Title: Knowledge Orchestration and Digital Innovation Networks: Insights from the Chinese Context

Jiayuan Liu

A thesis submitted in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy

University of Warwick
Warwick Business School
November, 2017

Table of Contents

Table of Contents……i

List of Tables……..iii

List of Figures……iv

Acknowledgements……v

Declarations……...vi

Publication……...…..……..viii

Abstract……..ix

CHAPTER 1 Introduction……...……1

CHAPTER 2 Literature Review……..…12

2.1 Digital Innovation……..12

2.2 Digital Innovation Networks……15

2.3 Material and Symbolic Artefacts in Digital Innovation Networks…...16

2.4 Social Network Structures of Digital Innovation Networks……..23

2.5 Knowledge Orchestration in Innovation Networks……...30

2.6 Knowledge Gap in the Literature……33

CHAPTER 3 Knowledge Orchestration and Material Artefacts: The Role of Epistemic Objects in Innovation Alliance……..……..……...…...36

3.1 Introduction……...…37

3.2 Theoretical Background……38

3.3 Research Model and Hypothesis Development……...42

3.4 Research Methods and Results……45

3.5 Discussion and Implications……..54

3.6 Conclusion……..58

CHAPTER 4 Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation……...……...……59

4.1 Introduction……60

4.2 Theoretical Background……61

4.3 Research Design……70

4.4 Research Results……74

4.5 Discussion and Conclusions……..81

CHAPTER 5 When *Guanxi* Meets Structural Holes…..……...…86

5.1 Introduction……...87

5.2 Literature Review……..89
5.3 Methords……99
5.4 Results……..……106
5.5 Discussion and Conclusions……116
CHAPTER 6 Conclusion……...124
6.1 Summary of Contributions……124
6.2 Theoretical and Practical Implications……..133
REFERENCES……...146

List of Tables

Table 1.1 A summary of the three studies of the thesis……..……10
Table 3.1 Summary results of measurement model……53
Table 4.1 Summary results of the measurement model……..76
Table 5.1 Demographic profiles of the two types of survey respondents……101
Table 5.2 Demographic characteritics of the participating interviewees…….102
Table 5.3 Summary of the measurement model results of the two samples…….108

List of Figures

Figure 3.1 Research model…….43
Figure 3.2 Project Architecture Figure (PAF)……... 48
Figure 3.3 Summary results of hypothesis testing…….53
Figure 3.4 How epistemic objects coordinate the knowledge heterogeneity…….54
Figure 4.1 Result of the structural model……...77
Figure 5.1 Research model…….92
Figure 5.2 Summary of the results of hypothesis testing of the two samples……..109
Figure 5.3 The moderating effect of business *guanxi*……..110

Acknowledgements

I wish to sincerely thank all those who have contributed in one way or another to this study. First of all, words can only inadequately express my deep gratitude to my first supervisor, Professor Joe Nandhakumar, for his meticulous care, kindness and generosity. His fruitful comments and insightful suggestions have been a crucial formative influence on my present study. He has supported me in every possible way since the beginning of my research. After I took a gap year, he re-accepted me and gave me a second chance. His critical reading of my writing has saved me from a large number of errors. Without his guidance and encouragement, my research would have never come out in the present form. I have regarded him as a devoted scholar and simultaneously a supportive family. It also has been a memorable and enjoyable experience for me to work with him.

Second, I would like to express my sincere gratitude to my second supervisor Dr. Markos Zachariadis, for his continuous support of my Ph.D study and related research, for his patience, motivation, and immense knowledge. His guidance in mixed-methods research approach helped me in all the time of research and writing of this thesis. I could not have imagined having a better mentor for my Ph.D study.

Apart from my supervisors, I would like to thank Professor Ola Henfridsson, Dr. Maha Shaikh, and Dr. Jimmy Huang, the staff of Information Systems & Management Group in Warwick Business School, for their incessant inspiration, expert guidance, invaluable suggestions, and, above all, their moral support.

I would also like to take this opportunity to thank Dr. Stephen Smithson and Professor Ola Henfridsson - my viva examiners, for their very helpful comments and suggestions.

Finally, appreciation to my dearest parents and closest friends, Shiqi Xu, and NFarahin Ali for their constant encouragement and company.

Declarations

I hereby declare that this Ph.D. thesis entitled **"Knowledge Orchestration and Digital Innovation Networks: Insights from the Chinese Context"** was carried out by me for the degree of Doctor of Philosophy in English under the guidance and supervision of Professor Joe Nandhakumar, the Professor of Information Systems in Warwick Business School, The University of Warwick, UK, and Dr. Markos Zachariadis, the Associate Professor of Information Systems in Warwick Business School, The University of Warwick, UK.

The interpretations put forth are based on my reading and understanding of the original texts and they are not published anywhere in the form of books, monographs or articles. The other books, articles and websites, which I have made use of are acknowledged at the respective place in the text.

For the present thesis, which I am submitting to the University of Warwick, no degree or diploma or distinction has been conferred on me before, either in this or in any other University.

Place: Coventry, UK

Date: November 2017

Research Student: Jiayuan Liu

Publication

Liu, J., Nandhakumar, J. and Zachariadis, M. (2017), "'*Guanxi*' as a Shock Absorber: Lessening the Detrimental Effect of Structural Holes on the Acquisition and Integration of Knowledge", in *Proceedings of the 25th European Conference on Information Systems (ECIS)*, Guimarães, Portugal, June 5-10, 2017 (pp. 1600-1618).

Liu, J., Nandhakumar, Joe. and Zachariadis, M. (2017), "Objects as a Trust Trigger and a Knowledge Elicitor: Coordinating the Heterogeneity and Discontinuity in Knowledge Mobilized during an IT Innovation Alliance", in *PACIS 2017 Proceedings*, pp. 42.

Liu, J. (2018), "Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation", in *Proceedings of the 11th IADIS International Conference on Information Systems.*

Liu, J., Zachariadis, M. and Nandhakumar, J. (2017), "When *Guanxi* Meets Structural Holes: The Role of Social Networks in Knowledge Orchestration among Chinese Digital Entrepreneurs", *Journal of Strategic Information Systems*, Special Issue: Digital Entrepreneurship, being under third round of review.

Liu, J. (2018), "Epistemic Objects and Knowledge Orchestration: Coordinating the Knowledge Fragmentation and Heterogeneity in Digital Innovation Networks", *Journal of Knowledge Management*, being under first round of review.

Abstract

As digital innovation increasingly pushes heterogeneous actors to connect with each other across multiple organizational and community boundaries, a doubly distributed innovation network may emerge, leading to the knowledge being too fragmented and heterogeneous. Facing this problem, I place an emphasis on material artefacts and social network structures in the cultural context of Chinese digital innovators. On the one hand, as innovation is increasingly mediated by material artefacts, I focus on epistemic objects and activity objects, which are able to motivate the process of innovation. On the other hand, as innovation transforms the network actors' social space, I focus on the role of "*guanxi*" (i.e. a system of influential relationships in Chinese culture) and structural holes (i.e. the absence of a connection between two contacts) in digital innovation networks. At the same time, as the literature recognizes knowledge orchestration as a useful starting point to address the knowledge fragmentation and heterogeneity, I identify five activities as knowledge orchestration: knowledge mobilization, knowledge coordination, knowledge sharing, knowledge acquisition and knowledge integration. As traditional tools used to support knowledge management can no longer handle the fragmented and heterogeneous knowledge, there is limited studies contributing to our understanding of how the Chinese innovators use objects and social network structures to orchestrate knowledge in their innovation networks.

With these paucities of research in mind, this thesis explores how the material objects and the social network structures orchestrate knowledge for coordinating the fragmented and heterogeneous knowledge in Chinese digital innovation networks. From the perspective of material artefacts, my first study explores how epistemic objects affect the acquisition, integration and sharing of knowledge among collaborative organizations during their IT innovation alliances. My second study explores how activity objects affect the sharing, acquisition and integration of knowledge for crowdsourced digital innovation. From a social perspective, my third study explores how *guanxi* and structural holes affect the mobilization and coordination of knowledge among Chinese digital entrepreneurs in their innovation networks. Following the three studies, I show my key contributions, and discuss my theoretical and practical implications.

CHAPTER 1 INTRODUCTION

1.1 Background and Motivation

As one of the largest markets for high-tech digital devices and smart systems in the world, China has used digital innovation as a key driver of its macroeconomic and industrial productivity growth (Leavy, 2016). According to Accenture (2016), the number of smart devices sold in China increased to 700 million during the course of 2013. Digital innovations have increasingly changed the way in which people interact with their surrounding environments. Consumer electronic devices such as smart home appliances and televisions, with their ability to connect to the internet and offer novel capabilities and experiences with the help of operating systems and apps, have become the "next new thing" (McKinsey, 2014). For example, Haier, a famous Chinese electronics brand, has created the U-home solution (a home networking & control system for new home automation and operation) for customers to control their home devices remotely, manage their utility and energy expenses, and improve their home experiences of security, lighting and entertainment[1].

Quite broadly, digital innovation is defined by Fichman et al. (2014, p. 330) as "a product, process or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT". To be more specific, digital product innovation concerns novel products or services "either embodied in IT or enabled by IT" (Fichman et al., 2014, p. 334). In order to better capture the emergent, distributed, social, communal, and networked nature of digital product innovation (von Hippel, 2005; Lyytinen et al., 2015), over the last ten years, innovation scholars such as Boland et al. (2007), Tuomi (2002) and Van De Ven et al. (1999) have adopted images of 'wakes' or 'fluids' to highlight the dynamics of innovation networks, instead of the earlier model of "push and pull" (Cooper & Zmud, 1990) based on a conceptualization of the innovation as responding to a market demand. In other words, an increasing number of studies have recognized that digital product innovation emerges 'fractally' through webs of social and technical interactions that stem from re-combinations of earlier innovations (Arthur, 2009). During

[1] "Haier Launches U-Home for Networked Homes", 2013 Haier Inc.

such a non-linear dynamic process that is “neither stable and predictable, nor stochastic and random” (Van De Ven et al., 1999), heterogeneous actors, technologies, know-how, activities and artefacts create cooperative and competitive connections, cutting across varieties of boundaries, and enabling new socio-technical ecologies (Baldwin & von Hippel, 2011; Baum et al., 2000; Chesbrough, 2006; Clark, 1985; Dougherty & Dunne, 2011; Faraj et al., 2011; Faraj & Johnson, 2011; von Hippel, 1988; von Hippel, 2005; Latour, 1987; Yoo et al., 2008). Under such circumstances, no digital product innovation could be borne out of a single idea of a single innovator. Accordingly, in order to survive in highly dynamic, uncertain and competitive markets, digital innovators tend to create an innovation network, a socio-technical system with technical malleability and social heterogeneity, that enables heterogeneous, fragile knowledge resources to connect with outside distributed communities to spur digital product innovation (Gawer & Cusumano, 2008; Yoo et al., 2010).

With digital product innovation increasingly pushing heterogeneous actors to connect with each other across multiple organizational and community boundaries, no matter how “innocent” the original intent might be (Lyytinen et al., 2015, p. 23), the innovation network is likely to eventually move towards the anarchic form - a doubly distributed innovation network - in which the organizational and technological control over product components is distributed across firms of different kinds, and where the product knowledge is distributed across heterogeneous communities and specialties (Yoo et al., 2010). In such a network, the structure and dynamics of innovation are most sophisticated, bringing with them their own challenges (Lyytinen et al., 2015). Specifically, the radical reduction of communication and coordination costs as a result of using digital technology makes affordable the participation in the innovation process of otherwise disconnected actors. This breaks the standard model of innovation into pieces, and distributes the coordination of the activities, artefacts, capacities and outcomes of innovation more widely, intensifying the difficulty of controlling the participating actors with various knowledge bases and conflicting interests (Gupta et al., 2007; Tuertscher et al., 2014; Yoo et al., 2008). In addition, the loosely coupled layers embedded in these digital innovation networks enable high levels of flexibility (Ravasi & Verona, 2001), but result in greater fragmentation of the knowledge base common to the network actors (Nätti et al., 2006). Furthermore, the convergence of pervasive digital technology combines resources and components

in unforeseeable ways, spurring generativity, which cumulatively expands the social and cognitive heterogeneity along the 'rolling edge' of the network actors' capabilities to control (Berente et al., 2007; Rammert, 2004; Yoo, 2013; Yoo et al., 2010). In this way, digital innovators drawing on doubly distributed innovation networks, are likely to encounter a serious challenge in coordinating this heterogeneity of knowledge and countering its fragmentation.

1.1.1 Material & Symbolic Artefacts and Social Network Structures

Facing knowledge fragmentation and heterogeneity, the process of digital product innovation could be highly problematic and complex, requiring effective coordination between mutually dependent cognitive and social translations (Lyytinen et al., 2015). In terms of the cognitive translation in doubly distributed innovation networks, it involves multi-disciplinary collaboration that is increasingly mediated by material and symbolic objects (e.g. sketches, documents, PowerPoint, tables, graphs, graphic figures, slide decks, flipcharts, whiteboards etc.) (Knorr-Cetina, 1997; Nicolini et al., 2012). The idea that material and symbolic objects play a significant role in collaboration and innovation work is not new. For example, Nambisan (2013) showed how sketches embody knowledge, shape the way knowledge is captured and diffused across communities and affect the innovation networks. Boland and Tenkasi (1995) found that as different actors map the knowledge into visual representations and share them with other innovators within the network, such symbolic artefacts such as graphic figures can act as a means to create and refine knowledge for innovation. Kaplan (2011) demonstrated how PowerPoint performed cartographic efforts to define the boundaries around the scope of an innovation through legitimizing certain ideas and inviting document owners including or excluding specific slides or participants (Werle & Seidl, 2015). All of these studies have revealed how material and symbolic artefacts enable particular activities while restricting others and thus structure the collaboration and innovation work.

Two of the theoretical perspectives that organization scholars in general (Engeström & Blackler, 2005; Ewenstein & Whyte, 2009; Miettinen & Virkkunen, 2005; Nicolini et al., 2012; Werle & Seidl, 2015) and innovation scholars in particular Kaplan

(2011) and Nambisan (2013) have mobilized in their studies of materiality are the theory of epistemic objects (Knorr-Cetina, 1997, 2001; Rheinberger, 1997, 2005) and that of activity objects (Engeström, 1999; Kaptelinin & Nardi, 2006; Miettinen, 2005). These two theories provide a particularly fruitful lens through which why and how the work of collaborative digital product innovation takes place in doubly distributed innovation networks can be better demonstrated. Specifically, epistemic objects and activity objects are defined by Nicolini et al. (2012, p. 625) as "primary objects of collaboration", having the capacity to show what motivated and fueled the collaborative practices of digital product innovation in the first place. In addition, these two kinds of objects are symbolic, with an ability to represent an innovation network's negotiated ideas and distributed cognition, and to structure how innovating work gets done among network actors (Henderson, 1995).

More specifically, the concept of epistemic objects is originally introduced by Rheinberger (1997), to highlight the power of material artefacts in knowledge work as driving forces. They were further defined as objects of investigation embodying what one does not yet know (Rheinberger, 2005), that is things that are not definite things whose properties emerge and evolve only during the investigation process itself, and that are therefore continually 'in the process of being materially defined' (Knorr-Cetina, 2001, p. 181). It is this lack of completeness that produces energy, and the attempt to fill this void explains the motivation of individuals in their initial search for alignment for collaboration (Nicolini et al., 2012). Ewenstein and Whyte (2009) took sketch as an example to explicate the use of epistemic objects in design and innovation work: even though the sketch embodied knowledge about design, it was not fully defined. Thus, the sketch actively attracted attention to its limitations and raised questions back to the designer for the next step. In order to respond, the designer tried various methods and evaluated their different impacts on the design, which eventually shaped the development of exploration. The role that the sketch played was therefore not only what it embedded, representing the epistemic work, but also what it did not include so that it was incomplete, wanting and open to evolve in uncharted directions.

