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Exploring Regional Innovation Ecosystems: An Empirical Study in China

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This paper explores the Regional Innovation Ecosystem (RIE) aiming to fully understand its static and dynamic nature. We investigate how organizations co-evolve within an ecosystem and how does it affect their ecosystems. Based on the longitudional qualitative in-depth case study analysis of the three most representative Chinese RIEs, we empirically explore and validate a 4C framework. The framework includes construct, cooperation, configuration, and capability and offers insights into a better redistribution of roles and coordination of ecosystem resources, delivering a better understanding of the dynamic and co-evolution nature of ecosystem development and inspiring the practitioners to further explore their complementary partners. The key findings imply importance of within and inter RIE complementarity based collaboration, which with an appropriate and well informed governmental support can significantly boost National Innovation System.

Keywords: Regional Innovation Ecosystem (RIE), case study, dynamics, co-evolution, China, 4C framework

JEL CLASSIFICATIONS: O30, M16, R58

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1 Introduction

The ecosystem concept has been gaining increasing attention among management scholars (Moore, 1993; Iansiti and Levien 2004; Parente et al., 2019; Rong et al.2020). Only within the recent years, many scholars initiated discussions about the conceptual origins of the ecosystems (Rong et.al 2015; Scaringella and Radziwon, 2018), similarities and differences between ecosystems and inter-organizational networks (Shipilov and Gawer, 2020), for attempted to conceptualize the ecosystem construct (Rong and Shi 2014; Adner 2017) and develop the theory of ecosystems (Kapoor 2018). At the same fragmentation and certain level of ambiguity in regards to the use of ecosystem concept has been raised (e.g. Oh et al., 2016; Adner, 2017; Ritala and Almpanopoulou, 2017). While referring to ecosystems management studies to focus on interorganizational linkages, networks, and interdependencies, and co-evolution (Ahuja et al., 2012; Dyer and Singh, 1998; Owen-Smith and Powell, 2004; Provan et al., 2007; Radziwon and Bogers, 2019), the most common ecosystem type is the business ecosystem first introduced in by Moore (1993) followed by innovation ecosystem (Adner 2017; Dias Sant'Ana et al, 2020), service ecosystem (Trischler et al., 2020), entrepreneurial ecosystem (Cavallo et al., 2019), knowledge ecosystem (Aaldering et al., 2019) and recently also discussed platform ecosystem (Panico and Cennamo, 2020). In order to shed some more light into the field, our research will focus on one of the most controversial concepts within ecosystem domain, which is innovation ecosystem (Oh et al., 2016; Adner, 2017; Ritala and Almpanopoulou, 2017).

Different from the concept of an innovation system, which is mainly focused on the static view to explore what they have and how to operate them (Cooke et al., 1997), innovation ecosystem with focus on dynamics and coevolution has been regarded as drivers of regional innovation (Thomas, 2016). Within the area of innovation system, the concept of regional innovation system (RIS) is

generated with considerations of regional factors contributing to innovation performance (Braczyk et al., 1998). A RIS can be defined as *a set of interacting private and public interests, formal institutions, and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use, and dissemination of knowledge* (Lund and Karlsen, 2020; Ritala et al., 2013; Radziwon et al., 2017). However, RISs were more separate and dedicated to their own business and skills within their own regions, and failed to make good value by connecting to the other RISs (Belussi et al., 2010). Obviously, nowadays a company can have various linkages and cooperation with external actors, and the importance of these external ties has been increasingly recognised as a crucial factor in accelerating technological changes and innovation processes (Karna et al., 2013). Hence, in this research we propose the concept of regional innovation ecosystem (RIE) to address this gap. Extended from the current broad research on reginonal innovation system and the ecosystem approach, in this paper we define regional innovation ecosystem as *a regional innovation community consisted of stakeholders such as industrial organizations, governments, institutions, and customers who dynamiclly interact and co-evolve with each other and the uncertain environment, to achieve ongoing technological innovation and development*. In particular, we will explore the concept and its dynamic nature (Rong et. al, 2018).

There are several challenges faced during the emergence, development, and co-evolution of stakeholders in a RIE. These are related to establishing and building relationships between ecosystem stakeholders, coping with industry uncertainties and ensuring sustainable ecosystem development (Zhang et al., 2007; Rong et.al 2011). In order to disentangle some of these challenges from the overall complexity of the ecosystem multilayer nature, this paper focuses on exploring the way how organisations co-evolve within an ecosystem in a specific region and how does it affect their ecosystems. Following this logic, this paper reports findings from an in-depth case study of the three most representative RIE s in China. These are located in deltas rivers Bohai, Yangtze and Pearl. Our finding led us to develop a framework, which comprehensively outlines the static and dynamic nature

of the RIEs. Exploring RIEs can offer interesting managerial implications both for practitioners and policy makers by providing a insights into a better redistributions of roles and coordination of ecosystem resources (Snehota and Hakansson, 1995); delivering better understanding on the dynamic nature of ecosystem development (Liu and Rong 2015); and inspiring the practitioners to further explore their complementary partners (Lorenzoni and Lipparini, 1999).

The paper structure covers a literature review, more in- depth insides into the research design and data collection described in the methodology section followed by the discussion of the identified configuration patterns and capabilities of the RIE, conclusion and further research outlook.

2 Literature Review

Scaringella and Radziwon (2018) explored the ecosystem archetypes and went through the territorial approach that takes into account not only economic but also social factors important for the exchange of knowledge. They outlines the connections between territorial innovation models and ecosystems. From the archetypes point of view Regional Innovation System (RIS) is seen as one of (Regional) Innovation Ecosystem predecessors the connection between these two constitutes an interesting theoretical and practical gap that we intend to explore. In the following section, we propose key highlights of an in-depth analysis of the territorial and ecosystem literature, which we conclude by identification of the key concepts, which play a major role in the co-evolution process among ecosystem members in China.

2.1 Regional Innovation Systems

Within the current literature, there are two construct elements, social network (Granovetter, 1985) or community network, and value network and industrial system (Sexenian, 1996), which are imperative to a RIS (Gordon and McCann, 2001). We further elaborate on the importance of these constructs for RIS.

First, the *social network or community network*, which includes financial capital, social capital,

and human capital, is a critical resource pool to support the development of a RIS. The financial capital, which comprises of particularly seed capital, venture capital, and government funds, is identified as the success factors that support a system's innovation (Chiaroni and Chiesa, 2006). The skilled human capital, both cultivated by the local universities and attracted from outside, makes up the fundamental soft infrastructure for the growth of a knowledge-intensive RIS (Cooke, 2001). Social capital is defined as the ability to secure resources by virtue of membership (Su and Hung, 2009). It enables the linkage between different organizations. Especially in emerging countries like China, the term "Guanxi" is utilized to describe very close social capital which could generate values (Knight and Yueh, 2008).

Second, besides the community network of those who are loosely connected, there are also some established *industrial systems* with a matured value network in each RIS. The factors like entrepreneurship and networking within the value network are essential to the success of a RIS (Lin et al., 2006). Entrepreneurship is a critical element in the formation and viability of innovative industries and the RIS (Feldman et al., 2005). Local entrepreneurs also facilitate the quality of mutual dependence and networking among organizations (Owen-Smith et al., 2006). In addition to the local network, there are also networks linking different parts of the region, and linking the region to other regions and to other countries (Lundvall, 2010). In this sense, RISs should not be conceived as isolated entities, since they are encapsulated in national and supra-national innovation systems.

The current literature has mainly focused on examining the key construct elements including the community network and value network (Gordon and McCann, 2001), but it is still a relatively static view to look at the structure of a RIS (Cooke et.al, 1997; Zhang et al., 2007, Attour and Burger-Helmchen, 2014). Unfortunately, a more dynamic view looking at the interaction and co-evolution of the different construct elements, which are driving the evolution of a RIS, has been less addressed in current literature (Ritala et al., 2013; Radziwon et al., 2017).

Hence, In light of the static view of the research on RIS in current literature, this paper proposes the application of the concept of the RIE to extend current research with a more dynamic view.

2.2 *RIE*

The ecosystem approach is based on ecology; the term business ecosystem was described as an economic community composed by interacted industrial practitioners, government, institutions, customers and other stakeholders, who co-evolve and share their fate with each other (Gawer and Cusumano, 2014; Iansiti and Levien, 2004; Rong et al., 2013). It addresses the interaction and co-evolution between value networks and their dynamic environment (Rong and Shi, 2014; Rong et al., 2015). Meanwhile, those companies can be seen as not only members of an industry, but also part of a business ecosystem that covers several industries (Moore, 1993), which is common especially for the emerging industries (Liu and Rong, 2015; Ma et al., 2018; Rong et al., 2018). Hence, interaction and co-evolution play an essential role in sustaining the ecosystem in an evolutionary way (Moore, 1993), companies in a business ecosystem are not only working cooperatively and competitively but also co-evolving around a new innovation to support new products and (or) services to satisfy customer needs (Scaringella and Radziwon, 2018; Radziwon and Bogers, 2019). That's why this paper proposed application and further develops the concept of a RIE to reflect both static and dynamic elements of the RIS and to addresses both internal and external linkages and co-evolutions.

