact of different regional institutions will be analysed next.

Figure 3: Visualisation of case firms' innovation networks



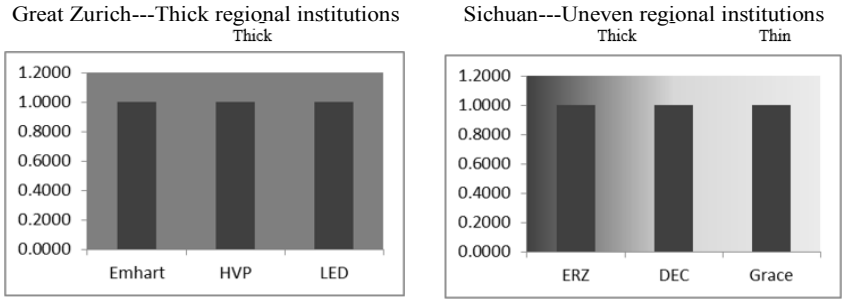
(Circle node=IntraIN actor, Square node=InterIN actor, size of node=number of connections)

5.3 Analysing the Connectedness of Case Firms' Intrains and Interins and the Impact of Regional Institutions on Them

5.3.1 In Both Thick and Uneven Regional Institutions of Great Zurich and Sichuan, Firms' Intrains are Similarly Dense

No significant difference is found in the densities of IntraINs within and between the thick regional institutions of Great Zurich and the uneven one of Sichuan. The IntraINs of all these six case firms are 100% connected networks. The densities of all the six case firms' IntraINs are similarly high (see Figure 4). This means all the different functional departments or groups closely work together for the innovation activities in all the case firms in both thick and thin regional institutions.

Figure 4: Comparison of IntraINs' density of case firms' innovation networks in the two regions

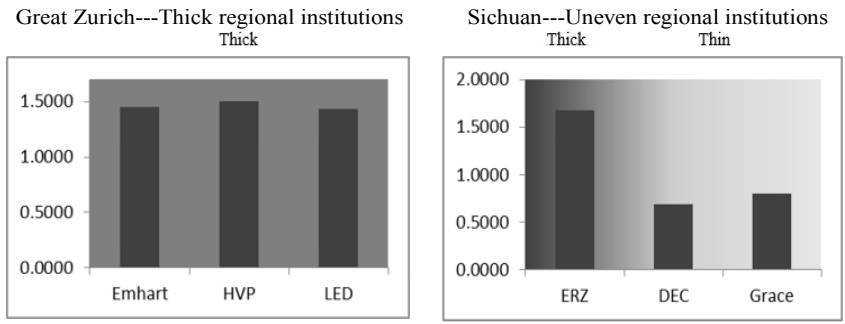


5.3.2 In The Thick Regional Institutions of Great Zurich the Case Firm's Interins are Dense. while in the Uneven Regional Institutions of Sichuan, for the Firm in the Thick Part of The Regional Institution, Its Interin is Dense; for Those in the Thin Part of The Regional Institution, Their Interins are Sparse

As seen in Figure 5, the densities of case firms' InterINs in the thick regional institutions of Great Zurich are all high. It shows that in thick regional institution,s firms and outside organisations closely work with each other for the innovation of the firms in question.

As shown in Figure 5, it is obvious that for the firm in the thick part of the regional institution, its InterIN is dense; for those in the thin part of the regional institution, their InterINs are sparse.