Moving to activity objects, they stem from cultural historical activity theory, which is built on the work of Leont'ev (1978), Engeström (1999), Miettinen (2005) and

Kaptelinin and Nardi (2006). Authors endorsing this theory suggest that on the one hand, any collective human activity emerges around a specific object so that the division of labor, the identity and position each member will assume, and the tools and rules to be utilized all depend on this object; on the other hand, such an object is also the result of the practices, interests and expectations of the community that gathers around it (Miettinen, 2005). Due to its material manifestation, this object is able to retroact on the community who produced it and to "bite back" (Engeström & Blackler, 2005). To better explain how an activity object works, Nicolini et al. (2012) took a patient as the object of work of various professionals in the same hospital to make an example. Specifically, each member has a various way of constructing this object of their common activity, where for the administrator, the patient is a client to satisfy, for the nurse, the patient is a person to care for, and the surgeon sees the patient as a body to repair. The organization of care in the hospital to some extent depends on how these diverse opinions of this object are coordinated together. Eventually the unhappy patient might "bite back" (Nicolini et al. 2012; Engeström & Blackler, 2005).

At the same time, as digital product innovation emerges within a web of social relations, and as an innovation process transforms the social space of the network actors, a social translation takes place at the boundaries of communities, where actors seek to mutually modify and align their conflicting interests and perspectives into a temporary synthesis (Boland et al., 2007; Galison, 1997; Lyytinen et al., 2015). In this sense, social translations involve a constant political positioning that contains "a series of back-and-forth movements into positions within a social space" (Lyytinen et al., 2015, p. 10), thereby influencing the innovation network actors' subsequent behaviour. As a result, a focus on the social network structures of innovation networks could better explain the process and practices of digital product innovation, based on the fact that digital product innovation is "the result of well-orchestrated teams, formal and mostly informal social networks, as well as processes of intense collaboration and a tradition of prior knowledge" (Peschl & Fundneider, 2014, p. 346) and that "social structures are both mediums for and outcomes of human activities" (Nicolini et al., 2012, p. 614). In this research, I focus on the role of "*guanxi*" (i.e. a system of influential relationships and social network dynamics in Chinese culture) and structural holes (i.e. the absence of a connection between two contacts) (Burt,

1992) in Chinese digital innovation networks. Although most studies highlighting the benefits that accrue to structural holes have restricted their scope to western contexts (Burt, 1997, 2000, 2005), Scholars such as Batjargal (2005, 2010) and Xiao and Tsui (2007) highlighted that the collectivistic value of China undermines the ways in which the Chinese brokers gain their control and information benefits. However, it is not clear that whether or not such disadvantages can be buffered, when *guanxi* is bound to have a unique influence on structural holes. Hence a focus on exploring the dynamics of *guanxi* on the behaviour of Chinese digital innovators, especially those who sit at the center of their innovation networks, could enhance our understanding of the process, practices and outcomes of digital product innovation in China.

1.1.2 Knowledge Orchestration

The Information Systems (IS) literature suggests that in addition to material & symbolic artefacts and social network structures, knowledge orchestration could simultaneously be a useful means to address the knowledge fragmentation and heterogeneity in innovation networks. According to the work of Hislop et al. (2000), Kale et al. (2000), Yoo et al. (2010) and Yoo et al. (2008), networking and knowledge management are intertwined closely with each other in the achievement of digital product innovations. Hence when encountering such problems, a certain amount of orchestration, influence and direction is needed for the network actors to appropriately diffuse, acquire as well as integrate knowledge without sacrificing flexibility and independence in innovation processes. Drawing on the network orchestration model created by Dhanaraj and Parkhe (2006), who suggested a set of processes to orchestrate innovation networks in order to maximize innovation outputs, I extend their work by identifying five purposeful, deliberate and interrelated activities for knowledge orchestration - knowledge mobilization (knowledge sharing and knowledge acquisition) and knowledge coordination (knowledge integration) - which can take place in a distributed cognitive space forming a heterogeneous innovation network. Specifically, *knowledge mobilization* concerns the ease with which knowledge is transferred and accepted within the network (Dhanaraj & Parkhe, 2006; Weber & Khademian, 2008). Specifically, knowledge transfer (knowledge sharing) is predominantly referred to in the network literature as an ‘asset’ which carries value for a network (Nahapiet & Ghoshal, 1998). Particular emphasis is placed on standardizing or estab-

lishing compatible methods of communication to facilitate the sharing of this form of intellectual capital across the 'syntactic' boundaries (Carlile, 2002), from one actor to the next (Podolny & Page, 1998; Weber & Khademian, 2008). When the transferred knowledge is complex, and there is not clarity of purpose, the challenge then shifts to the acquisition of knowledge (knowledge acquisition), where a 'semantic' approach (Carlile, 2002) is needed to recognize the different ways in which each actor interprets and accepts the disseminated message. Next, knowledge coordination (knowledge integration) occurs when the full potential of the innovation network can only be realized, if and when the heterogeneous knowledge resources of independent actors are combined together and transformed into an innovation (Crossan & Inkpen, 1995; Kogut & Zander, 1996). *knowledge coordination* is defined as the extent to which the network members integrate their diverse domains of expertise (Schutz et al., 2009). Beyond a "syntactic" or "semantic" lens, Carlile (2002, p. 442) proposed a "pragmatic" view of knowledge as situated, "localized, embedded, and invested in practice". In the context of doubly distributed innovation networks, this approach to knowledge presents a challenge for the network actors, namely, fully exploring their unique local context, without losing their capacity to interrelate, leverage and transform heterogeneous types of 'hard-won', practice-based knowledge into a novel, useful, and practical innovation that spans its customary pragmatic boundaries (Carlile, 2002; Yoo et al., 2012).

1.1.3 Research Gap

With doubly distributed innovation networks emerging, the ability of traditional knowledge management tools in the "age of modularity" (Baldwin & Clark, 1997; 2000) to cope with the increasingly fragmented and heterogeneous knowledge is challenged (Yoo et al., 2008; 2010; 2012). In this way, although material and symbolic artefacts in digital innovation networks have attracted significant attention from a collection of IS scholars, there is still a lack of understanding of the interaction between relevant objects and knowledge orchestration. At the same time, understanding whether and how the social network structures of innovation networks influence the orchestration of knowledge is a critically important issue that still needs to be explored further and in more depth. Overall, within digital innovation networks, there is a dearth of studies contributing to our understanding of how Chinese

innovators utilize material & symbolic objects and social network structures to orchestrate knowledge for coordinating the knowledge fragmentation and heterogeneity, in order to better position themselves for capturing digital innovation opportunities and thriving as part of "Digital China" (Accenture, 2016). More detail on this is presented in literature review- section 2.6.

1.2 Research Aims and Research Questions

Traditional centralized activities, procedures, technologies, and tools, used to support knowledge management in the "age of modularity" (Baldwin & Clark, 1997), have limited capacity to handle the knowledge fragmentation and heterogeneity in doubly distributed innovation networks (Yoo et al., 2008; 2010; 2012). Encountered with this challenge, the IS filed has shifted its attention to the material and symbolic artefacts as well as the social network structures, based on a core idea that digital product innovations require the effective coordination of inherently intertwined cognitive and social translations (Cecez-Kecmanovic et al., 2014; Latour, 2005; Orlikowski, 2007; Orlikowski & Scott, 2008). Nevertheless, there is still a dearth of studies contributing to our understanding of how Chinese innovators utilize such objects and social network structures to influence the orchestration of knowledge in their digital innovation networks. With these paucities of research in mind, I aim to explore how the material and symbolic objects as well as the social network structures orchestrate knowledge for coordinating the fragmented and heterogeneous knowledge in doubly distributed innovation networks in the Chinese context. From the perspective of material artefacts (Leonardi et al., 2012), my research explores how epistemic objects and activity objects affect the sharing, acquisition and integration of knowledge in order to coordinate the fragmented and heterogeneous knowledge for digital product innovation; from a social perspective (Boland et al., 2007; Galison, 1997; Lyytinen et al., 2015), my investigation explores how *guanxi* and structural holes affect the mobilization and coordination of knowledge among Chinese digital innovators in their innovation networks. Hence, the dissertation addresses three research questions:

In a context where IT innovation is fluid and open to new meanings, I perceive an innovating enterprise information system as an epistemic object, which is defined as an object of investigation by virtue of its opacity, its surplus, and its material tran-

scendence (Rheinberger, 2005), and that is simultaneously an under-defined, unfolding object in collaboration. In this study, I aim to explore how epistemic objects serve to orchestrate knowledge among collaborative organizations in their IT innovation alliance networks for coordinating the knowledge heterogeneity and discontinuity.

- **RQ1 (study 1): How do epistemic objects affect knowledge acquisition, knowledge integration and knowledge sharing so as to coordinate the heterogeneity and discontinuity in knowledge that is mobilized during an IT innovation alliance?**

  As human activity is identified to be always mediated by cultural artefacts (Engeström, 1999), I shift my attention to activity objects that are partially emergent, partially fragmented and partially contradictory, and that maintain the activity around the pursuit of themselves (Miettinen, 2005). In my second study, I aim to explore how activity objects influence the sharing, acquisition and integration of knowledge for crowdsourced digital innovation.

- **RQ2 (study 2): How do activity objects orchestrate knowledge to coordinate its heterogeneity and counter its fragmentation in crowdsourced digital innovation?**

  Finally, moving the focus from the material & symbolic artefacts to the social network structures, my third study focuses on exploring the dynamics of *guanxi* on the behaviour of Chinese digital entrepreneurs, when engaged in knowledge orchestration activities, especially those who hold centrality in their innovation networks. Thus, my third study investigates how *guanxi* and structural holes influence knowledge mobilization and knowledge coordination among Chinese digital entrepreneurs in their innovation networks at different entrepreneurial stages.

- **RQ3 (study 3): How do Chinese digital entrepreneurs interact and leverage *guanxi* to orchestrate knowledge and add value to their innovation networks?**

1.3 Thesis Structure

Based on a three-paper route, this research focuses on exploring how the material & symbolic artefacts and the social network structures influence the orchestration of knowledge in order to coordinate the fragmented and heterogeneous knowledge in doubly distributed innovation networks in the Chinese context. The thesis is therefore structured in the following way. Chapter Two presents the review of literature themes that this research addresses. Chapters Three to Five presents the three studies that show the principal substantive and original content of the PhD, which are respectively entitled:

- *"Knowledge Orchestration and Material Artefacts: The Role of Epistemic Objects in IT Innovation Alliances",*

- *"Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation*", and

- *"When Guanxi Meets Structural Holes: The Role of Social Networks in Knowledge Orchestration among Chinese Digital Entrepreneurs"*.

Conclusions are presented in the Chapter Six, summarizing the research's contributions to knowledge and exploring the implications for future research and for practice. Table 1.1 presents a summary of the three studies of the thesis.

Paper Title	**Key Theme**	**Key Contribution**
"Knowledge Orchestration and Material Artefacts: The Role of Epistemic Objects in IT Innovation Alliances"	This study explores how epistemic objects orchestrate knowledge among collaborative organizations in their IT innovation alliances for coordinating the knowledge heterogeneity and dis-	1) My focus on both affective and cognitive trust triggered by epistemic objects, provides a novel source of motivation for collaborative activities of knowledge orchestration and digital innovation. 2) By recognizing epistemic objects as knowledge elicitors, I provide a new insight into identification and coordination of the knowledge heterogeneity within innovation networks. 3) By emphasizing the independent role of epistemic objects, I show an alternative to

	continuity.	human control with instrumental artifacts on collaborative practices of knowledge work and innovation.
"Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation"	The study explores how activity objects influence the sharing, acquisition and integration of knowledge for crowdsourced digital innovation.	1) it contributes a novel private-collective model for crowdsourced digital innovation with an integration of personal investment and collective action. 2) by highlighting the independent role of an activity object as a trigger for expansive learning, and a director and motivator, I contribute a novel understanding of the role of material objects and humans in crowdsourced digital innovation.
"When *Guanxi* Meets Structural Holes: The Role of Social Networks in Knowledge Orchestration among Chinese Digital Entrepreneurs"	It explores how *guanxi* and structural holes affect the mobilization and coordination of knowledge among Chinese digital entrepreneurs in doubly distributed innovation networks at different entrepreneurial stages.	1) it recognizes *guanxi* as a "shock absorber" to lessen the detrimental impacts of structural holes. 2) it uncovers the unique value that the Chinese "structural hole fillers" add to their innovation networks. 3) it presents how the "knowledge orchestrators" promote the mobilization and coordination of knowledge for maximizing the value of the innovation network. 4) it uncovers evidence of when and what type of *guanxi* is utilized the most among Chinese digital entrepreneurs.

Table 1.1 A summary of the three studies of the thesis.

CHAPTER 2 LITERATURE REVIEW

This chapter aims to demonstrate the review of literature themes that the research addresses. First, it provides a background for this research by introducing the definition and primary characteristics of digital innovation. Second, a range of relevant and significant definitions for the terms are introduced, namely digital product innovation, innovation network and doubly distributed innovation network. Third, the concepts of material and symbolic artefacts as well as social network structures are explained in more detail in the context of Chinese doubly distributed innovation networks. Fourth, a series of knowledge orchestration definitions for knowledge mobilization, and knowledge coordination are presented from the literature in the knowledge management discipline. Last, the three gaps in the literature that the research addresses are identified: 1) the interaction between epistemic objects and knowledge acquisition, knowledge integration as well as knowledge sharing among collaborative organizations during their IT innovation alliances; 2) the interaction between activity objects and knowledge sharing, knowledge acquisition as well as knowledge integration for crowdsourced digital innovation; 3) the interaction between *guanixi* & structural holes and knowledge mobilization & knowledge coordination among Chinese digital entrepreneurs in their innovation networks.

2.1 Digital Innovation

In the IS literature, a large number of scholars have defined digital innovation from different perspectives. For example, drawing on the work of Schumpeter (1934), Yoo et al. (2010, p. 725) defined digital innovation as "the carrying out of new combinations of digital and physical components to produce novel products" from the perspective of digitization. In their study, Yoo et al. (2010) highlighted a necessary condition for digital innovation as digitization which refers to the practice of converting analogue information into digital format. By giving physical products new properties of programmability, addressability, communicability, memorability, sensibility, traceability, and associability, making such digitally infused artefacts highly malleable, digitization opens up large novel domains of potential functionality (Yoo, 2010; 2009). In addition, Zammuto et al. (2007) explored digital innovation using the angle of Moore's Law, which refers to the rapid, often exponential, price-performance im-

provements in IT components (Fichman et al., 2014). Specifically, they used Moore's Law to explain the dominant enabling force of IT for digital product innovation (Zammuto et al., 2007), and considered Moore's Law as a basic enabler of disruptive innovation (Christensen, 1997) and creative destruction (Schumpeter, 1950). Furthermore, Shapiro and Varian (1999) defined digital innovation standing at the viewpoint of network effects, and highlighted that digital innovation tends to become increasingly valuable to any individual adopter in a growing adopter network because of network effects. These arise directly from network externalities among actors, and from different indirect supply-side mechanisms, allowing the participating innovators, who are part of large networks, to decrease the innovation cost and increase the innovation functionality more rapidly. Following these definitions from multiple perspectives, Fichman et al. (2014, p. 330) viewed digital innovation as a fundamental and powerful concept in the IS field and defined it as "a product, process or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT". To clarify this definition, "significant change" refers to important organizational change, and any digital technology that is new to an organization and that needs key change, is qualified as a digital innovation for that organization (Fichman et al., 2014). In past IS studies of innovation for example Utterback and Abernathy (1975), there is a central distinction between process and product innovation. In this research, I focus on digital product innovation, which primarily places an emphasis on product innovators who create new digital products, and on the different processes, artefacts, structures, cultural contexts, and social dynamics, shaping the development of innovating products (Swanson, 1994). According to Fichman et al. (2014, p. 334), digital product innovation is defined as "significantly new products or services that are either embodied in IT or enabled by IT", and examples encompass new consumer products, new enterprise information systems and existing products significantly improved by the utilization of digital technology.