Rooted in business ecosystem origin, we proposed the definition in the introduction section, which is in line with the idea that such an ecosystem requires a high level of collborative arrangement (Adner, 2006). Interdependencies, interaction, and co-evolution are essential to the success of an innovation ecosystem as it has already been highlighted in the original proposal of the concept of a business ecosystem (Iansiti and Levien, 2004; Rong et. al, 2018; Radziwon and Bogers, 2019). In this study we follow Iansiti and Levien (2004: 76) for whom interdependencies mean that *"the company must share the fate of the other participants in the ecosystem"*, but at the same time having an independent value proposition (Adner 2012, 2017). Close cooperation such as inter-firm collaborations and open innovation processes with other partners whose activities are interdependent is essential to enable technology advancements within the context of a highly interconnected business ecosystems

(Masucci et al., 2020). From a policy point view, it also needed that when effectively support a given technology should also consider the technological ecosystem, surrounding the target technology (Pichler et al., 2020). The co-evolutionary nature of an ecosystem is expressed by the ecosystem members experience in changes of the equilibrium by external constraints (emerging from an ecosystem's business environment and returns into a temporary stabilisatation, which allowing new structures and order to be created. In a more practical terms this self-driven mechanism, which tends to be externally moderated cover a simultaneous co-evolution of firm capabilities lead to mutual adaptation (Radziwon and Bogers, 2019). Interactions cover collaborative activities and behaviours with or without monetary transactions, which contribute to the development of both strong and weak ties between ecosystem members. Hence, innovation ecosystem per definition often place emphasis on collaboration (Granstrand and Holgersson, 2020). It has been also highlighted that companies need to build up an appropriate innovation strategy to mitigate risks in such a complex and uncertain innovation ecosystem (Adner, 2006). In this way, the concept of an innovation ecosystem will be very valuable and appropriate to model the economic dynamics of complex relationships. Different from previous researches on RIS that focusing on the interactions of its two static construct elements (community network and value network), this research emphasizes the co-evolution nature of the proposed concept of RIE. Hence this paper developed a 4C framework in below section to guide the research on RIE.

2.3 *4C Framework*

Following case study logic proposed by Gioia et al. (2013), we first identify and explore the key concepts, which play a major role in the co-evolution process among ecosystem members. In order to explore both the static and the dynamic nature and to uncover how organizations co-evolve within an ecosystem and how does it affect their ecosystems, we developed a 4C research framework (see

Figure). This conceptual research framework is based on a broad literature review and followed the logic of the 3C framework (Lin et al., 2009; Shi and Gregory, 1998; Zhang et al., 2007), which was

originally proposed to analyze a complex network system with the argument that a certain system structure and relationship forms a certain configuration pattern, which then generates a certain capability. 4C framework is used to to better understand RIE. In particular it guides the data collection analysis, which ensures the internal validity, and constructs the validity of the research (Gibbert et al., 2008).

Insert Figure 1 about here

As shown in

Figure , the first C - 'construct' demonstrates the building blocks of a RIE. The second C - 'cooperation' reflects the interaction mechanisms among those building blocks. The third C - 'configuration' categorizes the RIE into different patterns based on the construct and cooperation. The last C - 'capabilities' describes the ecosystem's ability to co-evolve and sustain innovation activities.

2.3.1 Construct

As discussed above, community network and value network are identified as the two main constructive elements when analysing a RIS. However, innovation activities within the value network are being examined in a relatively independent way (Feldman et al., 2005; Su and Hung, 2009). Ecosystem literature considers those community network elements and innovation activities as interrelated, and as co-evolved ones to create value within an economic community (Iansiti and Levien, 2004). Meanwhile, they will interact with the value network through their synergy effect (Battistella et al., 2013), hence the ecosystem approach will extend the analysis focus from entrepreneurship and networking to a systematic perspective of the value network covering R&D, production, and sales in the value network (Rong and Shi, 2014). The community network and the *value network* has been identified as the essential constructive elements in a RIE, which at the same time offer an important

link to RISs.

2.3.2 Cooperation

In terms of the relationship among different constructs elements and how it works with each other, the system approach in analysing the RIS mainly concerns the support of the internal and external resource pool to the entrepreneurship and networking within the value network (Belussi et al., 2010). Meanwhile, the innovation and the competitiveness of entrepreneurs enhance the financial capacity of the RIE through enabling a financial mechanism and rewarding the financial capital (Cooke et al., 1997; Etzkowitz and Leydesdorff, 2000). However, from an ecosystem view, the value network needs to co-evolve with the resource pool of the community network. The co-evolution, an adaptation of the community network, and the value network are considered as a reinforcing cycle, where the resource pool of the community network supports the innovation activity (Geels, 2005). And the industrial system rewards the community network by further enabling the resource pool of human, financial and social capital (Cooke, 2001; Iansiti and Levien, 2004).

2.3.3 Configuration

With a system approach, RIS research classifies its configuration into spontaneous and policy driven patterns statically (Sofouli and Vonortas, 2007). The spontaneous configuration pattern is the result of the spontaneous co-presence of key factors (Chiaroni and Chiesa, 2006). The presence of excellent scientific bases and technology transferring mechanisms are key factors for the emergence of the spontaneous configuration pattern (Su and Hung, 2009). The policy-driven configuration pattern is triggered by the strong commitment of governmental actors whose willingness sets the conditions for the cluster creation (Huang et al., 2012; Yang, 2010). It is widely regarded that the policy-driven pattern is more sponsored in emerging economies, but are less supported in developed economies (Huang et al., 2012). The policy-driven configuration pattern, for example, the industry parks (that are organized by the local government at the county level) and science parks (that are organized by the

central government at the national level), becomes a popular innovation system for industrial development in emerging economies (Sofouli and Vonortas, 2007). In some cases, there are hybrid patterns triggered by mixed processes from the above two patterns (Chiaroni and Chiesa, 2006), which means that the government coordinates and enables the elements like human capital and financial capital that already existed (Huang et al., 2012).

However, the evolutionary processes and mechanisms of these two patterns are still unclear, but this is what needs to be explored by the use of the ecosystem lens. From an ecosystem perspective, the evolution and co-evolution of different configuration patterns along its lifecycle could be driven by mixed stakeholders (Moore, 1996). All the stakeholders are encouraged to contribute to the development of the RISs and share their fate. The spontaneous configuration pattern of RIE could emerge from the complex interrelations among key factors (Nachira et al., 2007). The policy-driven configuration pattern may be triggered by the government's endeavour of nurturing related stakeholders to enable the growth of the innovation system (Rothschild, 1990). And the hybrid configuration pattern could be triggered by the co-evolution of key factors in hybrid configuration patterns (Richardson et al., 2012).

2.3.4 Capability

It is believed that a certain system configuration will create certain system capabilities, or certain capabilities are generated from a certain system configuration (Lin et al., 2009). In this research, this logic was applied to the analysis of regional innovation. Only a few types of research on the RIS have examined the role of system capability. Firm capability shows how well the firm explores and exploits internal and external resources, while in a RIE, capabilities could demonstrate how an value network evolves by coordinating other stakeholders in the innovation ecosystem. Through an ecosystem lense, complementors play an essential role in the success of the innovation strategy (Adner, 2006), and coordinating with those ecosystem stakeholders is extremely important (Lorenzoni and Lipparini,

1999). That is why the capability of “complementor readiness” is normally being regarded as one of the most important indicators showing the health of a business ecosystem in the process of acquiring internal and external resources. As a result, connection capability, which is the ability to build connections with both internal and external actors and other innovation ecosystems, becomes very important to ensure the success of an innovation ecosystem (Gawer and Cusumano, 2014; Rong et al., 2015). However, the RIS puts more emphasis on the capability of internal interactions but ignores the capability of external connections (Zhang and Liang, 2011). In an ecosystem context, such external connections are usually built up on a certain platform within a global context (Gawer and Cusumano, 2014).

These four dimensions are summarized in Table 1.

Insert Table 1 about here

As presented in Table 1, the dimensions of the construct, cooperation, configuration, and capability provide a comprehensive, systematic and dynamic perspective in exploring the evolution of a RIE. The construct identifies the value network and community network, but has extended the traditional scope of the RIS and addressed the co-evolution of key constructs systematically. The characteristics of industrial transformation and feedback are also reviewed to help in identifying the connotation of cooperation. As for the configuration pattern of the innovation ecosystem, the hybrid of spontaneous and policy-driven patterns extends the existing single configuration pattern of either the spontaneous or policy-driven one. This system configuration could generate certain ecosystem capabilities which support the performing of a series of effective innovation activities. Within an ecosystem, complementary and connection capabilities could enable the resource accessibility and cooperation of RIE.