Figure 5: Comparison of InterINs' density of case firms' innovation networks in the two regions

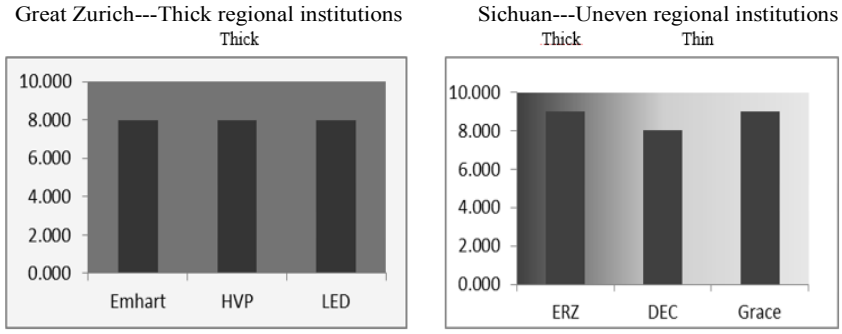


5.3.3 In Both Thick and Uneven Regional Institutions, Case Firms Have Similarly Dense Connections with Outsiders

Comparing the focal firm's degree of all the six case firms within and between these two regions, no apparent differences are found (see Figure 6). If dichotomising the weighted InterINs, the density of all the case firms' degree in the InterINs is quite similar. The ERZ and Grace have connection with all

the nine outside organisations while Emhart, HVP, LED, and DEC have eight connections out of nine. All the firms have similarly dense connection with outsiders in the innovation network.

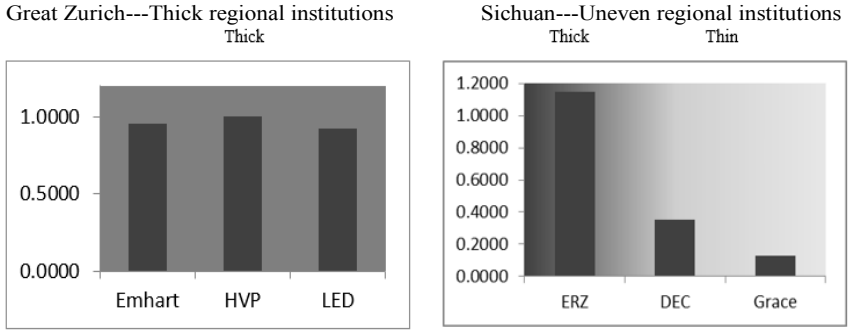
Figure 6: Comparison of the focal firms' Freeman degree in their innovation networks in the two regions



5.3.4 *The Case Firms in the Thick Regional Institutions of Great Zurich and the Thick Part of The Uneven Regional Institutions of Sichuan Have More Connections Among the Outsiders Than That in the Thin Part of the Uneven Regional Institutions of Sichuan*

Comparing the density of the alter-InterIN (the connection among outsiders) in thick and uneven regional institutions respectively (see Figure 7), it is found that in the thick regional institutions of Great Zurich and the thick part of Sichuan, the connections among outsiders are much higher than those in the thin regional institutions. Such density variation pattern reflects the InterINs' density variation pattern in the thick and uneven regional institutions (see Figure 5).

Figure 7: Comparison of alter InterINs' density of case firms' innovation networks in the two regions



These findings suggest that the impact of regional institutions on the case firms' innovation networks is mainly manifested through their impact on the connection among the outside organisations rather than direct connection between the focal firm and their outside collaborators or the internal connections among different departments and groups within the firms.

6. Discussions and Conclusions

This paper is an explorative and comparative case study which investigates the impact of regional institutions on the connectedness of case firms' internal innovation networks (IntraINs) and external innovation networks (InterINs). The paper selected six large high-and-medium-tech manufacturing firms with strong innovation capabilities in two different case regions - the Great Zurich region with thick institutions in Switzerland and the Sichuan province with uneven institutions in China.

The evidence uncovered through this comparative case study shows that the impact of regional institutions on the case firms' IntraINs and InterINs are different. The connectedness of the IntraINs of all case firms in both thick and thin regional institutions is similarly high. The same high connectedness is also found in the direct relations between the focal case firms and their outside collaborators. This suggests that the differences in regional institutions do not apparently lead to difference in the connectedness of the focal firms' internal relations and the direct relations with external actors in their innovation networks. Nevertheless, apparent difference is found in the connectedness of the relations among the outsiders in the case firms' innovation networks. Outsiders in an institutionally thick region have much higher connectedness than those in a thin region. These findings suggest that regional institutions matter more to the connectedness of the relations among outsiders rather than the direct relations of the firms in our cases.