2.1.1 Characteristics of Digital Product Innovation

The IS field has a tradition of dividing physical product architectures into integral and modular. By definition, an integral architecture is characterized by "a complex and overlapping mapping between functional elements and physical components,

where the interfaces between components are not standardized and are tightly coupled" (Yoo et al. 2010, p. 727). A modular architecture is characterized by "its standardized interfaces between components" (Yoo et al. 2010, p. 727). However, recent years have seen a world that is increasingly permeated with digital technology, with innovators embedding more and more digital components into physical products. A layered modular architecture (LMA) has thus emerged, defined as a hybrid between a modular architecture of a physical product and the layered architecture of digital technology (Yoo et al., 2010). Simply put, the logic of LMA is fundamentally different from that of modularity in three ways. First, with a traditional physical modular architecture, a product that is decomposed into components following a functional design hierarchy has a fixed boundary (Clark, 1985; Utterback, 1994). In contrast, with an LMA, the product boundary is fluid, and a product is usually enacted by orchestrating an ensemble of components from heterogeneous layers following multiple design hierarchies (Baldwin & von Hippel, 2011; Yoo et al., 2010). Second, in a modular architecture, a component is product specific (Yoo et al., 2010), while a component in an LMA is designed without fully knowing its final functions (Gawker, 2009; von Hippel, 2005). Third, unlike the primary goal of a modular architecture which is to reduce complexity and increase flexibility that could come from the "differences in degree" (Schilling, 2000; Simon, 1962; Yoo et al., 2010, p. 728), an LMA offers generativity, which is accomplished through loosely coupled layers, pursuing "differences in kind" (Yoo et al., 2010, p. 729). In this way, innovation with an LMA can spring up independently at any layer, which leads to cascading effects on other layers, giving rise to the distributed and combinatorial nature of digital product innovation (Baum et al., 2000; Boland et al., 2007; Chesbrough, 2006; Dougherty & Dunne, 2011; Faraj et al., 2011; Faraj & Johnson, 2011; von Hippel 1988; Kallinikos et al., 2013; Yoo, 2010; Yoo et al., 2008; Zammuto et al., 2007).

Specifically, in terms of the distributed characteristic of digital product innovation, the radical reduction of communication and coordination cost as a result of digital technology makes affordable the participation in the innovation process of otherwise disconnected actors, leading to a geographical dispersion of innovation (Gupta et al., 2007; Tuertscher et al., 2014; Yoo et al., 2008). In other words, with pervasive digital technology democratizing the innovation process, it breaks the standard model of innovation into pieces, and distributes more widely the coordination of the activities,

artefacts, capacities and outcomes of innovation (Chesbrough et al., 2006, von Hippel, 2005). In this way, the locus of innovation activities is moving more and more toward the periphery of organizations, and innovators increasingly pursue innovation outside of the organization (Yoo et al., 2012). In addition, as the almost limitless recombination of digital objects has become a new source of innovation (Arthur, 2009), the convergence of digital technology combines resources and components in unforeseeable ways, leading to the creation of combinatorial innovation. To be more specific, the digital convergence spurs generativity, that is "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain, 2006, p. 1980). In this way, with the combinatorial characteristic, digital product innovation brings together previously non-connected user experiences from otherwise separate industries, cumulatively expanding the social and cognitive heterogeneity along the 'rolling edge' of the participating innovators' ability to control (Berente et al., 2007; Yoo, 2013; Yoo et al., 2010).

2.2 Digital Innovation Networks

In order to better capture the distributed and combinatorial nature of digital product innovation (von Hippel, 2005; Lyytinen et al., 2015), over the last ten years, innovation scholars such as Boland et al. (2007), Tuomi (2002) and Van De Ven et al. (1999) have adopted images of 'wakes' or 'fluids' to highlight the dynamics of innovation networks, instead of the earlier model of "push and pull" (Cooper & Zmud, 1990) based on a conceptualization of the innovation as responding to a market demand. In other words, an increasing number of studies have recognized that digital product innovation emerges 'fractally' through webs of social and technical interactions that stem from re-combinations of earlier innovations (Arthur, 2009). During such a non-linear dynamic process that is "neither stable and predictable, nor stochastic and random" (Van De Ven et al., 1999), heterogeneous actors, technologies, know-how, activities and artefacts create cooperative and competitive connections, cutting across varieties of boundaries, and enabling new socio-technical ecologies (Baldwin & von Hippel, 2011; Baum et al., 2000; Chesbrough, 2006; Clark, 1985; Dougherty & Dunne, 2011; Faraj et al., 2011; Faraj & Johnson, 2011; von Hippel, 1988, 2005; Latour, 1987; Yoo et al., 2008). Under such circumstances, no digital product innovation could be borne out of a single idea of a single innovator. Accord-

ingly, in order to survive in highly dynamic, volatile and competitive markets, digital innovators tend to create an innovation network, forming a socio-technical system in a distributed cognitive space with technical malleability and social heterogeneity, that enables heterogeneous, fragile knowledge resources to connect with outside distributed communities to spur digital product innovation (Gawer & Cusumano, 2008; Yoo et al., 2010).

2.2.1 Doubly Distributed Innovation Networks

As digital product innovation is seen as inherently layered (Yoo et al., 2010), it increasingly pushes heterogeneous actors to connect with each other across multiple organizational and community boundaries, as well as across multiple layers to create new value-in-use, forming an innovation network (Henfridsson & Bygstad, 2013; Lessig, 2008). No matter how "innocent" the original intent might be (Lyytinen et al., 2015, p. 23), the innovation network is likely to eventually move towards the anarchic form — a doubly distributed innovation network — in which the organizational and technological control over product components is distributed across firms of different kinds, and where the product knowledge is distributed across heterogeneous communities and specialties (Yoo et al., 2010). This type of innovation network is generally populated with the most complex structure and dynamics of innovation (Lyytinen et al., 2015). As a result, in such a network, where widely dispersed, unconnected actors, with their own heterogeneous, often conflicting, perspectives and technological frames, cooperate or compete to establish novel products across multiple design hierarchies (Barrett et al., 2012; Joshi et al., 2010), the challenge is to coordinate highly heterogeneous and distributed knowledge.

2.3 Material and Symbolic Artefacts Used in Digital Innovation Networks

Within doubly distributed innovation networks, both the processes of cognitive and social translations could be highly complex and problematic (Lyytinen et al., 2015). On the one hand, the cognitive translation involves multi-disciplinary collaboration, that is recognized by Knorr-Cetina (1997) and Nicolini et al. (2012) as increasingly mediated by material artifacts and symbolic representations. Specifically, Leonardi et

al. (2012) defined material artefacts as objects that have physical and/or digital properties enduring across differences in place and time. In addition, symbolic artefacts are identified by Cole and Derry (2005) as representational objects with an ability to replace a real phenomenon in an emergent, provisional and conflictual innovation process, fulfilling the human intentions. Drawing on the work of many scholars (Barley & Tolbert, 1997; Hargadon & Sutton, 1997; Henderson, 1991; Hutchins, 1995), material objects and symbolic representations play a significant role in the process of cognitive translations in innovation networks. For example, Altshuller (1984) and Simon (1996) perceived the translation of cognitive ideas as an iterative and messy process, which is sustained, mediated, enabled and triggered by multiple kinds of objects. Nambisan (2013) highlighted that material objects are able to influence the innovation networks and to shape the way knowledge is captured and diffused across communities. Boland and Tenkasi (1995) noted that as different actors map the knowledge into representations and share them with other innovators within the network, such symbolic representations can act as a means to create and refine knowledge for innovation.

Before conceptualizing material and symbolic artefacts for digital innovation, several types of objects should first be introduced (Carlile, 2002; Knorr-Cetina, 1997; Nicolini et al., 2012; Rheinberger, 1997). For example, boundary objects serve to make collaboration possible by acting as translation and transformation devices to anchor between different intersecting communities with diverse social and technological worlds, and to meet the information needs of each of them (Carlile, 2002). Epistemic objects are defined as objects of investigation embodying what one does not yet know (Rheinberger, 1997, 2005). It is this lack of completeness that produces energy, and the attempt to fill this void explains the motivation of individuals in their initial search for alignment for collaboration (Nicolini et al., 2012). Infrastructure objects are usually regarded as humble and boring things, often forgotten, involving the taken-for-granted equipment and tools (Star, 1999), but they constitute the foundations of daily work activities (Orlikowski, 2007). Moving on to activity objects, they are, according to cultural historical activity theory, able to mediate any human activity, by enabling purposeful action, connecting agents to their social surroundings, and embedding into the activity the history that they embody (Engeström, 1999; Nicolini et al., 2012). At the same time, human activity is also oriented toward a cultural arte-

fact, recognized as a prospective outcome that motivates and directs the activity (Kaptelinin & Nardi, 2006).

In this research, I place an emphasis on epistemic objects and activity objects, which are identified by Nicolini et al. (2012, p. 625) as "primary objects of collaboration" in their proposed three-level framework for conceptualizing the role of objects in collaboration, with the ability to show what motivated, energized and fuelled the process of networked digital innovation, and to explain why individuals search for alignment for collaborative innovation in the first place. At the same time, such epistemic objects and activity objects are also symbolic so that they are able to represent an innovation network's negotiated ideas, and to structure how innovating work gets done among network actors (Henderson, 1995). In this way, a focus on epistemic objects and activity objects can better demonstrate why and how the collaborative practice of digital product innovation takes place in doubly distributed innovation networks.

2.3.1 Epistemic Object: A Symbolic Representation for Digital Product Innovation

Drawing on the work of Knorr-Cetina (1997; 1999) and Rheinberger (1997; 2005), the concept of epistemic objects has been identified as a particularly fruitful lens through which the collaborative work of digital innovation can be explored because it allows an investigation of the role of material and symbolic artefacts in the accomplishment of the innovation task, giving hints as to how the process of innovation can be energized and directed by such artefacts. The capacity of material and symbolic artefacts to fuel and shape the collaborative process of digital innovation derives from their being perceived as epistemic objects, a concept of which is originally introduced by Rheinberger (1997), to highlight the power of material artefacts in knowledge work as driving forces. They were further defined as objects of investigation embodying what one does not yet know (Rheinberger, 2005), that is things that are not definite things whose properties emerge and evolve only during the investigation process itself, and that are therefore continually 'in the process of being materially defined' (Knorr-Cetina, 2001, p. 181). This lack of completeness produces energy, passion as well as a desire to know. The attempt to fill this void explains the mo-

tivation why individuals initially search for alignment for collaborative innovation (Nicolini et al., 2012). Specifically, Knorr-Cetina (1997) emphasized how the open-ended nature of epistemic objects produces emotional investment and intimate attachment among collaborators by creating social bonds and bringing a deep emotional holding power, based on the fact that either the complexity caused by the innovation work needs diverse forces to be joined or the desire towards the same object forms the basis for a sense of belonging and mutual recognition. As digital product innovations need an integration of heterogeneous technical domains, and a collaboration among widely distributed actors (Choi et al., 2010), such emotional attachment is not restricted to individuals but performed as an engine of solidarity, a collective obligation and an emotional affiliation, constituting a morally binding force among collaborative innovators. Hence, any infringement of the collaboration may be perceived as an infraction of the collective obligations which turns a collection of participants into a 'proto-community' thereby nurturing the solidarity and fuelling the innovation process (Nicolini et al., 2012). The additional characteristic of epistemic objects is their generative nature and their capacity to direct the process of investigation (Knorr-Cetina, 2001). Rennstam (2012) proposing the concept of object-control, advocated a view of epistemic objects as active creators in the initiation and realization of a knowing process through which knowledge of what to do and how to do it is elicited. By provoking knowledge puzzles, objects of investigation serve as elicitors of knowledge and invite interested actors acting via the mechanism of interpellation so as to direct the process of innovation (Law, 2000).

Before exploring epistemic objects involved in the work of digital innovation, it is necessary to introduce the concept of partial objects, originally introduced by Knorr-Cetina (2001), the material and symbolic representations of epistemic objects, which are able to provide representations of the innovation work under investigation as well as to orient and steer the process of innovation explicitly. According to Knorr-Cetina (2001, p. 182), every epistemic artefact involves 'multiple instantiations' produced during the process of innovation, used to mediate the investigation of the epistemic object and to anchor the network actors' developing understanding. By serving as representations of the epistemic object, partial artefacts display an 'order of signs' (Knorr-Cetina, 1997, p. 64) to point to further areas of exploration and to make the need for further development apparent. Werle and Seidl (2015, p. 74) further distin-

guished between two types of partial objects. Primary partial objects are used as 'representations of the overall topic'; secondary partial objects are used as 'representations of some selective aspects of the topic'. On the one hand, drawing on the work of Knorr-Cetina (2001) and Werle and Seidl (2015), I conceptualize the collaborative digital innovation project as an epistemic object being investigated by its incompleteness, and use primary partial objects such as visual presentations to represent the overall project in order to introduce the work to participants and to direct them toward areas for further exploration. During the process of innovation, the representations of the overall project account for the drive which keeps involved actors in motion by remaining themselves unfulfilled, triggering a form of desire and stimulating attachment that have a libidinal rather than calculative origin (Nicolini et al., 2012); they can also actively invite collaborative innovators engaging in a knowing process through which knowledge of what to do and how to do it is elicited (Rennstam, 2012). On the other hand, I draw on the notion of secondary partial objects to represent selective aspects of the overall project and to emphasize particular items during the process of innovation in order to mediate the investigation of primary partial objects. A range of secondary partial artefacts, perceived as immediate representations of a selective aspect of the epistemic work can be found during the process of exploration. A sketch was an instance of a secondary partial object in the work of Ewenstein and Whyte (2009): even though the sketch embodied knowledge about design, it was not fully defined. Thus, the sketch actively attracted attention to its limitations and raised questions back to the designer for the next step. In order to respond, the designer tried various methods and evaluated their differing impacts on the design, which took the shape of exploration. The role that the sketch played was therefore not only what it embedded, representing the epistemic work, but also what it did not include so that it was incomplete, wanting and open to evolve in uncharted directions.

2.3.2 Activity Object: The Object of a Collective Digital Innovation Activity

According to cultural historical activity theory built on the work of Leont'ev (1978), Engeström (1999), Miettinen (2005) and Kaptelinin and Nardi (2006), activity objects are able to mediate any human activity, by enabling purposeful action, connect-

ing agents to their social surroundings, and embedding into the activity the history that they embody (Engeström, 1999; Nicolini et al., 2012). Simultaneously, human activity is also oriented toward a cultural artefact, recognized as a prospective outcome that motivates and directs the activity (Kaptelinin & Nardi, 2006). In this way, the lens of activity objects allows an investigation of the role of cultural artefacts in the accomplishment of a collective human activity, by taking into account the social and practical origins of human productive needs, and the potentially contradictory nature of the object of a collective activity and the division of labour (Miettinen, 2005). Thus, a focus on activity objects can give hints as to why the collective digital innovation activity happens in the first place, and how individuals contribute their knowledge to the construction of the activity object, as well as how they attach their different expectations to this object.