3 Research Methods

3.1 *Case studies*

Due to the contemporary nature of the RIE, this research has adopted a case study methodology (Yin, 2008). In order to enhance the robustness of the research results, this research uses multiple case studies, and each case, as it has the nature of longitudinal studies, provides even more compelling evidence, and produces more robust conclusions than a single case study of a snapshot time point. In order to improve the reliability (Gibbert et al., 2008) and quality of our theory building (Weick, 1995, 1989), we have designed the following clear steps and criteria as the case study protocol (Table 2).

First, this research focuses on three RIEs located at Shandong, Shanghai, and Shenzhen, which represents the key economic regions in China: *Bohai delta*, *Yangtze River delta* and *Pearl River delta*. The Bohai Delta is a high-efficient eco-economic zone consisting of both traditional manufacturing industries including machine equipment industries, and green manufacturing industries like e-vehicle manufacturing industry. Yangtze River Delta is more specialized in its semiconductor and biotech industries, while the Pearl River Delta has more advantages through consumer electronics. What is more, these RIEs have simultaneously engaged in several sectors, including mobile computing, electric vehicle, and semiconductor industries. Taking Shenzhen RIE as an example, this RIE evolved its sectors from VCD, mobile 2G, smartphone, and then towards tablets by synthesizing the specialist from the Shanghai, Taiwan RIEs (Rong et al., 2011).

Second, this study explored those RIEs via investigating the key projects and sector transformations as shown in

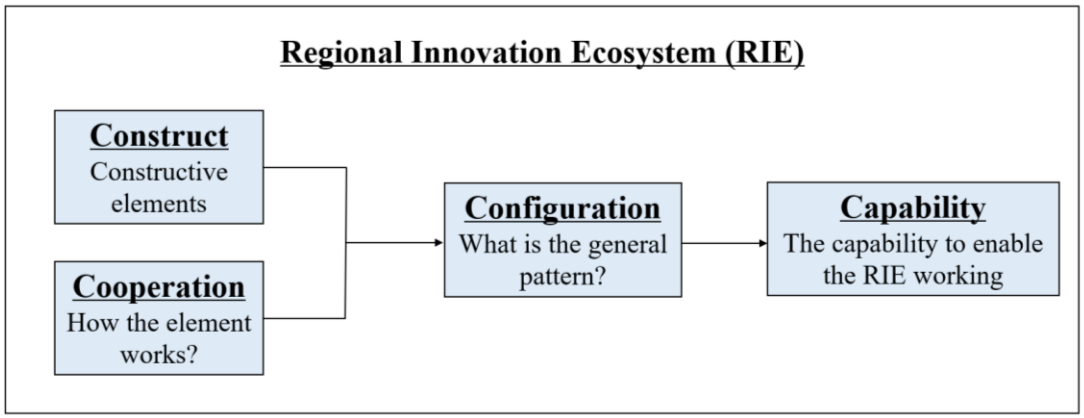

Figure . For each individual project, several senior project managers are interviewed to build longitude knowledge of the projects and industry developments. Most of those interviewees have at least 15 years of working experience in the company, which equipped them with sufficient knowledge of the development in their regions, and this ensures that the research can get the required longitude data.

Insert Figure 2 about here

Third, this research has selected the most representative companies in each region, and they have the most comprehensive experiences of the development of the whole region. In addition, the companies should be involved fully or partly in terms of the region's innovation development.

Fourth, the selected case companies, as the focal firms playing important roles pretty much at the centre of each of their respective RIE i.e. they own the product platforms which other stakeholders could add value to, such as suppliers, training centres, financial capital providers, policymakers and industrial associations. The interviewees also confirmed this.

These steps ensured that the theory development process included an explicit framework, and an accurate and detailed representation (Gibbert et al., 2008). The interview questions and interviewee list are included in order to present the case data and data sources. The data coding and analysis with the 4C framework is proposed to link the raw data, research framework and research findings. This also ensures the internal validity and construct validity of the research (Gibbert et al., 2008).

Table 2 shows the differences between these cases in terms of the five criteria, which aim to cover a wide range of different sectors and stages of development of each RIE. The first two criteria are used to select a specific region and companies for the main case studies, while the last three criteria are to help identify the relevant interviewee within the selected main cases.

Insert Table 2 about here

3.2 Data collection

Data were collected mainly through in-depth, semi-structured interviews with managers between April 2010 and August 2016. The interviews were conducted using pre-designed guidelines, which focused on the 4C dimensions in the proposed conceptual framework of RIE, to ensure data reliability and construct validity (Yin, 2008). The interview details are listed in Table 3. In total, we visited 31 interviewees, and the total interview time length is over 63 hours. Additional hours that were spent on browsing secondary documents are not included in this total amount. The secondary data include documents, news, company information, and industrial associations' reports.

Insert Table 3 about here

3.3 Data analysis

The unit of analysis of this article is the RIE, which is a non-conventional unit of analysis (Lorenzoni and Ferriani, 2008), and is more focused on the network of firms and organizations. This research adopted several strategies for data analysis. *Roadmap and process mapping*: following the nature of roadmap methods (Phaal et al., 2004) and a process research approach, we have summarized the longitude data on the evolutionary process to help to understand the industrial transformation. *Ecosystem perspective*: this research aims to better understand regional innovation via this approach to explore both the static and dynamic nature of the RIE. *Comparative analysis*: this research conducted a c*ross-project analysis* for each RIE to compare companies' engagement in different industrial sectors; *cross-case analysis* was conducted for each RIE in order to generalize the results, and *cross-region analysis* was conducted to understand the differences and links among those three regions. Such a cross- comparative analysis ensures the external validity of the research (Gibbert et al., 2008).

3.4 Summary of case studies

Following the case studies, we have summarized the key features of each case in terms of the four C dimensions of a RIE in Table 4.

Insert Table 4 about here

Within the last 30 years, from dominating by the central government initiatives to being motivated by the government and being supported significantly by entrepreneur's collaboration, the Shenzhen RIE experienced four stages of industrial development, moving from VCD, mobile 2G, Smart phone, and then to the Tablet era. Through that transformation journey, those three case

companies all realized the importance of the cooperation between the Shenzhen RIE and other RIEs like the Shanghai Design Centre and Dongguan's Manufacturing Centre which owns complementary capabilities to Shenzhen. Their development and interaction with other stakeholders could be regarded as the typical co-evolutionary development of the Shenzhen RIE.

Founded on the long-established vehicle manufacturing capability in Shandong province, the Shandong RIE developed very fast with its strong learning and manufacturing capability (over 100 suppliers, manufacturers, universities and research centers devoted their business to the low-speed EV area). Different from the Shenzhen RIE, the production of low-speed EV is only supported by the local government, hence the sales are limited to rural areas. However, close cooperation among those stakeholders, and good knowledge of the local and nearby market, play a critical role in facilitating the rapid development of the Shangdong RIE for the EV.

Founded in July 1992, ZJHP is located in the middle part of the Pudong New Area with a planned area of 25 km^2. Since 2000, ZJHP has entered into a high-speed development period, and become a national microelectronics base in particular for the IC industry. The increasing wide and deep global linkage, strong cooperation with universities, heavy investment, and the strong policy support, all these have strengthened the local innovation capability and cooperation to form the ZJHP RIE.

4 Research Findings

4.1 The static view of a RIE: Construct

The research results have shown that the constructs of the RIE can be identified as a community network and value network. For each RIE, these two constructive elements should have existed simultaneously as a stable structure, but structural details of these two elements are varied from different RIEs.

For the community network, the elements like social capital, financial capital and human capital play essential roles in supporting the growth of the value network (Kudic, 2013). For example,

in the case of the RIE in Shenzhen, the resource pool of the community network includes tax discount and infrastructure packages offered by the local government and has enabled the emergence of RIS though attracting a large number of investors. This introduces the financial capital to the region that further promotes the growth of the RIE. In the RIE of Shandong, the focal firm Shifeng gets the support of a financial capital company to enlarge its EV business. Besides this, Shifeng also acquired the support of human capital by inviting the key scholars and policy makers from famous universities. This enables the accumulation of social capital through the setting up of communities that can influence the policy making process of the central government. In the RIE case of Zhangjiang High-tech Park, the beneficial policies at national and local levels provide resource pools including financial investment and talent cultivation. The increasing overseas returnees are a critical enabler of the RIE's emergence and growth. They bring in the resources of overseas funding and the connection with local and global partners as in the case of Spreadtrum.