The findings can be explained by firm's endogenous capabilities and the boundary of utilising such capabilities. It is a question of to what extent can firm's capabilities can compensate for the insufficiency of regional institutions. All the six case firms are big leading firms with excellent innovation performance and strong capabilities for technological innovation. No matter they are in thick or thin regional institution, they all have successfully attracted talents for innovation, created innovation-friendly culture, and built up dense connections among the internal departments and groups as well as the external actors such as customers and suppliers for innovation. For example, in the case firms in the thin regional institutions of Sichuan province, some of the key R&D staff was recruited from other regions, some of the innovation methods and tools are imported from firms and organisations in other provinces in the country, even from abroad. The availability of talents and methods and tools in other regions mitigate the insufficiency of the local supply in thin regional institutions for IntraIN building. Hence, in a thin regional institution, firms with strong innovation capabilities still can build up dense direct network relations for innovation by leveraging their endogenous capabilities.

Nevertheless, to what extent the firms' endogenous capabilities can compensate for the insufficiency of regional institutional thickness is not infinite. 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-InterINs in which the focal firms are not directly involved. The establishment of the relations among the outside organisations for the innovation of the focal firm depends more on how strong that organisational presence (universities, research institutes, banks, IPR services among others) is in the region. It depends more on how much these organisations interact with each other, how well the legal structure can minimise sectionalism and rogue behaviour, and how well the mutual awareness and common agenda are developed in the region. In short, the construction of case firms' alter-InterINs depends more on the thickness of the regional institutions than the endogenous capabilities of the firms.

Based on the findings, the paper suggests a system approach for indicating where policy should play a role particularly in the developing or emerging countries where regional institutions are not fully developed but in a transition phase. The central idea of innovation system approach is that interaction matters to innovation. The paper further suggests that policy do not need to promote direct interaction that firms can perform in the market by themselves but should focus on indirect relations beyond the firms' endogenous capability particularly those involving knowledge infrastructures. Since developing and emerging countries may not have abundant resources to develop a strong and diverse knowledge infrastructure. It would be more practical to identify the regional system specificities of their regions in terms of industrial structures and technological bases and work on, first, enhancing organisational presence; second, provide effective and efficient rules and regulations to facilitate coordination between different actors and; actions and last but not least, to develop a regional strategy to promote mutual awareness and common agenda for innovation.

Acknowledgement

The work for this paper was supported in part by the National Natural Science Foundation of China (Grant number 71202073 and 71302083).

Notes

1. Institution, as defined in this paper, includes both formal/informal rules/ norms (such as laws, regulations, standards, conventions, shared values, believes, etc.) and organisations (such as universities, research institutes, intermediates, government agencies, etc.).
2. 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. HHI equals to the sum of S_i^2, S is the market share of firm i competing in the market. In this research only the top four companies with biggest market share is considered.

3. The R&D intensity specifies to what extent the technology of the firms is knowledge-based. The R&D intensity is measured by the ratio of expenditures by a firm on R&D to the firm's sales. The R&D cycle reflects the changing speed of technology which indicates the opportunity, appropriability, and cumulativeness of the technology in which the firms are involved with. It is measured by the average time period for developing a significant new product in the industry.
4. The research was conducted between 2007 and2010. The assessment of the regional institutions is based on the data and situation of that period of time. It does not include the institutional change after 2010.
5. In the 1990s, the science and technological system in Sichuan and other provinces of China experienced a transition from fully state-financed system to partially self-financed system. Research institutes were forced to partially finance themselves by providing service to industry, transfer technology to market, etc. University researchers were also allowed to do R&D with industry and start up their own enterprise which was forbidden before.

References

Acs, Z.J., & Audretsch, D.B. (1987). Innovation, Market Structure, and Firm Size. *The Review of Economics and Statistics, 69*(4), 567-574.