Because an activity's object is recognized as emergent, fragmented, and contradictory, collective human activity is always maintained around the pursuit of a partially emergent, partially fragmented, and partially contradictory object (Nicolini et al., 2012). Hence, an activity object can be viewed as a conflict trigger and a director and motivator of the community that evolves and revolves around itself. Specifically, an activity object can act as a representation for collective digital innovation from three perspectives. First, because an activity object is inherently multi-faceted, fragmented, and disputed, it can create a socio-material community around itself, into which "a naturally occurring and evolving collection of people" with contradictory interests, orientations and interpretations "engage in particular kinds of activity", and "develop and share ways of doing things as a result of their joint involvement in that activity" (Galagan, 1993, p. 33). With an activity object attracting heterogeneous actors with diverse knowledge boundaries to engage in the process of innovation, a crowdsourcing community emerges that absorbs the wisdom of each actor, and triggers reflective learning (Patil & Lee, 2016). Because an activity object can be seen as a trigger of conflict due to the potentially contradictory nature of collective activity (Miettinen, 2005; Miettinen & Virkkunen, 2005), the crowdsourcing community, that is composed of actors rooted in heterogeneous worlds with weak ties (Granovetter, 1973), is not an integrated whole in which parts move in harmony, but rather is a "community without unity", in which contradictions and expansive learning abound at the same time (Nicolini et al., 2012).

Second, an activity object is partly predetermined and partly emergent, reflecting the originally embedded, and constantly evolving, interests of the actors involved (Nicolini et al., 2012). Because a cultural artefact serves as an object of a collective digital innovation activity, it enables the collective action to emerge around it according to a shared goal; simultaneously, it is also the result of the practices and expectations of the crowdsourced communities that gather around it (Miettinen, 2005). As widely distributed and heterogeneous actors engage in the process of digital innovation, an activity object is able to help them "find the signal in the noise" while avoiding irrelevant content (Paul et al., 2012). Thus, such an object acts as a moving target with the capacity to direct the collective activity (Miettinen, 2005).

Third, as Leont'ev (1978, p. 66) emphasized, "the object of an activity is its true motive". An activity object is able to motivate its crowdsourcing communities to continually engage in the process of digital innovation, thereby fuelling the collective activity. Based on the social exchange theory, which suggests that individuals take actions according to their calculated benefits and costs (Lanham, 2006), the motives for actors devoting themselves to collective activities can either be extrinsic or intrinsic (Choudhury et al., 2014). Actors who contribute high-quality knowledge to collective digital innovation, expect to improve their reputation as a form of extrinsic reward (Jin et al., 2015). Besides reputation, attention, which has become a scarce resource in the information age, is another significant extrinsic motivator (Lanham, 2006). Drawing on the idea that, in the 'attention economy', information consumes its recipients' attention, Lanham (2006) described how social communities seek to compete for each other's attention. In this way, network actors are extrinsically motivated to exchange their knowledge for reputation and attention, which can also be explained in terms of the concept of desire, drive or struggle for recognition (Hegel, 1977, 1983). Specifically, social recognition is perceived as a primary source of personal identity, which is especially significant in crowdsourced activities where division of labour is a source of individuality (Miettinen, 2005). As social recognition is identified as "esteem achieved in community life", any recognition of individuals' uniqueness is positively related to the future contribution they will make to the collective activity (Miettinen, 2005, p. 62). This is particularly true in highly distributed, virtual, crowdsourcing communities, where the recognition, acknowledgement

and reward for the contributions that members make is important in assigning identity to themselves and maintaining their communities (Lerner & Tirole, 2001). It is noteworthy that this kind of social recognition can be achieved by objectified actions and objects (Kojève, 1969). In other words, actors pursue recognition for their actions and these actions' objectifications both within a cultural activity and in wider communities (Miettinen, 2005). This is because, as actors become increasingly recognized by participating in a collective activity, such participation can be objectified in the products of their actions, with their achievements constituting the objectified demonstration of their capability to contribute to their communities and the target activity (Knorr-Cetina, 1997). Therefore, activity objects are able to realize and demonstrate the unique contributions that members make, which continuously fuels their participation in and contribution to both the activity and their communities (Miettinen, 2005). Because extrinsic benefits provide the main motivations for crowdsourcing communities to initiate the behaviour of knowledge contribution for digital innovation, intrinsic rewards involved in social exchanges that emphasize unspecified obligations, such as social affiliation and feelings of belonging, trust and self-actualization, carry more weight in their motivation of continuous engagement in the community (Sigala & Chalkiti, 2015). Nicolini et al. (2012) pointed out that activity objects can trigger intimate emotional attachment that is not restricted to individuals but is performed as an engine of solidarity, a collective obligation and an emotional affiliation, constituting a morally binding force among community members. In this way, the object of a collective activity is able to provide a "family of invisible friends" with a "home" in which a sense of loyalty can be engendered in committing to the digital innovation goal (Abrams et al., 2003). Such community affiliation, triggered by the activity object, intrinsically motivates crowdsourcing communities to identify themselves with the communal goal, while putting their self-interests aside, which fuels the impetus for them to commit to the totality.

2.4 Social Network Structures of Digital Innovation Networks

Apart from a cognitive translation, a social translation simultaneously takes place, when digital product innovation emerges within a web of social relations and transforms the social space of the network actors, where they seek to mutually modify

and align their conflicting interests and diverse perspectives into a temporary synthesis at the boundaries of different communities (Boland et al., 2007; Galison, 1997; Lyytinen et al., 2015). It can therefore be seen that social translations involve a constant political positioning, the process of which contains "a series of back-and-forth movements into positions within a social space" (Lyytinen et al., 2015, p. 10), thereby influencing the network actors' subsequent behaviour for innovation. This argument is also supported by many scholars (Bijker, 1995; Latour, 1987). For example, King and Lyytinen (2004) highlighted the nature of digital innovation as not neutral, when it reflects the involved innovators' social values and beliefs which are shaped by cultural contexts and institutional mechanisms. Peschl and Fundneider (2014, p. 346) identified digital product innovation as "the result of well-orchestrated teams, formal and mostly informal social networks, as well as processes of intense collaboration and a tradition of prior knowledge". Nicolini et al. (2012, p. 614) recognized social structures as "both mediums for and outcomes of human activities". As a result, a focus on social network structures of digital innovation networks could better explain how social structures influence the outcome of innovation, how social contexts become embedded in the process of digital product innovation, and how social transformations emerge in digital innovation networks (Yoo et al., 2008). In this research, I focus on the role of "*guanxi*" (i.e. a system of influential relationships and social network dynamics in Chinese culture) and structural holes (i.e. the absence of a connection between two contacts) (Burt, 1992) in Chinese digital innovation networks. In general, an individual who holds a nodal position in their innovation network tends to use prominence (Wasserman & Galaskiewicz, 1994) and power (Brass & Burkhardt, 1993) to perform a "prime mover" role in knowledge orchestration. Thus, structural holes theory arises that a hub actor who connects two or more otherwise disconnected individuals has more advantages than an actor who does not occupy such a central position (Burt, 1992). Although most studies highlighting the benefits that accrue to structural holes have restricted their scope to western contexts (Burt, 1997, 2000, 2005), several scholars such as Xiao and Tsui (2007) highlighted that the collectivistic values of China undermine the ways in which the Chinese brokers gain their control and information benefits. However, it is not clear that such disadvantages can be mitigated, when "*guanxi*", is bound to have a unique influence on structural holes. Hence a focus on exploring the dynamics of *guanxi* on the be-

haviour of Chinese digital innovators, especially those who stay at the center of their innovation networks, could improve our understanding of the process of digital product innovation in the Chinese context.

2.4.1 *Guanxi* in Chinese Digital Innovation Networks

As highly particularistic ties between people (King, 1991), *guanxi* involves a mechanism governing different types of relationships with different degrees of social norms. In this context, *guanxi* is viewed as a means by which people can accomplish their personal, family or business goal (Bell, 2000), and members of different *guanxi* clusters are expected to fulfil their varying role obligations (Lin, 2001). In the context of Chinese digital innovation networks, where widely distributed actors with heterogeneous cognitive and social resources compete or cooperate to innovative, I place an emphasis on two types of *guanxi*: family or friend *guanxi* and business *guanxi*. Specifically, family or friend *guanxi* where members are related by blood or are emotionally very close, is characterized by a high degree of intimacy, obligation, and expectation due to the high level of mutual trust and dependence associated with each relation (Fan, 2002). Business *guanxi*, which is based on personal gain and loss, concerns seeking business solutions via personal connections (Yang & Wang, 2011). Unlike legal contracts, such *guanxi* is unstable due to the sparse interconnections and low levels of trust having transient ties which enable people to treat each other as outsiders in one business deal (Yau et al., 2000).

Unlike traditional *guanxi* which is built for long-term cooperation with high levels of commitment (Ambler et al., 1999), nor swift relationships stressing one-time transaction in online marketplaces which are quick and shallow (Ou et al., 2014), *guanxi* between the Chinese innovators in digital innovation networks is more dynamic, highlighting that any given *guanxi* is not fixed in a given circle but that it can move outward to become more distant or inward to become closer (Chen & Chen, 2004). Thus, cultivating *guanxi* is a gradual transition process from being treated as an outsider to becoming a part of an in-group (Lee et al. 2001). Such *guanxi* inherits the traditional Confucian philosophy (Chen et al., 2004) facilitating resource mobilization, by exchanging favours, accumulating *renqing* (i.e. favour in Chinese culture) and preserving *mianzi* (i.e. face in Chinese culture) before, during or after the pro-

cess of innovation. Specifically, among all the elements measuring *guanxi*, *renqing* which highlights the social exchange nature of *guanxi*, is a lubricant for emotional and economic favour exchange in the pursuit of relational longevity; *renqing* also emphasizes reciprocity that is reflected in highly symbolic interactions, where many signals are silently embedded in mutual understanding, trust and expectation between the two sides (Wang, 2007). As Yang (1994) suggested, once *renqing* is developed, a person can ask a favour from someone with an obligation to return this favour in the future. Such reciprocal favour returns are therefore significant for maintaining *guanxi* in highly uncertain innovation networks (Luo, 2005). In addition to *renqing*, *mianzi* serving as a social currency which has an absolute value in China: giving or saving *mianzi* symbolizes the social rituals in Chinese culture, while losing *mianzi* may degrade or dissolve the *guanxi* (Hwang, 1987). Seen from the perspective of hierarchical ties, the underlying social status of *mianzi* is a fundamental aspect of favour exchange. Between two Chinese digital innovators with a dramatic difference in social power, saving the senior innovator's face means a big favour-giving which may lead to a greater favour in return for the junior innovator (Zhang & Zhang, 2006).

Shedding light on the dynamics of *guanxi* in Chinese digital innovation networks, another unique element is "in-group" relationship (Leung & Bond, 1984): The Chinese tend to make a clear distinction between people belonging in or out of a group. They impose clearly defined boundaries on network membership. Imagine two concentric circles (Tsui et al., 2000), in-group is the inner circle implying a small yet trusted network, through which an abundance of valuable resources flow in the form of favour exchange; out-group is the outside of the circles composed of outsiders. The middle space between the two concentric circles indicates *guanxi* with a potential to become an insider, but time has neither yet proven the relation strong enough nor has trust been sufficiently built (Tsui & Farh, 1997). Thus, the middle group members within innovation networks needs to invest more efforts in accumulating enough *renqing* and preserving enough *mianzi*, so as to show the willingness and capacity to become an insider (Wang, 2007). However, actors who stay at the boundary of the two in-groups may be severely disadvantaged, as both in-groups tend to distrust them and treat them as outsiders, whose behaviour of having a foot in both camps is socially disparaging (Batjargal, 2005).

2.4.2 Structural Holes in Chinese Digital Innovation Networks

Drawing on concepts such as the strength of weak ties (Granovetter, 1973), betweenness centrality (Freeman, 1977), and structural autonomy (Burt, 1980), with their roots in the western worlds, Burt (1992) defined a structural hole as the absence of a connection between two contacts who are both linked to an actor. In the context of Chinese digital innovation networks, structural holes may occur when information disseminates faster within a group than across groups (Batjargal, 2010). In reality, actors can trace merely a few number of ties while losing track of many others, due to conflicting beliefs and heterogeneous expertise (Burt, 2005). Also, brokers, intermediaries between otherwise disconnected contacts, may deliberately maintain structural holes to pursue monopolistic information and control advantages, providing them with enough space to spot and recombine digital components across multiple layers in a novel way (Burt, 2002; Verona et al., 2006). Hargadon and Sutton (1997) originally recognized the value of bridging structural holes in technological innovation by finding how technology brokers enhance their innovation outcome from their in-between vantage points. Hargadon and Sutton (2000) further introduced the concept of knowledge brokers, and revealed how they take advantage of their central positions to transfer, access, and leverage knowledge for spurring innovation. Drawing on these concepts, particular emphasis is placed on how brokers leverage structural holes between distributed and heterogeneous digital players to stimulate innovation within doubly distributed innovation networks. Echoing the traditional information advantage that accrues to structural holes (Burt, 1992, 1997), the vantage points within an innovation network help brokers achieve a knowledge advantage (Verona et al., 2006). Specifically, standing at the hub makes brokers dialogue with a range of disconnected digital actors, leverage dispersed knowledge, filter out redundant knowledge and then redistribute it for innovation (Ahuja, 2000; Regans et al., 2004). Due to the central positions at the crossroads of networks, they are early to touch the novel intelligent resources which increases their speed of innovation (Arora et al., 2002; Burt, 1999). The vantage points also help them secure rare acquaintances with valuable innovation resources, making them attractive in order to become candidates for new innovation opportunities (Burt, 1997, 2000; Verona et al., 2006).

As the most significant benefit claimed in the traditional literature, brokers can also achieve the control benefit by brokering exchanges between disconnected actors, who lack access to each other within their innovation networks (Burt, 1992; Gulati, 1999). By acting as the third party who benefits (Burt, 1992), brokers can exercise control over "whose interests are served" (Burt, 2000, p. 354), and manipulate the relations by strategically playing isolated digital players against one another (Brass et al., 1998) to expand their power for innovation.

However, excessive structural holes may expose the intermediary actors to conflicting allegiances (Podolny & Baron, 1997), increasing their difficulty in optimizing the performance for innovation. When digital innovation is distributed among heterogeneous actors, excessive structural holes induce thick boundaries to the flow of cognitive and social resources, hindering the diffusion and realization of innovation (Brown & Duguid, 2000; von Hippel, 2005). Burt (2002) argues that the high maintenance cost is another issue; unlike *guanxi* which is cultivated in the long run, structural holes chase short-term benefits, as new direct links may appear between those who have not yet known each other, leading to the decay of previous structural holes. When distributed digital actors at the periphery of the innovation network connect with the focal innovator at the core, they tend to build direct links to each other in order to reduce their dependence on the core innovator, whose brokerage benefit then is deprived (Baum et al., 2003). Hence, maintaining structural holes consumes large efforts that attenuate their primary benefits, which is consistent with the work of Batjargal (2010) who highlighted that the Chinese do not benefit from structural holes as the cost of spanning structural holes is higher than its return.