As for the value network, activities like entrepreneurship and networking between stakeholders promote the evolution of the RIE. As for the RIE in Shenzhen, there are intensive activities like local entrepreneurs and intra and inter RIE networks in the value network. For example, the focal firm MTK established networks with the RIE in Taiwan, Shenzhen, and Shanghai to get access to the foundry, manufacturing and design resources respectively. Whilst in the RIE of Shandong, the focal firm built a network to outsource the production of a few components and enabled the marketing of its EV products.

4.2 Dynamic view of a RIE: Cooperation

Following these exploratory case studies, this paper argues that it is necessary for researchers within this field to contemplate on an alternative conceptual research framework to explore the dynamic and evolutionary nature of a RIE. The system constructs analysed above provide basic elements for the further analysis of a RIE's dynamic nature - cooperation, defined as the interdependencies, interaction, and co-evolution of those elements. The interactions and co-evolutions among those constructive

elements are the key difference between the traditional system approach and the ecosystem approach on RIE's development. For instance, in ZJHP's case, the dedicated government's support and overseas returnees promote the forming of wide and deep global linkages within the industrial system. For example, the cooperation with IMEC from Belgium and Jazz from the USA provides sources for HHNEC to assimilate related knowledge and build the indigenous capability.

The research results have demonstrated that the constructive elements interact with each other in nurturing and developing an emerging industry. Besides the constructive elements like the value network and community network, we also identified two cooperation elements, including industrial transformation and industrial feedback (as shown in

Figure), as the interaction mechanisms between constructive elements.

Insert Figure 3 about here

The building block of the community network is actually a resource pool, which shows that RIE players could make value out of their social ties. This is very important especially at the emerging stage of the new industrial development. Meanwhile, the industrial system acted as a value network with a business purpose. Within a RIE, the key for companies is to make an innovative idea to become a product/service in the industry network to provide value to customers. Hence, the cooperation elements play essential mechanism roles of interaction and co-evolution between the value network and community network. Such a mechanism has two parts; for one thing, it is the processes transforming the community network into an industrial system as a value network; for another, it is the feedback loop allowing the value network to enrich the resources pool/community network. For example, the MTK case has shown how the original innovative ideas became an innovative product providing value to the market. Lastly, it enhances the community network to further develop innovative

ideas. We can see that the ecosystem approach highlights the dynamics of a RIE, and provides a disclosure of the evolutionary process of a RIE. This is also the reason that one RIE could transform from one sector to another.

4.3 Configuration pattern of RIE

Based on the analysis on construct and cooperation, the research results have indicated that there are three typical configuration patterns of a RIE, including pure policy driven, spontaneously driven, and mixed driven. Different RIEs could show different features of the configuration pattern. Furthermore, different companies in the same RIE could even experience different features of the above three patterns. For example, as China only opened its door since the late 1970s and the central government heavily drove the economy, all of these RIEs started with government policies driving it. However, Shandong and Shenzhen mainly sustained its development by the local grass-root power, and the ZJHP was still relying on the policy's supports. Policy plays essential roles in the development of RIE in China.

The success of the Shenzhen RIE relied on its platform who integrated the innovative ideas from worldwide contacts or nations, and the capabilities of other RIEs such as the design capabilities in Shanghai and foundry capability in Taiwan. This RIE would get most of its innovative ideas quickly since it was close to Hong Kong and could get access to the world markets. In the meantime, due to the accumulation of resources, it could quickly turn such ideas into real products. This RIE has specialized in providing the total solution for any innovative ideas, especially in the consumer electronics industry.

The Shandong RIE previously was the key vehicle-manufacturing cluster in China. The main sectors, transforming from vehicles for agricultural use towards Electric Vehicles in the Shandong RIE, relied on their embeddedness into the local demand, and in their understanding of the big trends of the green economy. It acted similar to the Shenzhen RIS by connecting the stakeholders with specialized

capabilities in different national-wide RISs. However, it also faced challenges in terms of following the central government's policies. There, the policy became an obstacle instead of a driving force.

The ZJHP RIE was mainly developed through being policy driven. However, due to the global trend, overseas talents and returnees also brought global resources to stimulate the ZJHP's development. Due to the complex nature of the semiconductor industry, ZJHP still relied more on the government's support. That is the reason why this RIE seemed to be more stable instead of dynamic.

In summary, the configuration of the RIE becomes more complicated rather than policy driven, spontaneous or mixed. Instead, the configuration becomes more dynamically changing when various stakeholders such as policy makers, institutions, firms or even overseas returnees can also drive the evolution of the configuration.

4.4 Capabilities for a RIE

For each RIE, a certain configuration will create a certain capability to support the development and evolution of the RIE, in particular in an emerging industry like the Electric Vehicles (Shang and Shi, 2013). We have discovered two key capabilities that the previous research might neglect, but which are important to the nurture and development of a RIE. The first one is complementary and the other is the connection. Each RIE has usually specialized in the same product or industries. It was when the products became more complicated, that an inter-RIE collaboration was required. The ecosystem perspective required the firm to identify the complementary products, which could facilitate their own products' commercialization in an inter-RIE collaborative context. The Shenzhen and Shandong RIEs are very good at finding complementary products to enrich their own products. For example, they found the batteries supplier, mobile and vehicle designer for the products in other RIEs.

The second capability is a *connection*. The connection dimensions addressed the intra-, inter-company, and inter-country RIE collaboration. The complementary is mainly stated as the local connection within the single country. However, the connection means, as an innovative RIE, that it

should have a global connection and the local connection as well. For example, the ZJHP RIE specialized in the semiconductor industry, owning various global connections. Thus, this RIE benefits from global talent and resources, and the overseas returnee bridged that gap.

The complementary and connection both indicate the key idea of an ecosystem approach: the interaction and co-evolution between stakeholders in worldwide RIEs. The stakeholders in those RIEs need to acquire these two capabilities in order to make the value needed by coordinating those RIEs and coping with the industrial dynamics.

5 Concluding discussion

The traditional thinking of the RIS mainly focused on the static view to exploring only what the system has and how to operate it (Cooke et al., 1997). RISs were more separate and dedicated to their own business and skills within their own regions, and failed to make good value by connecting to the other RISs, but while they failed to understand why such a RIS should sustain its development and evolve into the different sectors, the boundaries of a RIS seemed to vanish during the pace of globalisation (Belussi et al., 2010). Nowadays a company can have various linkages and cooperation with external actors, and the importance of these external ties has been increasingly recognised as a crucial factor in accelerating technological changes and innovation processes (Karna et al., 2013). That is why this research proposed to explore regional innovation with an ecosystem approach to comprehensively understand the static and dynamic nature of a RIE as well as the synergy effects between RIEs. The ecosystem approach contains four dimensions: construct, cooperation, configuration, and capability. The traditional view on RIS failed to understand the dynamics and evolution of the RIS development, which cannot well explain the industrial transformation within the RISs. Besides this, the traditional studies also lack exploring the linkage and synergy among those RISs, and the way to make the value of those synergies (Scaringella and Radziwon, 2018). The ecosystem approach addressed these two issues by offering a better picture of the interdependencies, interactions, and co-evolution of constructive elements and the way to play the role of a specialized capability with the concept of RIE.

Most of the cases are driven by mixed forces neither by government, or entrepreneurs, but by a mixture of stakeholders. The configuration patterns of RIE have become more complicated than ever before. An ecosystem approach encourages all the stakeholders to contribute and add value to the evolution of a RIE. That is why the ecosystem perspective offers a better opportunity for the sustainable development of a RIE. This paper encourages the policy makers to understand the roles of different RIEs, and then provide the supporting policies to facilitate the collaboration between those RIEs.

The main output of this study is empirically validated conceptual framework that helps in developing a comprehensive understanding of the RIE concept. We have explored each dimension, by an in-depth analysis of the interdependencies, interaction, and co-evolution.

5.1 Theoretical contribution

5.1.1 From system to the ecosystem approach.

The research results indicated there are four aspects that the traditional RIS (Belussi et al., 2010) could learn from. We summarize this as an ecosystem approach: the traditional view on RIS is relatively static by summarizing the constructive elements but has failed to explore the dynamic nature of the interaction between them and the nature of their co-evolution. The ecosystem approach indicated the interaction between those elements, and the transformation and feedback to enrich the RIE resources pool. It is very important to understand the cycle between the existing value network (e.g. industrial systems) and the community network (e.g. resource pool, social network): how they can continuously interact and consolidate both sides. Thereafter, the RIE could produce more sustainable cross-sector innovation.

5.1.2 4C framework.

In order to fully understand a RIE, this paper developed a 4C framework to explore both its static and dynamic natures. This is based on the original 3C framework to analyse a complex network system (Lin et al., 2009; Shi and Gregory, 1998; Zhang et al., 2007). The construct indicates the RIE building

blocks, while the cooperation explains the interaction between those building blocks and how to consolidate them for future innovation. The configuration demonstrates the typical patterns of RIE with different drivers, while the capabilities introduce the ability that the RIE needed to evolve for future innovation.