Alnuaimi, T., Opsahl, T., & George, G. (2012). Innovating in the periphery: The impact of local and foreign inventor mobility on the value of Indian patents. *Research Policy, 41*(9), 1534-1543.

Amin, A., & Thrift, N.J. (1995). Globalisation, institutional thickness and the local economy. In Healey, P., Cameron, S., Davoudi, S., Graham, S., & Madinpour, A. (eds.), *Managing cities: The new urban context*. Chichester: Wiley.

Anand, N., Gardner, H. K., & Morris, T. (2007). Knowledge-based Innovation: Emergence and Embedding of New Practice Areas in Management Consulting Firms. *Academy of Management Journal, 50*, 406-428.

Arora, A., & Gambardella, A. (1994). Evaluating Technological Information and Utilizing It - Scientific Knowledge, Technological Capability, and External Linkages in Biotechnology. *Journal of Economic Behavior & Organization, 24*(1), 91-114.

Asheim, B., & Coenen, L. (2005). Knowledge Bases and Regional Innovation Systems: Comparing Nordic Cluster. *Research Policy, 34,* 1173-1190.

Asheim, B., & Gertler, M. S. (2005). The Geography of Innovation: Regional Innovation System. In Fagerberg, J., Mowery, D.S., & Nelson, R.R.

(eds.), *The Oxford Handbook of Innovation.* Oxford New York: Oxford University Press.

Becker, W., & Dietz, J. (2004). R&D cooperation and innovation activities of firms-evidence for the German manufacturing industry. *Research Policy, 33*(2), 209-223.

Beerepoot, M., & Beerepoot, N. (2007). Government regulation as an impetus for innovation: Evidence from energy performance regulation in the Dutch residential building sector. *Energy Policy, 35*(10), 4812-4825.

Bekkers, R., Duysters, G., & Verspagen, B. (2002). Intellectual property rights, strategic technology agreements and market structure - The case of GSM. *Research Policy, 31*(7), 1141-1161.

Blind, K., & Thumm, N. (2004). Interrelation between patenting and standardisation strategies: Empirical evidence and policy implications. *Research Policy, 33*(10), 1583-1598.

Boudreau, K. J. (2012). Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organization Science, 23*(5), 1409-1427.

Cohen, W. M. & Klepper, S. (1996). Firm size and the nature of innovation within industries: the case of process and product R&D. *The Review of Economics and Statistics*, *78*(2), 232-243.

Coleman, J. S. (1988). Social capital in the creation of human-capital. *American Journal of Sociology, 94,* S95-S120.

Cooke, P. (1996). The new wave of regional innovation networks: Analysis, characteristics and strategy. *Small Business Economics*, *8*(2), 159-171.

Coulson, A., & Ferrario, C. (2007). Institutional thickness: Local governance and economic development in Birmingham, England. *International Journal of Urban and Regional Research*, *31,* 591-615.

Crang, P. (1997). Cultural turns and the (re) constitution of economic geography. In Lee, R. and Wills, J. (eds.), *Geographies of Economies*. London: Arnold.

Dodgson, M., Mathews, J., Kastelle, T., & Hu, M. C. (2008). The evolving nature of Taiwan's national innovation system: The case of biotechnology innovation networks. *Research Policy, 37*(3), 430-445.

Dolfsma, W., & Leydesdorff, L. (2011). Innovation systems as patent networks: The Netherlands, India and nanotech. *Innovation-Management Policy & Practice, 13*(3), 311-326.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinant and direction of technological change. *Research Policy*, *11*(3), 147-162.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review, 23*(4), 660-679.

Edelenbos, J. & Klijn, E. H. (2007). Trust in complex decision-making

networks a theoretical and empirical exploration. *Administration & Society, 39*(1), 25-50.

Edquist, C. (2004). System of innovation: Perspectives and challenges. In J. Fagerberg, D. C. Mowery, & R. R. Nelson, (eds.), *The Oxford handbook of innovation*. New York: Oxford University Press.