2.4.3 The Potential Effect of *Guanxi* on Structural Holes in Chinese Digital Innovation Networks

The root of structural hole theory is in Western contexts (Burt et al., 2000), but whether it is valid in Chinese culture is worth exploring, where its institutional mechanism and cultural norm is totally different from that in Western culture. In order to reduce uncertainty in immediate environments, the Chinese tend to rely heavily on their *guanxi*, which serves as a protection against dysfunctional legal systems and as a substitute for formal institutional orders (Haveman et al., 2016). The Chi-

nese also like to preserve socially proximate *guanxi* ties leading to cohesive innovation networks with poor structural holes (Batjargal, 2005). Additionally, the collectivistic values affect the ways in which the Chinese digital innovators perceive structural holes and organize their innovation networks (Luo, 2007). Embedded in Confucian culture, the control benefit can barely be realized, since the Chinese do not appreciate the brokerage. This argument is supported by many scholars. For example, Xiao & Tsui (2007) revealed that the controlling behaviour is incongruent with the dominant spirit of the Confucian philosophy. Frye (2000) found that brokerage is perceived as unethical, as it triggers competition between two contacts to maximize the broker interest. Burt (2000, p. 354) indicated that by manipulating "accurate, ambiguous, or distorted information" strategically between two sides, the broker has a "disproportionate say in whose interests are served," adding value to the broker at the expense of the group as a whole. Thus, the Chinese digital innovators with high concerns for *renqing* and *mianzi* tend to keep them away from controlling the information and relations, the behaviour of which is at the expense of deteriorating collective interest and tarnishing personal reputation within their innovation networks. Apart from attenuated control benefits, the Chinese brokers cannot fully realize their personal knowledge benefit for innovation, because the social and cognitive mechanisms that highlight communal-sharing make them attribute a significant share of the pie as the group contribution and a small proportion as the broker contribution (Verona et al., 2006; Xiao & Tsui, 2007). At the same time, although the bridging function of structural holes increases the brokers' bargaining power, the severe sanction mechanisms prevent them from taking advantage of this power to achieve their fair share (Saxenian & Quan, 2005). The two mechanisms in combination substantially decrease the material and intellectual gains from brokerage thereby reducing their returns from structural holes (Xiao & Tsui, 2007). When brokers have to bear the high cost of maintaining structural holes while gaining a low return, they actually pay more social costs in reality. As a result, the Chinese innovators are less willing to brokerage, leading to a fewer number of structural holes in their innovation networks (Burt, 1992; Davison & Ou, 2008).

However, the knowledge benefit may not disappear entirely when the intermediary actor prefers to play the role of an integrator or a hole-filler rather than a controller in brokering conditions (Verona et al., 2006; Xiao & Tsui, 2007). When different

cliques exist inside a venture or between various ventures, effective coordination and communication across boundaries is vital (Oh et al., 2004). Thus, the Chinese, with their high concerns for *renqing* and *mianzi* tend to bridge the boundaries to facilitate the information flow, and bring dispersed actors together, making the whole network share the broker benefit for innovation (Gu et al., 2008). For example, in doubly distributed innovation networks, a variety of digital innovators with their heterogeneous cognitive resources struggle to create novel components based on shared digital platforms (Yoo et al., 2010). The connection between these innovators is identified as dialogical, when each actor who follows their own innovation trajectory interlaces with one another affecting the innovation of the whole network (Yoo et al., 2008). When the middlemen at the focal node of the innovation network build new links between otherwise disconnected contacts, they foster the information flow throughout the whole network, and make separate actors access mutual knowledge resources and then recombine it in novel ways, which accelerates the progress of innovation (Arora et al., 2002). In this way, the brokers tend to become the integrators, by filling in their structural holes and turning indirect ties into direct ties to help isolated actors access knowledge, not only from their partners but also their partners' partners (Ahuja, 2000). As widely distributed actors engage with various innovation trajectories in a trading zone (Boland et al., 2007), they cross mutual pragmatic boundaries to leverage knowledge for innovation.

2.5 Knowledge Orchestration in Doubly Distributed Innovation Networks

As the knowledge resources needed for implementing a digital product innovation usually will not reside inside a single firm or a single innovator, organizations increasingly rely on collaborative networks to achieve such innovations, where each network member seeks reciprocal learning to gain a positive trade in knowledge, while protecting their core knowledge assets (Pettigrew et al., 2002). Innovation networks thus emerge where widely distributed actors with heterogeneous knowledge collaborate to innovate (Barrett et al., 2012). As innovations increasingly move toward the periphery of the network, the knowledge becomes heterogeneous and disconnected (Yoo et al., 2008). Facing the knowledge fragmentation and heterogeneity within doubly distributed innovation networks, the IS literature has sug-

gested that knowledge orchestration could be a useful means to addressing this challenge (Yoo et al. 2008, 2010). In other words, when encountering such problems, a certain amount of orchestration, influence and direction is needed for the network actors to diffuse knowledge widely and quickly, to absorb knowledge that is hard to acquire via a pure market transaction, and to combine and recombine knowledge in a novel way, without sacrificing flexibility and independence in the innovation processes (Hislop et al., 2000; Kale et al., 2000).

2.5.1 Knowledge Mobilization in Innovation Networks

Drawing on the network orchestration model proposed by Dhanaraj and Parkhe (2006), knowledge mobilization is defined as the ease with which knowledge is transferred and accepted within the network (Doz, 1996; Parolini, 1999; Weber & Khademian, 2008). Specifically, knowledge transfer is predominantly referred to in the network literature as an 'asset' which carries value for a network (Nahapiet & Ghoshal, 1998). Particular emphasis is placed on standardizing or establishing compatible methods of communication to facilitate the sharing of this form of intellectual capital across the 'syntactic' boundaries (Carlile, 2002), from one actor to the next as well as identifying the structural components of networks that accelerate or slow down this process (Podolny & Page, 1998; Weber & Khademian, 2008). When the transferred knowledge is complex, and there is not clarity of purpose, then the challenge shifts to the receipt of knowledge, where a 'semantic' approach (Carlile, 2002) is needed to recognize the different ways in which each actor interprets and accepts the disseminated message. With digital technology affording a separation of contents from network and serving as a generative memory, knowledge resources can flow across multiple medium boundaries on a real-time basis that amplifies the distribution of knowledge over innovation activities (Gupta et al., 2007; Yoo et al., 2012). Drawing on a doubly distributed innovation network, the efficiency of knowledge mobilization in alleviating the fragmented knowledge resources depends on two capacities of the network orchestrator (Colombo et al., 2006; Spender, 1992; 1996). Specifically, it is highly dependent on the network orchestrator's ability to create and maintain a certain common ground for communication and interaction in order to reduce excessive stickiness of knowledge (Nonaka, 1994). In addition, it relies on the network orchestrator's capacity to promote transparency, foster trust building and

enahnce conflict resolution in order to facilitate the fluent knowledge exchange and receipt between the network actors (Dyer & Nobeoka, 2000; Kale et al., 2000; Pittaway et al., 2004).

2.5.2 Knowledge Coordination in Innovation Networks

Knowledge coordination occurs, when the full potential of the innovation network can only be realized, if and when the heterogeneous knowledge resources of independent actors are combined together and transformed into an innovation (Crossan & Inkpen, 1995; Kogut & Zander, 1996). Knowledge coordination can be defined as the extent to which the network members leverage and integrate their diverse domains of expertise (Gold et al., 2001; Schutz et al., 2009). Beyond a 'syntactic' or 'semantic' lens, Carlile (2002) proposed a 'pragmatic' view of knowledge as situated, or 'localized, embedded, and invested in practice'. Similarly, Scott (1998) perceived this kind of knowledge as "metis" that evolves through practice and is highly dependent on the identity of those actors who develop it through practice (Weber & Khademian, 2008). In the context of doubly distributed innovation networks, this approach to knowledge presents a significant challenge for the network actors, namely fully exploring their unique local context, without losing their capacity to interrelate, coordinate and transform different types of 'hard-won', practice-based knowledge into a novel, useful, practical innovation that spans its customary pragmatic boundaries (Carlile, 2002; Yoo et al., 2012). Specifically, as innovations increasingly move toward the network periphery, the diversity of knowledge increases exponentially which leads to a situation where the common cognitive schema is too vulnerable to adequately sustain knowledge integration (Carlile, 2002; Nätti et al., 2006). At the same time, digital technology enables a separation of service from device, which allows actors to add novel functionalities to or upgrade existing functionalities from a digital product without a total overhaul of the design (Henfridsson et al., 2014). Such an affordance exacerbates the flexibility and makes the network actors tinker with heterogeneous cognitive resources in parallel, thereby intensifying the challenge for a distinctive synthesis of intelligence across the network (Kallinikos et al., 2013; Tilson et al., 2010; Yoo 2013). Under such conditions, an efficient knowledge coordination mechanism is needed to maximize the variety of contributions stemming from a diversified knowledge base while creating a culture of coher-

ence. At the same time, the efficiency of knowledge coordination depends on the capacity of the network orchestrator to act as a radar to scan, filter and enagge relevant network actors, who have an adequate common knowledge base, and yet enough variety in their intelligence, for accessing embedded knowledge with target precision and jointly transforming it for resolution (Bacheldor, 2003; Benkler, 2006; Tsai, 2001). In other words, it is significant for the orchestrator to fully explore each network member's unique local context, while maintaining their willingness to interrelate their practice-based expertise with each other, in order to leverage the knowledge heterogeneity in doubly distributed innovation networks (Carlile, 2002).

2.6 Knowledge Gap in the Literature

In conclusion, when building the literature, first, I have introduced the material & symbolic artefacts as well as social network structures within digital innovation networks by presenting a range of relevant and significant concepts including digital product innovation, doubly distributed innovation networks, epistemic objects, activity objects, *guanxi* and structural holes. Following that, I have demonstrated a series of definitions for knowledge orchestration including knowledge mobilization, and knowledge coordination, while also discussing their possible effects in the context of Chinese doubly distributed innovation networks.

Drawing on the existing literature discussed above, I present the three gaps of the thesis. First, although most studies have highlighted how the open-ended nature of epistemic objects produces the motives for collaboration, and how their generative nature directs the process of investigation (Rheinherger, 1997, 2005; Knorr-Cetina, 1997, 1999, 2001), our understanding of the relationship between epistemic objects and knowledge orchestration, as well as their interaction effect on the coordination of the heterogeneity and discontinuity in knowledge mobilized during an IT innovation alliance is still very limited. Thus, my first study aims to explore how epistemic objects affect knowledge acquisition, knowledge integration and knowledge sharing among collaborative organizations.

Second, the current literature has recognized the role of cultural artefacts in providing the direction, motivation and meaning for a collective activity (Kaptelinin &

Nardi, 2006), and demonstrated how an activity object acts as a conflict trigger, and a director and motivator of the community that evolves and revolves around itself, but our understanding of how activity objects serve to orchestrate knowledge for crowdsourced digital innovation is still very limited. In order to fill this gap, my second study explores how activity objects influence the sharing, acquisition and integration of knowledge for crowdsourced digital innovation.

Moving on from material & symbolic artefacts to social network structures, prior literature has highlighted that an individual who holds a nodal position in their innovation network tends to use prominence (Wasserman & Galaskiewicz, 1994) and power (Brass & Burkhardt, 1993) to perform a "prime mover" role in knowledge orchestration. Thus, structural holes theory arises that a hub actor who connects two or more otherwise disconnected individuals has more advantages than an actor who does not occupy such a central position (Burt, 1992). Although most studies highlighting the benefits that accrue to structural holes have restricted their scope to western contexts (Burt, 1997, 2000, 2005), several scholars such as Batjargal (2005, 2010) and Xiao and Tsui (2007) suggested that the collectivistic values of China undermine the ways in which the Chinese brokers gain their control and information benefits. However, it is not clear that whether or not such disadvantages can be mitigated, and how *guanxi* moderates the detrimental impacts of structural holes on the orchestration of knowledge among Chinese digital entrepreneurs at different entrepreneurial stages remains largely unexplored thus far. In order to fill this third gap, my third study aims to explore how *guanxi* and structural holes influence knowledge mobilization and knowledge coordination among Chinese digital entrepreneurs in their innovation networks for coordinating knowledge heterogeneity and countering its fragmentation.

As a result, the knowledge gap in the literature is identified, that is simultaneously my contribution target grounded on the literature. Specifically, my contribution target is divided into two parts. From the perspective of material artefacts (Leonardi et al., 2012), there is little work of the studies contributing to presenting how epistemic objects and activity objects serve to coordinate the fragmented and heterogeneous knowledge for digital innovation, which still needs to be explored further for gap filling. From a social perspective (Boland et al., 2007; Galison, 1997; Lyytinen et al.,

2015), understanding how *guanxi* and structural holes influence the orchestration of knowledge in Chinese doubly distributed innovation networks is a critically important contribution target that still needs to be investigated in more depth. It can therefore be concluded that there is still a dearth of studies contributing to our understanding of how Chinese digital innovators utilize material & symbolic artefacts, as well as social network structures, to orchestrate knowledge in order to coordinate the fragmented and heterogeneous knowledge in doubly distributed innovation networks in the Chinese context.

CHAPTER 3 Knowledge Orchestration and Material Artefacts: The Role of Epistemic Objects in IT Innovation Alliances[2]

Abstract

As organizations are increasingly relying on inter-firm collaborative networks such as strategic alliances to pursue information technology (IT) innovation, a significant challenge is to coordinate the knowledge heterogeneity and discontinuity. Facing this problem, scholars suggest that epistemic objects- defined as objects of investigation that are under-defined, unfolding objects in collaboration- could provide a solution, but we have only limited insights into the relationship between epistemic objects and knowledge orchestration in IT innovation alliances. By using a mixed-methods research approach, we found that epistemic objects facilitate inter-firm acquisition, integration and sharing of knowledge. We make three contributions: 1) our focus on both affective and cognitive trust triggered by epistemic objects, provides a novel source of motivation for collaborative knowledge and innovation activities. 2) Our recognition of epistemic objects as knowledge elicitors provides a new insight into identification and coordination of knowledge heterogeneity within innovation networks; 3) we highlight the independent role of epistemic objects that present an alternative to human control with instrumental artifacts on collaborative knowledge and innovation work.

[2]Liu, J., Nandhakumar, Joe. and Zachariadis, M. (2017), "Objects as a Trust Trigger and a Knowledge Elicitor: Coordinating the Heterogeneity and Discontinuity in Knowledge Mobilized during an IT Innovation Alliance", in *PACIS 2017 Proceedings*, pp. 42.