5.1.3 Linkage among sector and national innovation systems.

Furthermore, by fully exploring the RIE with the proposed 4C framework, we could also discover how RIE could link with Sectoral Innovation System (SIS) (Malerba, 2002) and National Innovation System (NIS) (Lundvall, 2010), so as to secure an integrated effect as shown in

Figure . The horizontal view of the Figure 4 is the community network from the degree of specific to expanded scope , while the vertical view is the value network from degree of certainty to uncertainty(cross-sectors). The SIS is locating at the specific industry while RIS composes of several value networks and locates at specific region. The RIE develops itself by combining the features of RIS and SIS. This is because, each specialized RIE is based on different sectors (for example, chips, design, or software industries) who could work together to produce a mobile phone. Meanwhile, those sectors are based in RIEs locating at various geographic locations. All of those systems (RIS, SIS and RIE) together finally generate the NIS as a whole. Thereafter, the ecosystem view could well link the RIS, RIE, SIS and NIS, which could then explain the relationship of those concepts.

Insert Figure 4 about here

5.1.4 Extending the ecosystem approach via connecting geographic and sectors dimensions.

Studies on the business ecosystem usually neglect the dimension of geographic location; instead, they use the product or industrial platform to connect those stakeholders worldwide in different regions (Gawer and Cusumano, 2014). However, in most of the cases in this RIE research, each component supplier or complementors are mainly clustered in specific regions. In other words, the task for the keystone firm of a RIE is to not only know the right roles but also they have to know the place to connect the roles.

Thus, the geographic dimensions could enrich the research on RIE via not only by understanding the role of local complementors but also by the connection with global complementors and other stakeholders. The business ecosystem study is mainly on the complementary view, while the RIE study includes the geographic dimensions, which could also inspire the RIE study to seek for an understanding of the complementors and other stakeholders in a global context.

5.2 Practical implications

5.2.1 Management implications.

This paper provides several managerial implications for different roles like focal firm and complementors. Firstly, companies in a RIE should build up a co-evolution view to cooperate and interact with other stakeholders to achieve better performance of innovation. In particular, to the focal firms of each RIE, they should clearly identify the complementors in the region or other regions, and try to establish connections with those complementors and link its RIE with other RIEs in a local, national or global context. For example, the focal firm could provide a platform to connect those complementors in the different RIEs.

Secondly, the key to success is to categorize the RIE into different roles with specialized functions and capabilities. The research results indicated the importance of interaction and co-evolution, which is one of the key features of a RIE with the ecosystem approach – connecting with each other could reach better innovation performance than working individually. As a result, building connection capabilities is highly recommended to companies who are involved in the development of a RIE.

5.2.2 Policy implications.

The research result highlighted the importance of policy in a RIE, hence this paper also provides some feasible practical implications for the government: the central government should understand the different RIEs within the country and understand their roles and capabilities. Furthermore, the government should also understand how these RIEs could be connected with each other to produce a synergy effect of all-win. This study would guide the government to issue the relevant policies to support those RIE developments. In summary, if those RIEs worked well with each other, then, the performance of a National Innovation System is expected.

5.3 Research limitations and further research outlook

While this study contributes both to theory and managerial practices, it has number of limitations. Our study concentrated on — exploring and validating a 4C framework, which includes constructing, cooperation, configuration, and capability. Despite of the contributions offered by bridging terrirotial and ecosystem approach and linckages between sector and national innovation systems there are number of questions that emerged along the way of this study.

First, community network and value network are very important constructs to consider while studying how organisations co-evolve in ecosystems. Our study offer an exploratory insights based on the three most representative Chinese Regional Innovation Ecosystems. More research in other contexts, industries and by application of different methodologies could offer more validity of this study. The latter point is very much in line with Shilipov and Gawer (2020) who suggest a further integration of a maturing research on organizational and interorganizational networks and in particular mapping these interdependencies (moving beyond technological components) by using graph theoretic methods. Another interesting method, which could offer us more insights into the actual innovation or the performance level of ecosystems, which are charactezed by causal complexity is Qualitative Comparative Analysis (QCA) (see Meuer et al., (2015) and Meuer (2014) for the examples of QCA application in innovation systems and inter-firm relations respectively). In order to capture different configurations of causes and the assymetry of their effects on innovation outcomes of innovation ecosystems we would certainly need to be able to collect the data from a larger number of ecosystems.

Second, our findings indicate presence of three typical configuration patterns of a RIE, which are pure policy driven, spontaneously driven, and mixed driven. As much as pure policy driven pattern may be related to the political system (central government influence on configuration dynamics), further research could explore the invariants between ecosystems embedded and dependent on the political systems and ecosystems within strongly regulation driven and public support dependent

ecosystems. Some of the examples innovation ecosystems could cover on the product side renewable energy centered ecosystems – e.g. within nanotechnology, windmill industry (Knudsen et al., 2019) or an emerging transportation drone industry (Yaghmaie et al.,2020). On the service side further conceptual and empirical research conducted in the context of fintech or other data driven and data protection bounded innovation ecosystems could offer additional insights related to more industry related configuration patterns.

Third, one of the aspects, which are or high relevance and interest to innovation ecosystem and ecosystem literature in general, which was not speficically explored in our study, but could offer complementary insights in the context of cooperation and configuration is related to the governance mechanisms of the innovation ecosystems. In particular, it would be interesting to further explore best governance structures and ecosystem architectures, which would further allow to capture the dynamic nature of external environment by handling unforeseen contingencies and allow building foundations for systemic innovations while effectively managing multilateral interdependencies (Foss et al.,2020; Adner, 2012, 2017). Moreover in line with these thoughts future research could also explore relationship dynamics among organizations and industries and how these contribute to the generation, use, and dissemination of knowledge within and across innovation ecosystems, which are in line with the recent open innovation results triangle proposed by Chesbrough (2020).

Forth, our study we extend a static RIS approach by looking beyond the capability of internal interactions by including the capability of external connections (Zhang and Liang, 2011; Gawer and Cusumano, 2014). In particular our findings indicate the importance of complementarity and connections for nurturing and further development of a RIE. Further studies will benefit from an integration of the network effects literature (Katz and Shapiro, 1994) as well as Service-Dominant Logic literature (Vargo & Lusch, 2004, 2017) in ecosystem research. In particular both of these literature streams could be very useful in exploring the relationships between the number of RIE users/stakeholders and complementarity along with compatibility of resources available or needed in

an ecosystem. Following the effords of Shipilow and Gawer (2020) in the area of bridging the network and ecosystem literature a similar approach to integrate ecosystem literature with other concepts like Service-Dominant Logic could offer new energy and broaden the theoretical and empirical toolkit for further investigation of innovation ecosystems.

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6 Reference

Aaldering, L.J., Leker, J. and Song, C.H. 2019. Competition or collaboration? – Analysis of technological knowledge ecosystem within the field of alternative powertrain systems: A patent-based approach. Journal of Cleaner Production. 212, pp. 362-371.

Adner, R., 2006. Match your innovation strategy to your innovation ecosystem. *Harvard Business Review* 84, 98.

Adner, R. 2012. *The Wide Lens: A New Strategy for Innovation*. Ney York, NY: Penguin.

Adner, R., 2017. Ecosystem as structure: an actionable construct for strategy. *Journal of Management*, 43, 39-58.

Ahuja, G., Soda, G. and Zaheer, A., 2012. The genesis and dynamics of organizational networks. *Organization Science*, 23, 434-448.

Attour, A. and Burger-Helmchen, T., 2014. Écosystèmes et modèles d'affaires: introduction. *Revue d'économie industrielle,* (146), 11-25.

Battistella, C., Colucci, K., De Toni, A.., Nonino, F., 2013. Methodology of business ecosystems network analysis: A case study in Telecom Italia Future Centre. *Technological Forecasting & Social Change* 80, 1194–1210.

Belussi, F., Sammarra, A., Sedita, S.R., 2010. Learning at the boundaries in an "Open RIS": A focus on firms' innovation strategies in the Emilia Romagna life science industry. *Research Policy* 39, 710–721.

Boschma, R.A., Ter Wal, A.L., 2007. Knowledge networks and innovative performance in an industrial district: the case of a footwear district in the South of Italy. *Industry and Innovation* 14, 177–199.

Braczyk, H.-J., Cooke, P.N., Heidenreich, M., 1998. Regional innovation systems: the role of governances in a globalized world. Psychology Press.

Cavallo, A., Ghezzi, A. and Balocco, R. 2019. Entrepreneurial ecosystem research: present debates and future directions. International Entrepreneurship and Management Journal . 15, pp. 1291–1321. https://doi.org/10.1007/s11365-018-0526-3

Chesbrough, H., 2020. *Open innovation results: Going beyond the hype and getting down to business*. Oxford University Press.