Eliasson, G. (1997). Competence Blocs and Industrial Policy in the Knowledge Based Economy. *STI review*, *22*, 209-42.

Etzkowitz, H. (2008). *The triple helix: University-industry-government innovation in action*. Routledge.

Freeman, C. (1982). Technological Infrastructure and International Competitiveness. *Industrial and Corporate Change, 13* (3), 541-569.

Freitas, I. M. B., Geuna, A., & Rossi, F. (2013). Finding the right partners: Institutional and personal modes of governance of university–industry interactions. *Research Policy, 42*(1), 50-62.

Gallini, N. T. (2002). The economics of patents: Lessons from recent US patent reform. *Journal of Economic Perspectives, 16*(2), 131-154.

Gertler, M. S., & Wolfe, D. A. (2002). Innovation and social learning: An introduction. In Gertler, M.S., & Wolfe, D.A. (eds.) *Innovation and Social Learning: Institutional Adaption in an Era of Technological Change*. New York: Palgrave Macmillan.

Gertler, M. S. & Wolfe, D. A. (2004). Local social knowledge management: Community actors, institutions and multilevel governance in regional foresight exercises. *Futures, 36*(1), 45-65.

Gilsing, V., & Nooteboom, B. (2005). Density and strength of ties in innovation networks: an analysis of multimedia and biotechnology. *European Management Review, 2*(3), 179-197.

Gulati, R., & Singh, H. (1998). The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly, 43*(4), 781-814.

Gössling, T. (2004). Proximity, trust and morality in networks. *European Planning Studies, 12*(5), 675-689.

Granovetter, M. (1985). Economic action and social structures: The problem of embeddedness. *American Journal of Sociology, 91*, 481-510.

Granovetter, M. (1992). Economic Institutions as social constructions - A framework for analysis. *Acta Sociologica, 35*(1), 3-11.

Gruber, H. (2001). Competition and innovation: The diffusion of mobile telecommunications in Central and Eastern Europe. *Information Economics and Policy, 13*(1), 19-34.

Hagedoorn, J. (1993). Understanding the rationale of strategic technology partnering - Interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal, 14*(5), 371-385.

Hagedoorn, J., & Duysters, G. (2002). Learning in dynamic inter-firm networks: The efficacy of multiple contacts. *Organization Studies, 23*(4),

525-548.

Hollingsworth, J. R. (2000). Doing institutional analysis: implications for the study of innovations. *Review of International Political Economy, 7*(4), 595-644.

Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly, 24*, 602–611.

Johnson, B. (1992). Institutional learning. In B. A. Lundvall, *National systems of innovation: Towards a theory of innovation and interactive learning* (pp. 23-44). London: Pinter.

Kamien, M.I., & Schwartz, N. L. (1982). *Market structure and innovation*. Cambridge: Cambridge University Press.

Lam, A. (2007). Knowledge networks and careers: Academic scientists in industry-university links. *Journal of Management Studies, 44*(6), 993-1016.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131-150.

Lipton, J.P. (1977). On the psychology of eyewitness testimony. *Journal of Applied Psychology, 62,* 90-95.

Liu, J., & Chaminade, C. (2010). Dynamics of a technological innovator network and its impact on technological performance. *Innovation, 12*(1), 53-74.

Liu, J., Chaminade, C., & Asheim, B. (2013). The geography and structure of global innovation networks: a knowledge base perspective. *European Planning Studies, 21*(9), 1456-1473.

Lundvall B. A. (ed.) (1992). *National systems of innovation: towards a theory of innovation and interactive learning.* London: Pinter.

Lundvall B. A., & Christensen J. L. (2004). Introduction: Product innovation on why and how it matters for firms and the economy. In J. L. Christensen, & B. A. Lundvall, (eds.), Product innovation, interactive learning and economic performance. Amsterdam: Elsevier.

Lundvall, B. A. (2004). Introduction to Technological infrastructure and international competitiveness by Christopher Freeman. *Industrial and Corporate Change, 13*(3), 531-539.