3.1 Introduction

As the resources needed for developing an information technology (IT) innovation usually will not reside inside a single firm, organizations are increasingly relying on inter-firm collaborative networks such as strategic alliances to pursue such innovations (Baum et al., 2000; Yoo et al., 2008). Thus, a significant challenge arises: to coordinate the heterogeneity and discontinuity in knowledge that is mobilized during an innovation (Yoo et al., 2010). With collaborative knowledge orchestration activities are increasingly mediated by material artefacts, scholars who have contributed to a general appreciation of the need to study the strategic utilization of epistemic objects, defined as objects of investigation "by virtue of their opacity, their surplus, their material transcendence" (Rheinberger, 2005, p. 406) that are under-defined, unfolding objects in collaboration, suggested that they could provide a solution to this problem (Engeström & Blackler, 2005; Ewenstein & Whyte, 2009). However, most studies have given prominence to the role of epistemic objects in providing the motives for collaboration (Rheinherger, 1997, 2005; Knorr-Cetina, 1997, 1999, 2001), our understanding of the relationship between epistemic objects and knowledge orchestration, as well as their interaction effect on the coordination of the heterogeneity and discontinuity in knowledge mobilized during an innovation is still very limited. In order to fill the gap, we conceptualize collaborative knowledge orchestration as inter-firm knowledge acquisition, knowledge integration and knowledge sharing, fuelled and shaped by epistemic objects. These activities take place in a distributed, heterogeneous cognitive space forming an IT innovation alliance network. Thus, our research question is: how do epistemic objects affect knowledge acquisition, knowledge integration and knowledge sharing so as to coordinate the heterogeneity and discontinuity in knowledge that is mobilized during an IT innovation alliance? The rest of the paper is organized as follows. Next, we review the literature; then we develop a model with three hypotheses based on the existing literature; following that we conduct a case study with semi-structured interviews to enrich the model, and we use surveys to test the hypotheses; finally, we show our discussion with theoretical and practical implications.

3.2 Theoretical Background

To understand better the relationship between epistemic objects and knowledge orchestration, as well as their interaction effect on the coordination of the knowledge heterogeneity and discontinuity, our literature review expands across two themes: conceptualizing epistemic objects and knowledge orchestration in IT innovation alliances.

3.2.1 Conceptualizing Epistemic Objects in IT Innovation Alliances

In this study, we define IT innovation alliances as formalized collaborative arrangement among multiple organizations in order to develop jointly innovative information systems, which need an integration of diverse intersecting technical domains, and a close collaboration between system integrators, line employees, IT experts and end-users (Choi et al., 2010; Levina, 2005). Drawing on the work of Knorr-Cetina (1997, 1999) and Rheinberger (1997, 2005), we identify the concept of epistemic objects as a particularly fruitful lens through which a collaborative work of IT innovation can be explored in that it allows the role of material objects to be investigated in the accomplishment of the innovation task and it gives hints how the process of innovation can be energized and directed by such artefacts. The capacity of material objects to fuel and shape the collaborative practice of IT innovation derives from their being perceived as epistemic objects, the concept of which is originally introduced by Rheinberger (1997), to highlight the power of material artefacts in knowledge work as driving forces. They are further defined as objects of investigation embodying what one does not yet know (Rheinberger, 2005), which are not definite things whose properties emerge and evolve only during the process of investigation itself, and hence continually “in the process of being materially defined” (Knorr-Cetina, 2001, p. 181). This lack of completeness produces energy, passion as well as a desire to know, and the attempt to fill this void explains the motivation why individuals initially search for alignment for innovation (Nicolini et al., 2012). Specifically, Knorr-Cetina (1997) highlighted how the open-ended nature of epistemic objects produces emotional investment and intimate attachment among collaborators by creating social bonds and bringing a deep emotional holding power, based on the

fact that either the complexity caused by the innovation work needs diverse forces to be joined or the desire towards the same object forms the basis for a sense of belonging and mutual recognition. As IT innovations need an integration of heterogeneous technical domains, and a collaboration among widely distributed actors (Choi et al., 2010), such emotional attachment is not restricted to individuals but performed as an engine of solidarity, a collective obligation and an emotional affiliation, constituting a morally binding force among collaborators. Hence, any infringement of the collaboration may be perceived as an infraction of the collective obligations which turns a collection of participants into a 'proto-community' thereby nurturing the solidarity and fuelling the process of innovation (Nicolini et al., 2012). The additional characteristic of epistemic objects is their generative nature and their capacity to direct the process of investigation (Knorr-Cetina, 2001). Rennstam (2012) proposing the concept of object-control, advocated a view of epistemic objects as active creators in the initiation and realization of a knowing process through which knowledge of what to do and how to do it is elicited. By provoking knowledge puzzles, objects of investigation serve as elicitors of knowledge and invite interested actors acting via the mechanism of interpellation so as to direct the process of innovation (Law, 2000).

Before exploring epistemic objects involved in the practices of IT innovation, we first introduce the concept of partial objects originally raised by Knorr-Cetina (2001), the material representations of epistemic objects, which are able to provide representations of the innovation work under investigation as well as to orient and steer the process of innovation explicitly. According to Knorr-Cetina (2001, p. 182), every epistemic artefact involves "multiple instantiations" produced during the process of innovation, which are used to mediate the investigation of the epistemic object and to anchor the developing understanding of the project team. By serving as representations of the epistemic object, partial artefacts display an "order of signs" (Knorr-Cetina, 1997, p. 64) to point to further areas of exploration and to make the need apparent for further development. Werle and Seidl (2015, p. 74) further distinguished between two types of partial objects as primary partial objects, which are used as "representations of the overall topic", and secondary partial objects used as "representations of some selective aspects of the topic". Drawing on the work of Knorr-Cetina (2001) and Werle and Seidl (2015), on the one hand, we conceptualize the collaborative IT innovation project as an epistemic object being investigated by

its incompleteness, and use primary partial objects such as visual presentations to represent the overall project in order to introduce the project to its participants and to direct them toward areas for further exploration. During the process of innovation, the representations of the overall project account for the drive keeping involved actors in motion by remaining themselves unfulfilled, triggering a form of desire and stimulating attachment that have a libidinal rather than calculative origin (Nicolini et al., 2012); they can also actively invite collaborators engaging in a knowing process through which knowledge of what to do and how to do it is elicited (Rennstam, 2012). On the other hand, we draw on secondary partial objects to represent selective aspects of the overall project and to emphasize particular items during the process of innovation in order to mediate the investigation of primary partial objects. A range of secondary partial artefacts, perceived as immediate representations of a selective aspect of the epistemic work can be found during the process of exploration. A sketch was an instance of a secondary partial object in the work of Ewenstein and Whyte (2009): though the sketch embodied knowledge about design, it was not totally defined. Thus, the sketch actively attracted attention to its limitations and raised questions back to the designer for the next step. In order to respond, the designer tried various methods and evaluated their differing impacts on the design, which took the shape of exploration. Hence the role that the sketch played was not only what it embedded representing the epistemic work but also what it did not include so that it was incomplete, wanting and open to evolve in uncharted directions.

3.2.2 Inter-firm Knowledge Orchestration in IT Innovation Networks

As the knowledge needed for implementing an information technology (IT) innovation usually will not reside inside a single firm, increasing organizations prefer strategic alliances achieving such innovations by which each partner seeks reciprocal learning in order to gain a positive trade in knowledge while with the protection of their core resources (Pettigrew et al., 2002). An innovation network thus occurs where widely distributed actors with heterogeneous knowledge collaborate to innovate (Barrett et al., 2012). As innovations are increasingly moving toward the periphery of the network, the knowledge becomes heterogeneous and disconnected (Yoo et al., 2008). Therefore, the success of collaborative IT innovation relies on the

capacity of the project group to absorb knowledge that is hard to acquire via a pure market transaction, to integrate it in a novel way, and to diffuse it widely and quickly (Kale et al., 2000). Central to knowledge orchestration, we identify three activities: knowledge acquisition, knowledge integration, and knowledge sharing.

Firstly, *knowledge acquisition*, described as the gateway to knowledge management, concerns for the process of accessing, absorbing and securing knowledge from external resources so as to increase the depth and breadth of knowledge available to the firms (March, 1991). Thus, the efficiency of organizations to assimilate essential knowledge depends on their ability to act as radar to scan the alliance network quickly and to detect the precise knowledge required from a myriad of alternatives (Bacheldor, 2003).

Second, *knowledge integration* is a process where alliance firms access the stock of knowledge of each other to develop novel associations between heterogeneous, disconnected knowledge in order to create new value based on their understandings of the business environments (Yang, 2005). Many studies have highlighted its importance to IT innovation. For example, Sammarra and Biggiero (2008) believed that innovation is an inter-functional and interdisciplinary complex process requiring the combination and recombination of discrete, diverse pieces of knowledge. As the volume, domain and diversity of knowledge has increased exponentially during the process of innovation, the efficiency of knowledge integration relies on those collaborative firms' ability to tinker with heterogeneous cognitive resources in parallel, and to engage in a learning process where critical reflexivity is inspired and those things taken for granted are questioned (Gold et al., 2001; Yoo et al., 2010).

Last, *knowledge sharing* concerns for the process by which alliance organizations identify and communicate their various information (Lynn et al., 2000). It is conducive to spurring innovation, because the emergence of new ideas can be diffuse, cascading knowledge through the network and providing access across the syntactic boundaries to a more diverse group of actors (Okhuysen & Eisenhardt, 2002). Nonaka and Takeuchi (1995) believed that employees tend to disseminate their learned new knowledge beyond their working environments so as to achieve organizational knowledge sharing. From the view of organizational learning, when technical know-

how is diffused throughout the network, the learning effect expands from the level of an individual or an organization to the level of the innovation network, which in turn facilitates the flow of knowledge and increases the depth of the synergistic learning among the alliance partners (Crossan et al., 1999). Thus, the outcome of knowledge sharing depends on the ability of collaborative firms to pass down idiosyncratic knowledge from the central network to each person (Hsu, 2008).

Drawing on the existing literature discussed above, although scholars have pointed out the power that epistemic objects have to produce emotional attachment to fuel the practice of innovation (Knorr-Cetina, 1997; Nicolini et al., 2012; Rheinherger, 1997), as well as to initiate a knowing process where knowledge of what to do and how to do it is elicited to direct the process of innovation (Law, 2000; Rennstam, 2012), our insight into how epistemic objects affect knowledge orchestration so as to coordinate the heterogeneous and disconnected knowledge mobilized during an innovation is still very limited. There is thus a need for further understanding of the relationship between epistemic objects and knowledge acquisition, knowledge integration and knowledge sharing in IT innovation alliances to answer our research question. Next, we will discuss in more detail how these affect one another and develop our hypotheses based on the literature.

3.3 Research Model and Hypothesis Development

Our model (Figure 3.1) explores the relation between epistemic objects and knowledge orchestration in IT innovation alliances. Specifically, we construct three hypotheses regarding the impact of epistemic objects on knowledge acquisition, knowledge integration and knowledge sharing at the inter-firm level.

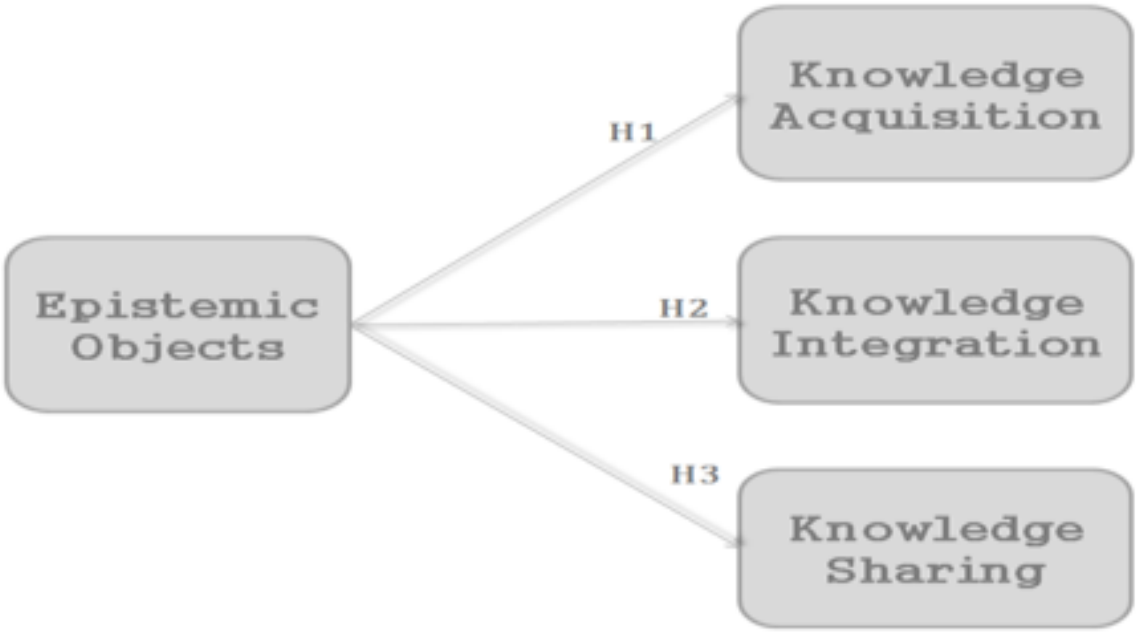

Figure 3.1. Research Model.

Regarding the characteristics of epistemic objects, we hypothesize that they could foster inter-firm knowledge orchestration in IT innovation alliances for two reasons. First, by creating social bonds and inducing a deep emotional holding power, epistemic objects produce emotional investment and intimate attachment among the collaborative partners (Knorr-Cetina, 1997); simultaneously the desire towards the same artefact forms the basis for a sense of belonging and mutual recognition so that a high degree of trust likely emerges which is perceived as a prerequisite to promoting knowledge management. Many scholars have showed support for this argument. For instance, Inkpen and Currall (1998) found that when alliance firms are inter-embedded into the network with a strong level of trust, they are more willing to commit cognitive resources to foster the assimilation of knowledge. Parkhe (1993) emphasized that the lock-in effect triggered by the intimate collaboration enables the information to mobilize quickly throughout the network and accelerates the flow of knowledge among alliance members, thereby making them absorb knowledge more easily. In addition, McEvily and Marcus (2005) highlighted that strong trust and promise provides alliance members an environment conducive to knowledge leverage, where the sources and recipients are more inclined to credit each other's ideas for joint problem-solving and less engage in cost-benefit calculus before investing

their time in an alliance; in this way, the diffusion of diverse interpretations of problems and solutions is enhanced, which fosters the development of involving members' shared understanding and promotes the integration of heterogeneous knowledge. Some other scholars also demonstrated implicit support. For example, a high trust (Molm et al., 1999), an intimate network and a strong promise (Yang, 2005) among partners are related positively to knowledge combination and recombination. Furthermore, Nonaka (1994) emphasized the role of trust in triggering open, influential and substantive knowledge sharing by alleviating the fear of risk and encouraging an atmosphere essential for information transmission and knowledge mobilization. Regans and McEvily (2003) revealed that a high level of trust, promise and reciprocity norms among alliance members enhances their motivation and willingness to exchange information with each other, which fosters rapid communication of ideas and alleviates the discontinuity in knowledge. Lynn et al. (2000) believed that intimate attachment helps collaborative partners embedded in the dense network develop a stable relationship, which increases the speed of information diffusion and access. Such trust is significant to transfer tacit, embedded knowledge that is hard to be as communicated readily as information. It is particularly true in the context of IT innovation alliances where actors are distributed widely with heterogeneous knowledge, and thus it is difficult for them to enforce, measure or monitor their implicit knowledge contributions (Gulati & Singh, 1998).