Chiaroni, D., Chiesa, V., 2006. Forms of creation of industrial clusters in biotechnology. *Technovation* 26, 1064–1076.

Cooke, P., 2001. RISs, clusters, and the knowledge economy. *Industrial and Corporate Change* 10, 945–974.

Cooke, P., Gomez Uranga, M., Etxebarria, G., 1997. RISs: Institutional and organisational dimensions. *Research Policy* 26, 475–491.

Dias Sant´Ana, T., de Souza Bermejo, P.H., Moreira, M.F. and de Souza, W.V.B. (2020), "The structure of an innovation ecosystem: foundations for future research", Management Decision. In press. https://doi.org/10.1108/MD-03-2019-0383

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

Etzkowitz, H., Leydesdorff, L., 2000. The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy* 29, 109–123.

Feldman, M., Francis, J., Bercovitz, J., 2005. Creating a cluster while building a firm: Entrepreneurs and the formation of industrial clusters. *Regional Studies* 39, 129–141.

Foss, J.N., Schmidt, J. and Teece, D.J., 2020. Microfoundations of Integration in Innovation Ecosystems: Ecosystem Leaders and the Institutional Structure of Systemic Innovation. Research Policy Special Issue Conference, (virtually) Copenhagen, Denmark

Gawer, A., Cusumano, M.A., 2014. Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management* 31, 417–433.

Geels, F.W., 2005. *Technological transitions and system innovations: a co-evolutionary and socio-technical analysis.* Edward Elgar Publishing.

Gibbert, M., Ruigrok, W., Wicki, B., 2008. What passes as a rigorous case study? *Strategic Management Journal* 29, 1465–1474.

Gioia, D.A., Corley, K.G. and Hamilton, A.L., 2013. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, 16(1), 15-31.

Gordon, I.R. and McCann, P., 2000. Industrial clusters: complexes, agglomeration and/or social networks?. *Urban Studies*, 37(3), pp.513-532.

Granstrand, O. and Holgersson, M. 2020. Innovation ecosystems: A conceptual review and a new definition. *Technovation*. 90-92, pp. 1-12.

Granovetter, M., 1985. Economic action and social structure: The problem of embeddedness. *American journal of Sociology*, 91(3), pp.481-510.

Huang, K.-F., Yu, C.-M.J., Seetoo, D.-H., 2012. Firm innovation in policy-driven parks and spontaneous clusters: the smaller firm the better? *Journal of Technology Transfer* 37, 715–731.

Iansiti, M. and Levien, R., 2004. *The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability.* Harvard Business Press.

Knudsen, M.P., Frederiksen, M.H. and Goduscheit, R.C., 2019. New forms of engagement in third mission activities: a multi-level university-centric approach. *Innovation*, pp.1-32.

Kapoor, R., 2018. Ecosystems: broadening the locus of value creation. Journal of Organization Design, 7(1), 12.

Karna, A., Täube, F., Sonderegger, P., 2013. Evolution of Innovation Networks across Geographical and Organizational Boundaries: A Study of R&D Subsidiaries in the Bangalore IT Cluster. *European Management Review* 10, 211–226.

Katz, M.L. and Shapiro, C., 1994. Systems competition and network effects. *Journal of Economic Perspectives*, 8(2), pp.93-115.

Knight, J., Yueh, L., 2008. The role of social capital in the labour market in China1. *Economics of Transition* 16, 389–414.

Kudic, M., 2013. Small-world network characteristics and firm innovativeness-Empirical evidence from the German laser industry. *European Management Review* 4, 77–91.

Lin, B.-W., Li, P.-C., Chen, J.-S., 2006. Social capital, capabilities, and entrepreneurial strategies: a study of Taiwanese high-tech new ventures. *Technological Forecasting and Social Change* 73, 168–181.

Lin, Y., Zhou, L., Shi, Y., Ma, S., 2009. 3C framework for modular supply networks in the Chinese automotive industry. *International Journal of Logistics Managemen*t, 20, 322–341.

Liu, G. and Rong, K. 2015. The nature of the co-evolutionary process: complex product development in the mobile computing industry's business ecosystem. *Group & Organization Management*, 40(6), pp.809–842.

Lorenzoni, G., Ferriani, S., 2008. Searching for new units of analysis: firms, dyads and networks. *European Management Review* 5, 125–133.

Lorenzoni, G., Lipparini, A., 1999. The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study. *Strategic Management Journal* 20, 317–338.

Lund, H.B. and Karlsen, A. 2020. The importance of vocational education institutions in manufacturing regions: adding content to a broad definition of regional innovation systems. *Industry and Innovation*. 27(6), pp. 660-679, DOI: 10.1080/13662716.2019.1616534.

Lundvall, B.-AAke, 2010. *National systems of innovation: Toward a theory of innovation and interactive learning.* Anthem Press.

Ma, Y., Rong, Kc Mangalagiu , D., Thornton , T. and Zhu, D. 2018. Co-evolution between urban sustainability and business ecosystem innovation: evidence from the sharing mobility sector in Shanghai. J*ournal of Cleaner Production*, 188, pp. 942-953.

Malerba, F., 2002. Sectoral systems of innovation and production. *Research Policy* 31, 247–264.

Masucci, M. Brusoni, S. and Cennamo, C. 2020. Removing bottlenecks in business ecosystems: the strategic role of outbound and open innovation. Research Policy. 49 (1), pp. 1-17.

Meuer, J., 2014. Archetypes of inter-firm relations in the implementation of management innovation: A set-theoretic study in China's biopharmaceutical industry. *Organization Studies*, 35(1), pp.121-145.

Meuer, J., Rupietta, C. and Backes-Gellner, U., 2015. Layers of co-existing innovation systems. *Research Policy*, 44(4), pp.888-910.

Moore, J., 1996. *The death of competition: leadership and strategy in the age of business ecosystems.* HarperBusiness New York.

Moore, J., 1993. Predators and prey: a new ecology of competition. *Harvard Business Review* 71, 75–86.

Moulaert, F. and Sekia, F., 2003. Territorial innovation models: a critical survey. *Regional Studies*, 37, 289-302.

Nachira, F., Dini, P., Nicolai, A., 2007. A network of digital business ecosystems for Europe: roots, processes and perspectives. *European Commission, Bruxelles, Introductory Paper.*

Oh, D.S., Phillips, F., Park, S. and Lee, E., 2016. Innovation ecosystems: A critical examination. *Technovation*, 54, 1-6.

Owen-Smith, J. and Powell, W.W., 2004. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science,* 15, 5-21.

Owen-Smith, J., Powell, W.W., Braunerhjelm, P., Feldman, M., 2006. Accounting for emergence and novelty in Boston and Bay Area biotechnology. *Ann Arbor* 1001, 48104–2590.

Panico, C. and Cennamo, C. 2020. User preferences and strategic interactions in platform ecosystems. Strategic Management Journal. Special issue; 1– 23. https://doi.org/10.1002/smj.3149

Phaal, R., Farrukh, C.J.., Probert, D.R., 2004. Technology roadmapping–A planning framework for evolution and revolution. *Technological Forecasting and Social Change* 71, 5–26.

Parente, R., Rong, K., Geleilate, J.-M, and Misati, E. 2019. Adapting and Sustaining Operations in Weak Institutional Environments: A Business Ecosystem Assessment of a Chinese MNE in Central Africa. *Journal of International Business Studies*. 50(2), pp. 275-291.

Pichler, A., Lafond, F. and Farmer, D.F. (2020). 'Technological interdependencies predict innovation dynamics'. *INET Oxford Working Paper*, No.2020-04.

Provan, K.G., Fish, A. and Sydow, J., 2007. Interorganizational networks at the network level: A review of the empirical literature on whole networks. *Journal of Management,* 33, 479-516.

Radziwon, A. and Bogers, M., 2019. Open innovation in SMEs: Exploring inter-organizational relationships in an ecosystem. *Technological Forecasting and Social Change.*

Radziwon, A., Bogers, M. and Bilberg, A., 2017. Creating and capturing value in a Regional Innovation Ecosystem: A study of how manufacturing SMEs develop collaborative solutions. *International Journal of Technology Management*, 75-1.

Richardson, C., Yamin, M., Sinkovics, R.R., 2012. Policy-driven clusters, interfirm interactions and firm internationalisation: Some insights from Malaysia's Multimedia Super Corridor. I*nternational Business Review* 21, 794–805.

Ritala, P., Agouridas, V., Assimakopoulos, D. and Gies, O., 2013. Value creation and capture mechanisms in innovation ecosystems: a comparative case study. *International Journal of Technology Management,* 63, 244-267.