Lundvall, B. A. (2007). National innovation systems - Analytical concept and development tool. *Industry and Innovation, 14* (1), 95-119.

Lundvall, B. A. (2010). Introduction. In B. A. Lundvall, (ed.) *National system of innovation: towards a theory of innovation and interactive learning*. London, New York: The Anthem Press.

MacLeod, G. (1997). 'Institutional Thickness' and industrial governance in lowland Scotland. *Area, 29*(4), 299–311.

Mahmood, I. P., & Rufin, C. (2005). Government's dilemma: The role of government in imitation and innovation. *Academy of Management*

Review, 30(2), 338-360.
Malerba, F., & Orsenigo, L. (1996). Schumpeterian patterns of innovation are technology-specific. *Research Policy, 25*(3), 451-478.
Miotti, L., & Sachwald, F. (2003). Co-operative R&D: why and with whom? An integrated framework of analysis. *Research Policy, 32*(8), 1481-1499.
Motohashi, K. (2005). University–industry collaborations in Japan: The role of new technology-based firms in transforming the National Innovation System. *Research Policy, 34*(5), 583-594.
Mowery, D. C., & Sampat, B. N. (2005). Universities in national innovation systems. *The Oxford handbook of innovation* (p. 209-239).
Nelson, R.R., & Winter S. (1982). *An evolutionary theory of economic change*. Cambridge: The Belknap Press of Harward University Press,
Nelson, R. R. (1993). *National innovation systems: A comparative analysis*. Oxford and New York: Oxford University Press.
Nelson, R. R., & Rosenberg, N. (1993). Technical innovation and national systems. In R. R. Nelson, (eds.), *National innovation systems: A comparative analysis*. Oxford and New York: Oxford University Press.
North, D. (1990). *Institution, institutional change and economic performance*. Cambridge: Cambridge University Press.
OECD. (1999). Managing National Innovation Systems.
Owen-Smith, J., & Powell, W. W. (2008). Networks and institutions. *The Sage handbook of organizational institutionalism*, 596-623.
Perkmann, M. (2007). University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews, 9* (4), 259-280.
Pettigrew, A. M. (1990). Longitudinal field research on change: Theory and practice. *Organization Science, 1*, 267-292.
Ponds, R., Van Oort, F., & Frenken, K. (2010). Innovation, spillovers and university–industry collaboration: An extended knowledge production function approach. *Journal of Economic Geography, 10*(2), 231-255.
Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: The Free Press.
Powell, W. W. (1991). *The new institutionalism in organizational analysis*. University of Chicago Press.
Powell, W.W., Koput, K.W., & Smith-Doerr, L. (1996). Inter-organisational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*,116-145.
Rasiah, R., Kimura, F., & Oum, S. (2014). Host-site institutions, production networks and technological capabilities. *Asia Pacific Business Review* (ahead-of-print), 1-18.
Razak, A. A., & Saad, M. (2007). The role of universities in the evolution of the Triple Helix culture of innovation network: The case of Malaysia. *International Journal of Technology Management & Sustainable*

Development, 6(3), 211-225.

Rogers, M. (2004). Networks, firm size and innovation. *Small Business Economics, 22*(2), 141-153.

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126.

Storper, M. (2002). Institutions of the Learning Economy. In Gertler, M. S. & Wolfe. D. A. (eds.), *Innovation and social learning: Institutional adaptation in an era of technological change*. New York: Palgrave Macmillan.

Thrift, N., & Olds, K. (1996). Refiguring the economic in economic geography. *Progress in Human Geography, 20*, 311–337;

Tödtling, F., & Trippl, M. (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy, 34*(8), 1203-1219.

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 42*(1), 35-67.

Walker, R. M. (2006).”Innovation type and diffusion: an empirical analysis of local government. *Public administration, 84*(2), 311-335.

Wernerfelt, B. (1984). A Resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Sage Publications.

Youtie, J., & Shapira, P. (2008). Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research Policy*, *37*(8), 1188-1204.