Secondly, by virtue of their open-ended nature with the sense of lack of completeness, epistemic objects serve to fuel, energize and direct the process of innovation by actively provoking a knowing process, through which knowledge of what to do and how to do it is elicited, and attracting alliance members to access, assimilate and gather up knowledge needed for solving innovation problems from each other's different domains of specialization (Rennstam, 2012). In addition, epistemic objects elicit the knowledge of each member and direct them to utilize their knowledge to solve problems by provoking innovation puzzles, inviting them to interact with the puzzles and encouraging them to leverage the integration of heterogeneous knowledge to solve the puzzles (Rennstam, 2012). By recognizing the required knowledge for accomplishing the task and eliciting each other's knowledge, epistemic objects enable widely distributed members to intelligently exploit their differentiated knowledge to create innovations (Fjeldstad et al., 2012), which coordinate the

knowledge heterogeneity. Furthermore, the generative nature of epistemic objects makes them a focal point and invites members engaging in a dialogue where various sources of information are accessed, novel ideas are exchanged and creative solutions are diffused, alleviating the discontinuity in knowledge (Rennstam, 2012). For example, Kappa was found to benefit from the causal mapping for eliciting and disseminating tacit knowledge (Ambrosini & Bowman, 2008). Specifically, the executives invented the practice of causal mapping to surface non-codified knowledge by building a map as a focal point and encouraging their employees to write down the success factors as well as to mark the links between those factors so that every disconnected piece of embedded knowledge was explicated and transferred. Hence, based on the existing literature, the following hypotheses are developed:

H1: Epistemic objects positively affect inter-firm knowledge acquisition among collaborative organizations in their IT innovation alliances.

H2: Epistemic objects positively affect inter-firm knowledge integration among collaborative organizations in their IT innovation alliances.

H3: Epistemic objects positively affect inter-firm knowledge sharing among collaborative organizations in their IT innovation alliances.

3.4 Research Methods and Results

We used a mixed-methods research approach involving a sequential approach which began with a qualitative method to expound the theoretical constructs of the model and followed this with a quantitative method to test the hypotheses. In general, mixed-methods research approach is used to ensure the obtainment of a more systematic picture of a phenomenon (Zachariadis et al., 2013). Specifically, qualitative methods have the capacity to not only construct propositions but also identify the mechanisms by which complex phenomena interact between them, while quantitative methods are able to identify unobvious regularities in a larger sample where a qualitative method would not have been able to do so. In our study, we used interviews as part of a case study to not only explore the relationships but also make better sense of the quantitative results by revisiting our interview data. In parallel, our

quantitative analysis of the survey enabled us to test these relationships which was then discussed in combination with our qualitative results.

3.4.1 Qualitative Research

In terms of qualitative research, we conducted a case study to explain the model. Specifically, we chose Sinosoft Company Limited as our research site in China to collect data whose core business is large-scale application software development and integration. The IT innovation project that was originated by Zhoushan Ministry of Transport, aimed to develop an innovative emergency command system covering the management of highways and road transport as well as marine transport. We focused on the partnership between a system integrator company (Sinosoft), a software technology firm, an IT firm and a hardware application firm. Regarding data collection, we conducted 25 semi-structured interviews with the project members. Sinosoft also provided us access to conduct observations and thus we could observe not only the formal work activities but also their informal social interactions. The data analysis involved coding interview transcripts to identify key themes and categories. The analysis began with some initial codes and enabled further ones to emerge progressively. By recursively moving back and forth between data and theories, we worked to check whether the data support the emerging themes and whether theories make sense of the empirics.

3.4.2 Quantitative Research

As for quantitative research, we used web-based surveys to test the hypotheses. The theoretical items constructed in the model were measured using seven-point Likert scales ranging from 1=strongly disagree to 7=strongly agree. The study population consisted of 100 IT firms listed in the China Credit Information Service Incorporation yearbook by stratified random sampling. We distributed 150 questionnaires to participants who had been involved in IT innovation alliances, and deemed 107 were usable for the quantitative analysis with a response rate of 71%. To achieve reliable data, we requested key informants to respond to the surveys like the project managers who have a clear understanding of the whole project and frequently use their expertise to solve problems.

In terms of measurement, first we measured epistemic objects (EO) with four items and asked respondents to assess, by interacting with the object of knowledge such as a project architecture figure, a sketch or a brainstorming map, to what extent they had: (1) generated a high level of trust and promise; (2) achieved the opportunity to target each partner's domains of specialized knowledge; (3) formed a temporary knowledge community around the object and developed different relationships with it; (4) engaged in joint problem-solving (Knorr Cetina 1997; Rennstam 2012). Secondly, we used four items to measure knowledge acquisition (KA) and asked respondents to rate to what extent during the process of innovation they had: (1) accessed diverse system/sub-system function information; (2) assimilated system/sub-system design information from their partners; (3) gained system/sub-system interface design information from relevant technical trainings; (4) absorbed system/sub-system configuration information from external sources (March, 1991; Nonaka, 1994). Third, we measured knowledge integration (KI) with three items and asked respondents to rate to what extent they had: (1) spanned diverse expertise to create a shared understanding; (2) blended new expertise with existing skills for innovation; (3) leveraged dispersed pieces of information into coherent knowledge for innovation (Moorman, 1995; Yang, 2005). Last, we measured knowledge sharing (KS) with four items and asked respondents to assess to what extent they had: (1) kept each other fully informed about information affecting their innovation; (2) kept discussing technology issues candidly and freely; (3) organized live technology training for solution diffusion; (4) avoided hiding their information from each other (Lynn et al. 2000).

3.4.3 Qualitative Results

In this section, first an outline of the epistemic objects used in the project is provided and then close-ups are presented illustrating two particular phenomena: the generation of trust and the elicitation of knowledge, which respectively coordinated the discontinuity and heterogeneity in knowledge.

Generation of primary partial objects and secondary partial objects

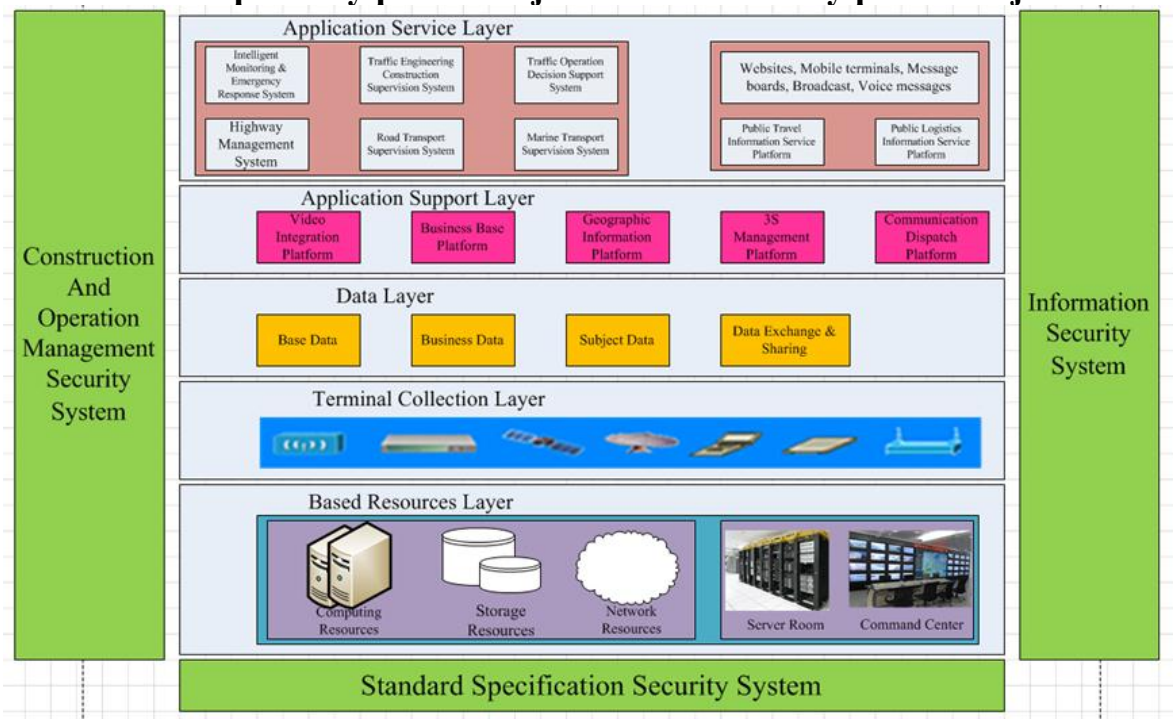

Figure 3.2. Project Architecture Figure (PAF).

The overall project was defined by the emergence of a primary partial object depicted in Figure 3.2. In the very early stage of the process of innovation, the project participants organized a workshop where they engaged in brainstorming to identify all the relevant parts regarding the project in order to develop the Project Architecture Figure (PAF) that consisted of five layers and three security systems. Throughout the process of innovation, the project members utilized it as a visual representation of the overall project being investigated. By serving as a primary partial object, the PAF was able to catch the attention of engaged actors to explain what the project was about and what the next steps would be. In the engagement with the PAF, the project team additionally developed several secondary partial objects to provide representations of selective aspects and to present particular contributions to the overall project. For example, in an attempt to explore the item labelled 'Traffic Operation Decision Support System' in the application service layer depicted in the PAF, a sketch was created to demonstrate an unfinished interface design that actively attracted attention to its limitations, raised questions back to the members and offered them crucial inspirations for the further development.

Acting as a trust trigger

During the process of innovation, we observed how the PAF remained itself unfulfilled to trigger the form of wanting, and how the emotional investment towards the PAF performed as the engine of solidarity, where a high level of trust emerged among the project members to foster information transmission, alleviating the knowledge discontinuity (Knorr-Cetina, 1997). For example, during a workshop, the participants sat together and brainstormed to discuss the feasibility of the PAF ("*how we should allocate tasks so that we could deliver it on time*"), its applications ("*we need to integrate the decision support system into the transport management*"), its challenges ("*once we integrate disparate sub-systems together, it might be hard to make it work as a whole*"), its possibilities ("*we should realize the potentials associated with diverse combinations of different modules*") and its solutions ("*before developing a shared interface, we must consider all the coordination entities*"). The discussion continued for almost five hours, and each member focused on cracking the problems around the PAF that made them highly motivated: "*we will stay here as long as it needs because it is very important. Only we solve these problems, we can move forward*". In this way, the PAF kept raising questions and articulating multiple possibilities to trigger a pattern of desire among the members, and the compulsion to know fuelled their attachment for the PAF so that a strong solidarity was nurtured by their promise to achieve the common goal (Nicolini et al., 2012). The wanting towards exploiting the PAF built the foundation where mutual trust was fostered, so that the members were more willing to commit their cognitive resources, and less to engage in cost-benefit calculus, which accelerated information diffusion, facilitated knowledge assimilation and alleviated the knowledge discontinuity. Specifically, by interacting with the PAF, the participants from the Sinosoft, the user company and other sub-contractors jointly engaged in the process of innovation and produced the promises of making rational decisions and creating feasible solutions. In this way, they were highly motivated to contribute their expertise to the group, to exchange their valuable experiences with each other and to leverage their heterogeneous, disparate pieces of knowledge in a novel way. As a result, each member had multiple opportunities to receive, exchange and compare an abundance of information, which helped them absorb complete and richly understood knowledge for spurring innovation, as a senior project manager said: "*the PAF kept us together. When we met prob-*

lems around it, we discussed together and checked what and how other excellent engineers did. We were willing to exchange our ideas and experiences, and we would not stop until we found the solutions".

Apart from enhancing the willingness to contribute to the project in an emotional way, the high level of trust triggered by the PAF additionally helped the participants directly target each other's domain of specialized knowledge and increased their confidence in each other's competence. That is, interacting with the PAF made the project members have a full understanding of each other's expertise so that they could quickly identify the persons who complement each other, leading them to purposefully engaging in the efficient integration of knowledge, which in turn positively coordinated the knowledge heterogeneity for innovation (Rennstam, 2012). Such knowledge of who knows what (Wegner, 1987) facilitated the development of cognition-based trust in a project group, where the sources and recipients are more inclined to credit each other's ideas for joint problem-solving, conducive to the transfer of tacit knowledge, as a senior engineer highlighted: "*the PAF helped us disclose information indicating our own expertise and engaged us in collective, reflective learning so that we could understand each other's implicit capacity and anticipate each other's behaviour more easily*".

Acting as an elicitor of knowledge

In addition to triggering trust, we also saw how the PAF invited the members developing a knowledge community around itself and engaged them in an open dialogue, where heterogeneous streams of knowledge were elicited, and how the PAF acted back on its behalf in the struggle between conflicting strands of knowledge when being acted upon, thereby coordinating the knowledge heterogeneity (Rennstam, 2012). First, at the early stage of the process of innovation, the PAF established various strands of knowledge relationships with each member, turning a collection of members into a temporary knowledge community. In this way, the PAF acted as an object of investigation, inviting the community knowing and defining it in order to make it complete (Knorr-Cetina, 1997; Rennstam, 2012). Specifically, the members sat together to discuss how to configure the six systems embedded in the application service layer, and whether these systems could be integrated effectively, during the

process of which, different kinds of knowledge relationships were created. For example, when the client representative interacted with the PAF, a relationship was developed: "*The users will appreciate a system that is simple and easy to handle, and simultaneously it needs to be updatable*". The senior IT expert raised the possible solution to the problem of integration, suggesting that "*Before [integrating the systems], it is key to design a common, shared interface that has a high level of affordance and compatibility*". Last, the relationship between the PAF and the project manager was built, by emphasized the importance of delivering the systems and accomplishing the integration on time: "*We must look at the big picture*". This example showed how the PAF recognized the knowledge needed for solving project problems and gave rise to various knowing processes, where different kinds of perspectives were induced and diverse bodies of knowledge were elicited (Ewenstein & Whyte, 2009) so as to leverage the integration of heterogeneous knowledge for exploiting innovation. By interacting with the PAF jointly, the community accessed the knowledge of each other, leveraged existing knowledge and applied it to collective problem-solving thereby coordinating the knowledge heterogeneity.

Secondly, in the engagement with the PAF, the project group also created a brainstorming map to explore the feasibility of implementing the 'Geographic Information Platform' contained in the application support layer, where the materiality of this map shaped the pattern of interaction among the community and offered significant inspirations for the further development by acting back on its behalf when exposed to certain treatments (Rennstam, 2012). Specifically, the participants sat around a circle, and built the brainstorming map drawn on the board to place diverse ideas and possible solutions. The map thus served as a focal point to sensitize the members to particular areas of concern, to actively attract attention to its current limitations and to raise questions back to the community for the next step on its behalf. By making reference to the brainstorming map, joint problem-solving was induced, and different knowledge orchestration practices were enhanced when they engaged in a dialogue, where various bodies of knowledge were accessed, exchanged, questioned, and leveraged for exploiting innovation.

3.4.4 Quantitative Results

In terms of the measurement model, we conducted an exploratory factor analysis of the four measures (EP, KA, KI, KS) by using a principal axis factoring analysis with *Oblimin* oblique rotation with Kaiser normalization rotation (Table 3.1). Specifically, KMO was 0.756, indicating that the data was suitable for factor analysis. In addition, the data showed support for the four factors, which had eigenvalues greater than 1 and explained 93.505% of the variance. Furthermore, the measures suitably represented the four factors whereby all the primary loadings exceeded 0.671. Finally, the Cronbach's alpha was 0.866, implying a high degree of reliability of internal consistency of the measures.

Besides exploratory factor analysis, we further conducted a confirmatory factor analysis to estimate the model using SPSS Amos, consistent with the two-step approach proposed by Anderson and Gerbing (1988). First, all indexes illustrated a strong good fit with the model: the observed CMIN was 454.15 with 384 DF, and CMIN/DF was 1.183. The NFI was 0.980, CFI was 0.990, and RMSEA was 0.021 suggesting a good model fit. Secondly, we examined the convergent validity by testing the significance of the factor loadings and their gap to the standard error (S.E.) (Koufteros, 1999). All item loadings were above the suggested cut-off of 0.6 (Hair et al. 1998) with strong significance level (***$p<0.001$). In addition, all the S.E. values were basically around 0.1, indicating that all the items had a clear relationship with their own latent variables. Furthermore, all the composite reliability (CR) values were above 0.7 also displaying a good convergent validity. Last, all the square roots of the average variance extracted (AVE) shown on the diagonal of the correlation matrix were greater than the off-diagonal construct correlations, implying a good discriminant validity (Koufteros, 1999).