Ritala, P. and Almpanopoulou, A., 2017. In defense of 'eco'in innovation ecosystem. *Technovation,* 60, 39-42.

Rong, K., Hu, G., Lin, Y., Shi, Y., Guo, L., 2015. Understanding business ecosystem using a 6C framework in Internet-of-Things-based sectors. *International Journal of Production Economics* 159, 41–55. doi:10.1016/j.ijpe.2014.09.003

Rong, K., Lin, Y., Li, B.Y., Burstrom, T., Butel, L. and Yu, J. 2018. Business ecosystem research agenda: more dynamic, more embedded and more internationalized. *Asian Business and Management*. 17(3), pp.167-182.

Rong, K., Lin, Y., Shi, Y., Yu, J., 2013. Linking Business Ecosystem Lifecycle with Platform Strategy: A Triple View of Technology, Application and Organization. *International Journal of Technology Management* 62, 75–94.

Rong K., Lin Y., Yu J., and Zhang, Y. 2020. Manufacturing strategies for the ecosystem-based manufacturing system in the context of 3D printing. *International Journal of Production Research*. 58(8), pp. 2315-2334.

Rong, K., Liu, Z., Shi, Y., 2011. Reshaping the business ecosystem in China: case studies and implications. *Journal of Science and Technology Policy in China* 2, 171–192.

Rong, K., Patton, D. and Chen, W. 2018. Business model and ecosystem in the 3D printing industry: the interplay between business models and business ecosystems. *Technological Forecasting and Social Change*. 134, pp. 234-245.

Rong, K., Shi, Y., 2014. *Business Ecosystems: Constructs, Configurations, and the Nurturing Process.* Palgrave Macmillan, U.K.

Rothschild, M., 1990. *Bionomics: Economy as business ecosystem.* Beard Books.

Saxenian, A., 1996. *Regional advantage.* Harvard University Press.

Scaringella, L. and Radziwon, A., 2018. Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles? *Technological Forecasting and Social Change*, 136, 59-87.

Shang, T., Shi, Y., 2013. The emergence of the electric vehicle industry in Chinese Shandong Province: A research design for understanding business ecosystem capabilities. *Journal of Chinese Entrepreneurship* 5, 61–75.

Shi, Y., Gregory, M., 1998. International manufacturing networks—to develop global competitive capabilities. *Journal of Operations anagement* 16, 195–214.

Shipilov, A. and Gawer, A., 2020. Integrating Research on Interorganizational Networks and Ecosystems. Academy of Management Annals, 14(1), 92-121.

Snehota, I., Hakansson, H., 1995. *Developing relationships in business networks*. Routledge.

Sofouli, E., Vonortas, N.S., 2007. S&T Parks and business incubators in middle-sized countries: the case of Greece. *Journal of Technology Transfer* 32, 525–544.

Su, Y.-S., Hung, L.-C., 2009. Spontaneous vs. policy-driven: The origin and evolution of the biotechnology cluster. *Technological Forecasting and Social Change* 76, 608–619.

Thomas, M., 2016. Innovation ecosystems as drivers of regional innovation - validating the ecosystem [WWW Document]. URL http://www.know-hub.eu/knowledge-base/videos/innovation-ecosystems-as-drivers-of-regional-innovation-validating-the-ecosystem.html#footnote3 (accessed 5.11.2019).

Trischler, J., Johnson, K. and Kristensson, P. 2020. A service ecosystem perspective on the diffusion of sustainability-oriented user innovations. Journal of Business Research. 116, pp. 552-560.

Vargo, S.L. and Lusch, R.F., 2004. Evolving to a new dominant logic for marketing. *Journal of Marketing*, 68(1), pp.1-17.

Vargo, S.L. and Lusch, R.F., 2017. Service-dominant logic 2025. *International Journal of Research in Marketing*, 34(1), pp.46-67.

Weick, K.E., 1995. What theory is not, theorizing is. *Administrative Science Quarterly* 40, 385–390.

Weick, K.E., 1989. Theory construction as disciplined imagination. *Academy of Management Review* 14, 516–531.

Yaghmaie, P., Vanhaverbeke, W. and Roijakkers, N., 2020. Value Creation, Value Capturing, and Management Challenges in Innovation Ecosystems: A Qualitative Study of the Nano-Electronics Industry in Belgium and the Netherlands. *Journal of Business Ecosystems,* 1(1), pp.20-37.

Yang, C.-J., 2010. Launching strategy for electric vehicles: Lessons from China and Taiwan. *Technological Forecasting and Social Change* 77, 831–834.

Yin, R., 2008. *Case study research: Design and methods.* Sage Pubns.

Zhang, J., Liang, X.-J., 2011. Business ecosystem strategies of mobile network operators in the 3G era: The case of China Mobile. *Telecommunications Policy* 35, 156–171.

Zhang, Y., Gregory, M., Shi, Y.J., 2007. Global engineering networks: the integrating framework and key patterns. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 221, 1269–1283.

Table 1. 4C framework of analysing a RIE

		System approach	**Ecosystem approach**
Construct	Industrial system as value network	Examine the activities like entrepreneurship and network within the industrial system in a relatively independent way (Feldman et al., 2005; Su and Hung, 2009).	Extend the researches from entrepreneurship and network to a systematic perspective of the value network from R&D, production to sales in the value network (Battistella et al., 2013; Rong et al., 2015).
	Community network	Identify the key elements of the community network like social capital, financial capital and human capital (Cooke, 2001; Knight and Yueh, 2008).	Explore the interrelated and co-evolution of social capital, financial capital and human capital within a community (Cooke et al., 1997; Iansiti and Levien, 2004).
Cooperation	Industrial transformation	Focus on the support of the resource pool to the value network (Belussi et al., 2010; Boschma and Ter Wal, 2007).	Highlight the industrial dynamics supported by mixed Stakeholders' powers (Cooke, 2001; Iansiti and Levien, 2004).
	Industrial feedback	The activities in the value network reward the resource pool (Cooke et al., 1997; Etzkowitz and Leydesdorff, 2000).	Highlight the co-evolution and adaptation of the value network to the community network (Geels, 2005; Moore, 1993).
Configuration	Spontaneous configuration pattern	Emerged from the spontaneous co-presence of key factors (Chiaroni and Chiesa, 2006).	Emerged from the dynamic and complex interrelations of key factors (Nachira et al., 2007).
	Policy-driven configuration pattern	Triggered by the strong commitment of governmental actors whose willingness is to set the conditions for the cluster creation (Huang et al., 2012; Yang, 2010).	Triggered by the government's endeavour of nurturing related stakeholders to enable the growth of the innovation system (Rothschild, 1990).
	hybrid configuration pattern	Triggered by the hybrid configuration patterns of spontaneous and policy-driven (Huang et al., 2012).	Triggered by the co-evolution of key factors in hybrid configuration patterns (Richardson et al., 2012).
Capability	Complementary capability	Addressed the capability of manufacturing efficiency. Overlook the capability of accessing complementary resources (Lin et al., 2009).	The capability that coordinates ecosystem stakeholders (Lorenzoni and Lipparini, 1999).
	Connection capability	Emphasized the capability of internal interactions. Neglected the capability of external connections (Zhang and Liang, 2011).	The capability of building connections with external actors and RISs (Gawer and Cusumano, 2014; Rong et al., 2015).

Table 2. Case selection criteria for case studies

Case selection criteria	RIE 1 – Shenzhen	RIE 2 - Shandong	RIE 3 - Shanghai ZJHP
1) Most representative in certain region	Yes, Pearl river delta	Yes, Bohai delta	Yes, Yangtze river delta
2) Key process	Several projects towards mobile computing	Several projects towards EV	Mainly focus on semiconductor manufacturing industry, and towards chipset design
3) Typical firms	MTK; Kenxinda; White-brand OEM	Shifeng; Baoya; Tangjun	SMIC; HHNEC; Spreadturm
4) Focal firm and stakeholders' interaction	Focal firm; various stakeholders interaction	Focal firm; various stakeholders interaction	Focal firm; various stakeholders interaction
5) Data available	Primary and secondary data	Primary and secondary data	Primary and secondary data

Table 3. Interview list

	Key firms	Firm type	Roles of interviewee	Number of interviewees, followed by email communication	Average time (hrs/person)	Total (hrs)
RIE 1: Shenzhen	MTK	Chip design	Marketing director, project manager	3	2	6
	Kenxinda	Mobile phone manufacturer	CEO, COO, project manager	3	4	12
	White-brand OEM	Mobile phone manufacturer	CEO; marketing manager; project manager	3	3	9
RIE 2: Shandong	Shifeng	Low-speed EV manufacturer	COO, EV project manager	3	2	6
	Baoya	Low-speed EV manufacturer	CEO, COO, Department director; Project manager	5	2	10
	Tangjun	Low-speed EV manufacturer	Marketing director, Business Development Manager and two assistants	4	2	8
RIE 3 Shanghai	HHNEC	Chip foundry	CEO, CFO, COO	4	1.5	6
	Spreadturm	IC design	Vice president, Director	3	1	3
	SMIC	Chip foundry	Vice president, Director,	3	1	3
In total				31 Interviewee		63 hours

Table 4. Data mapping of each RIE

RIE	Case company	Construct	Cooperation	Configuration	Capability
Shenzhen	MTK	Local manufacturing network, Shanghai design, Taiwan Foundry park	MTK experienced the Shenzhen industry transformation	Shenzhen RIE was initiated by the central government, mainly depend on the thousands of firms (suppliers)	Complementary to local and national level; connection with other RIE
	Kenxinda	Local manufacturing network, Shanghai Design Centre, agents for the global market	Experienced the Shenzhen RIE evolution from mobile 2G phone towards smartphone	Shenzhen RIE was initiated by the central government, now mainly depend on the local entrepreneurs	Global marketing in middle-east, Russia; local connection and national wide connection with Shanghai Spreadtrum
	White-brand OEM	Acted as Mobile OEM, local supply chain	Coordination of the local supply chain, experience the mobile and netbook industry	Shenzhen RIE was initiated by the central government, mainly depend on the local entrepreneurs; the local government also support	National level connection and also outsource the design to Shanghai cluster; export to African countries
Shandong	Shifeng	The focal firm, national wide research institute, financial capital, strong community network	Dominated by Shifeng, embedded into the local market, from an agriculture use vehicle towards a business one and electric vehicles	Strongly supported by the local government, mainly triggered by the local rural market	Local embeddedness and national connection with car design and batteries supplier
	Baoya	Focal firm, research alliance with universities, batteries joint venture, strong community network and financial capital	Work closely with the local market and global market, get feedback and renew the three-wheel, beach car towards electric vehicles	Mainly developed by the entrepreneurship, in the late stage, they got access to local government support	Complementary locally and connect to national wide suppliers, the global market
	Tangjun	The focal firm, research alliance with universities, national wide suppliers, government funds	Experienced the Shandong RIS from the vehicle for business use towards the electric vehicles; close to the local and nearby provincial market	A state-owned enterprise got sponsorship from local government, but mainly developed by their own entrepreneurship	Complementary local partners and connect national wide suppliers, connect to the provincial markets
ZJHP	SMIC	The focal firm, hybrid funding	Coordination of the local and global suppliers	Mainly developed by the entrepreneurship, in the late stage, they got access to the central local government support	Complementary to the global market, and recently to the local market
	Spreadtrum	The focal firm, overseas funding, local and global partners in and outside the park	Experienced the recent development phases to indigenous innovation	Mainly developed by the entrepreneurship, in the late stage, they got access to central and local government support	Local connection and national wide connection with local phone vendors
	HHNEC	The focal firm, government with orders, and funds, local partners in the park	Experienced most of the development phases within the park, mainly focus on the semiconductor industry	Owned sponsorship from the government; took the market orders from the government, for example, the chips for the 2nd generation ID card.	Complementary local partners and connect national wide suppliers, connect to the government controlled market

Figure 1 Research framework for exploring the RIE

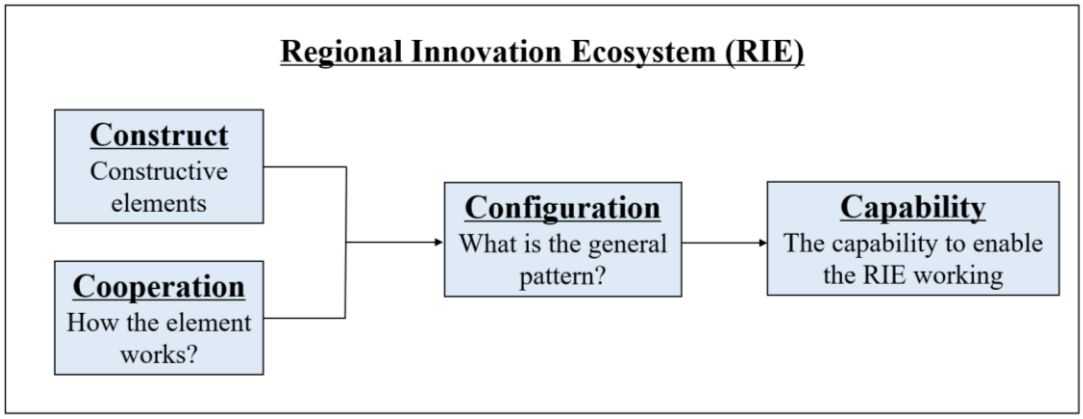

Figure 2 The typical cases in each RIE and their development routes

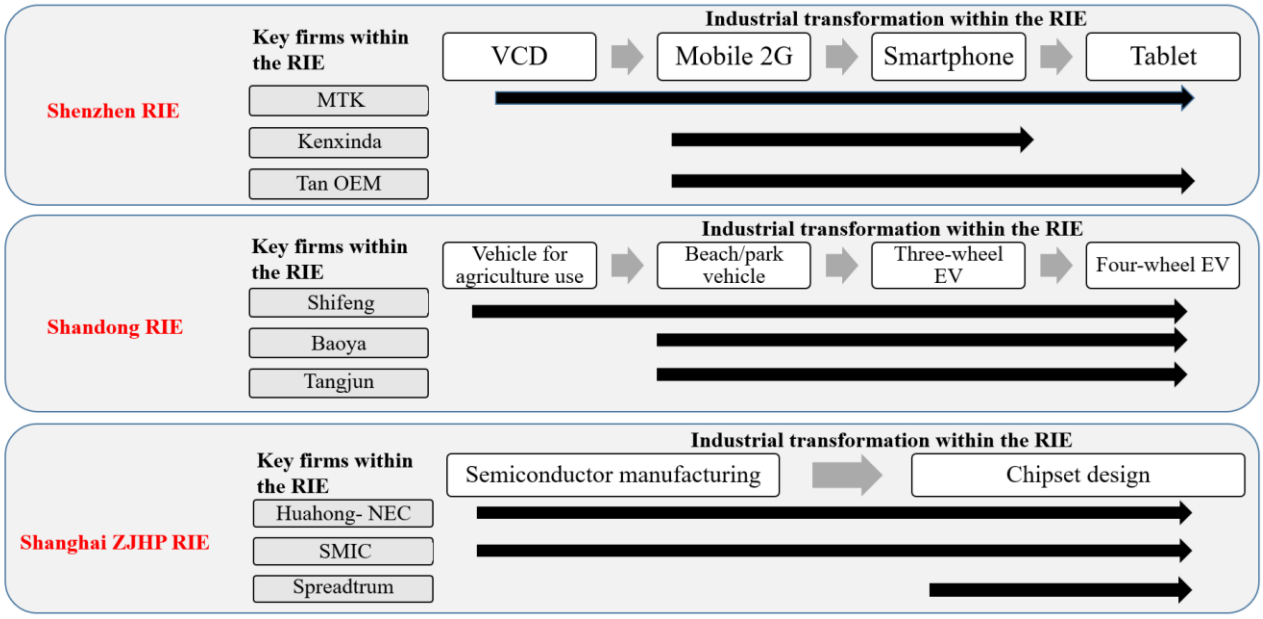

Figure 3 The dynamic nature of a RIE

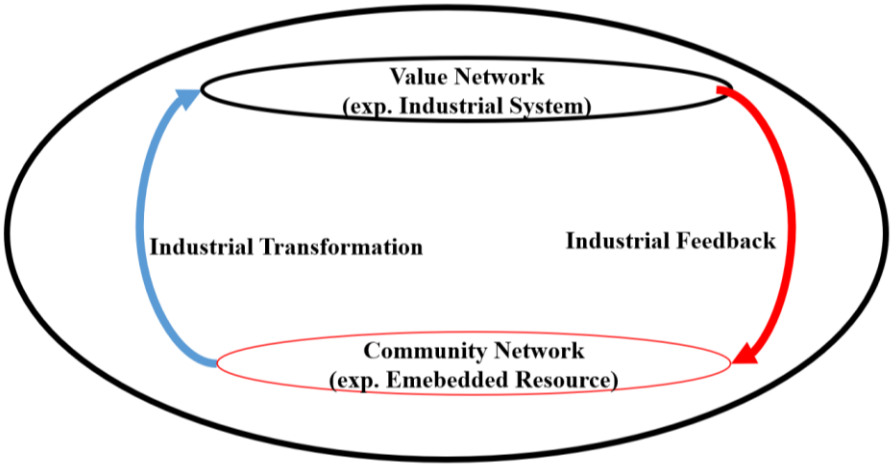

Figure 4 RIE: Integrating RIS and SIS