With regard to the structural model, we used Amos software to test the hypotheses, and the results were shown in Figure 3.3. Specifically, the coefficients of epistemic objects were strongly positive and significant for knowledge acquisition ($\beta = .578$, $p<.001$), knowledge integration ($\beta = .436$, $p<.001$), and knowledge sharing ($\beta = .493$, $p<.001$). This support H1, H2 and H3, suggesting that, epistemic objects do positive-

ly affect inter-firm acquisition, integration and sharing of knowledge among collaborative organizations in their IT innovation alliances.

Constructs	Items	Loading	S.D.	C.R.	KMO	Cronbach's α	Factor				EP	KA	KI	KS
							1	2	3	4				
Epistemic Objects	EP1	.713	.116	.847	.779	.914	.713				**.816***			
	EP2	.709	.100				.709							
	EP3	.728	.114				.728							
	EP4	.705	.115				.705							
Knowledge Acquisition	KA1	.811	.129	.779	.680	.764		.811			.473	**.806**		
	KA2	.717	.135					.717						
	KA3	.671	.134					.671						
	KA4	.739	.124					.739						
Knowledge Integration	KI1	.742	.119	.822	.728	.833			.742		.215	.450	**.799**	
	KI2	.673	.118						.673					
	KI3	.788	.109						.788					
Knowledge Sharing	KS1	.807	.096	.867	.837	.953				.807	.205	.130	.548	**.769**
	KS2	.715	.098							.715				
	KS3	.749	.094							.749				
	KS4	.757	.105							.757				

*Square root of average variance extracted

Table 3.1. Summary Results of Measurement Model.

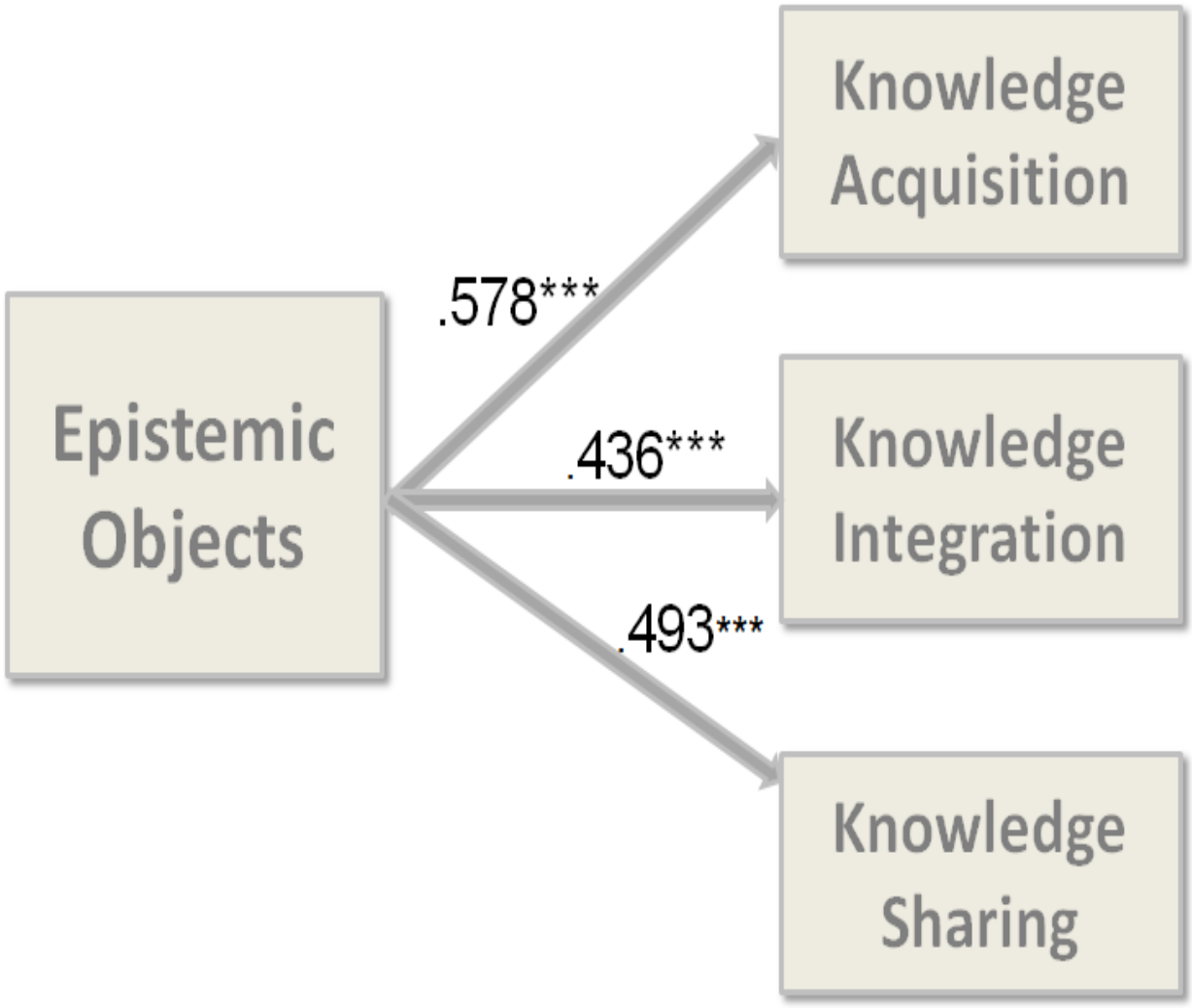

Figure 3.3. Summary Results of Hypothesis Testing.

3.5 Discussion and Implications

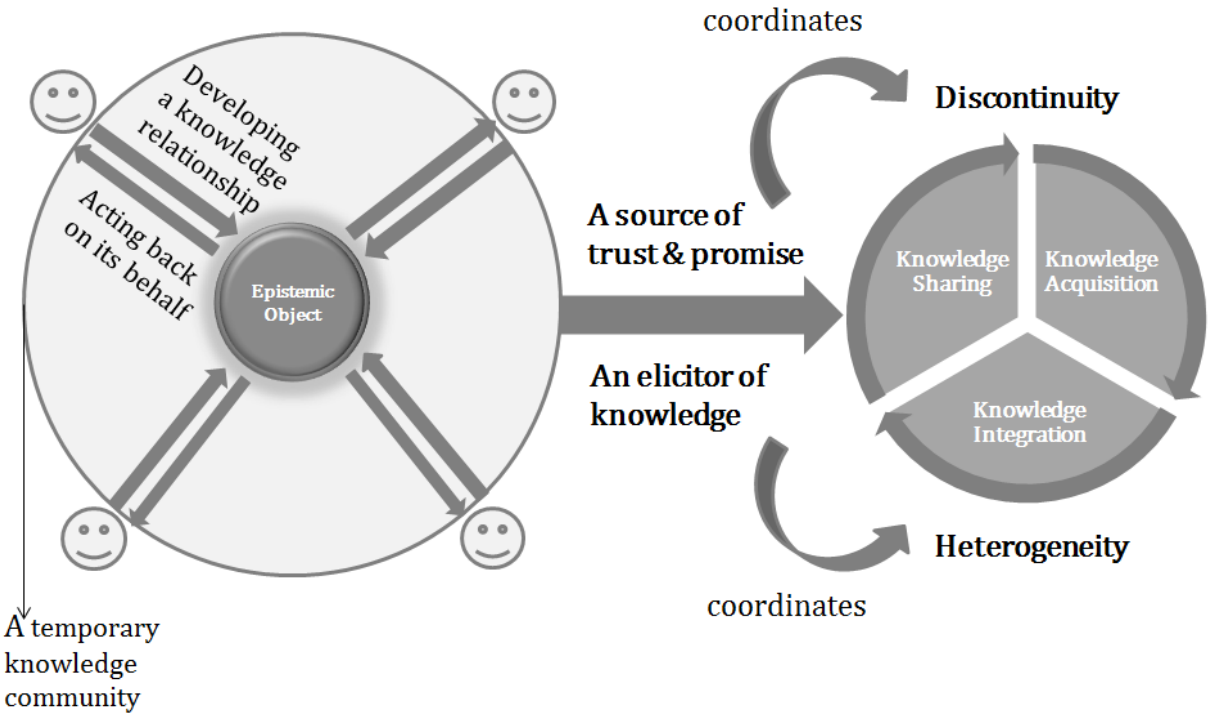

Figure 3.4. How Epistemic Objects Coordinate the Knowledge Heterogeneity and Discontinuity.

Our results manage to answer how epistemic objects affect knowledge acquisition, knowledge integration and knowledge sharing so as to coordinate the heterogeneity and discontinuity in knowledge that is mobilized during an IT innovation alliance depicted in Figure 3.4, and thus make three contributions. First, epistemic objects arouse 'interest in them' as well as keep them "alive as targets of research" (Rheinberger, 2005, p. 406), and most literature has emphasized this motivation that comes from the compulsion to know (Covington, 1992). Drawing on their work, we further highlight a high degree of both affective and cognitive trust triggered from the emotional investment toward and the intimate attachment for the same epistemic artefacts (Knorr-Cetina, 1997) among a temporary knowledge community. Specifically, a community of practice can be created around an epistemic object when the actors engage in a knowing work jointly and what holds them together is a shared interest, a common goal and a need to know what each other knows (Mandl et al., 1996). In this way, affective trust may be developed among the community members, which contains a strong confidence that their "interests will be fully protected", resulting in

the creation of a collective better than the sum of its individual parts (Lewicki & Bunker, 1996, p. 122). Meanwhile, this knowledge community is also a temporary group, recognized as "a set of diversely skilled people working together on a complex task over a limited period of time" (Goodman & Goodman, 1976, p. 494). Thus, swift trust, or cognitive trust may emerge in such a group, dependent on the appearance of everything in a proper order and the attitude of respect for the capacities of the other partners to carry out their share of the tasks at hand (Holste & Fields, 2005). Hence we extend the intrinsic desire triggered by the unfulfilled epistemic objects to a high level of affective and cognitive trust, which contribute a new insight into how epistemic objects develop a knowledge community around themselves and produce a novel source of motivation among the members that increases not only their willingness but also their confidence in each other's competence to contribute to collaborative knowledge and innovation work, extending beyond the studies focusing on formal incentives such as monetary rewards or normative control (Robertson & Swan, 2003).

Secondly, our focus on the capacity of epistemic objects to elicit knowledge contributes a novel understanding of identification in collaborative knowledge orchestration and innovation work. We find that by engaging in a knowing process and establishing various relationships with the epistemic object, the members can achieve a sense of identity associated with their own domains of expertise in their community so that they are more engaged in their specialization. Drawing on the work of Brown and Lewis (2011) who brought to the fore a source of identification for the community members themselves in order to make them concentrate more on their specialized knowledge, we additionally highlight the capacity of epistemic objects to allow the members to have a complete picture of each other's area of knowledge so as to help them detect the precise knowledge required quickly. Via the mechanism of knowledge elicitation, the participants have the opportunity to gain an identification with the knowledge of their community, so that they have a full understanding of what they already have, what they still need, who knows what and how they can acquire the needed knowledge from the right person, which lead them to a distinctive recombination of heterogeneous pieces of knowledge for innovation. In this way, we link the theory of transactive memory to epistemic objects, contributing a better understanding of how epistemic objects trigger the development of transactive memory

among the community, and how this knowledge of who knows what enhances their collective sense-making so as to facilitate the transformation from dispersed information input to high-quality knowledge output thereby coordinating the knowledge heterogeneity for innovation (Lewis, 2003; Wegner, 1986).

Third, our emphasis on the independent role of the epistemic object in inviting a knowing process, establishing various knowledge relationships with the participants, eliciting heterogeneous knowledge and empowering the knowledge on its behalf, contributes a unique insight into the role of materiality and human in collaborative knowledge management and innovation work. Prior literature has perceived material artefacts as technical objects or managerial instruments in the hands of managers who speak on their behalf, and highlighted that these artefacts are generally utilized to sustain and support the daily work of those managers (Orlikowski, 2007); the literature also emphasized the active role of managers as the agent of control through supervision or normative means (Vázquez, 2006). Drawing on the literature, we highlight the role of an object of knowledge (Knorr-Cetina, 1997) as a trigger and an elicitor by initiating a knowing process and creating a temporary knowledge community around itself, where the materiality of the object struggles with conflicting strands of knowledge, thereby fuelling and directing the knowing process on its behalf (Rennstam, 2012). Hence, we contribute an alternative to human control with instrumental objects on knowledge elicitation and provide a novel understanding of how epistemic objects and other types of formal managerial control can beneficially coexist to coordinate the heterogeneous and disconnected knowledge mobilized during an innovation.

Our study has three theoretical implications. First, we highlight the combination of both affective and cognitive trust as a novel source of motivation for knowledge diffusion that provides a theoretical implication on the coordination of the knowledge discontinuity within the innovation network. Specifically, we highlight the role of strong trust in fostering the information transmission which helps mobilize and aggregate disconnected pieces of knowledge, adding to the work of Granovetter (1973) and Vazquez and Moreno (2003) who believed the strength of weak ties in accelerating information diffusion within the network. Second, our focus on knowledge elicitation complements the work of Brown and Lewis (2011) and Wegner (1986) by

demonstrating how epistemic objects trigger the development of transactive memory among the participants, and how this knowledge of who knows what enhances the collective sense-making in order to positively coordinate the knowledge heterogeneity for innovation. Thus, we provide a theoretical implication on task decomposition and heterogeneous knowledge distribution. As IT innovations' core tasks are increasingly modularized and their required knowledge is widely distributed, research on traditional modes of organizing for innovation may be not enough (Boudreau & Lakhani, 2009), and it is vital for scholars to connect the theory of epistemic objects with open innovation, exploring how to utilize epistemic objects smartly to coordinate the heterogeneous and disconnected knowledge for spurring more innovations. Thirdly, our emphasis on the independent role of epistemic objects as a trust trigger, an inviter in knowing process and a knowledge elicitor provides a theoretical implication on the increasing power of material artefacts, the decreasing power of formal managerial control, and their potential co-existence to promote collaborative knowledge orchestration and innovation activities.

Besides theoretical implications, we also have several practical implications. Firstly, our finding regarding epistemic objects as a source of both affective and cognitive trust provides an additional motivation for collaborative knowledge management and innovation practices, and presents a practical implication on the alleviation of the knowledge discontinuity. Thus, we suggest that it is significant for those project managers who nurture IT innovation alliances to utilize epistemic objects intelligently to produce a sense of belonging and cognition-based trust among the members in order to make them committed enough to diffuse and leverage disparate ideas for innovation over limited time. Second, our focus on the role of epistemic objects in fostering knowledge elicitation has an implication on the transfer of tacit, embedded knowledge in the context of IT innovation. As implicit knowledge is hard to be transferred via structured processes and can be easily lost (Pfeffer & Sutton, 1999), a complete transactive memory system drawing on the epistemic objects allows the community to get acquainted with each other. Hence, when initiating knowledge work, it is critical for managers to take advantage of epistemic objects to achieve the identification with the knowledge of the formed community in order to foster the diffusion of each other's implicit expertise. Our finding regarding knowledge elicitation has an additional practical implication on open innovation, task decomposition, and

the coordination of the knowledge heterogeneity and discontinuity in strategic alliance. With increasing modularity via task decomposition (Fjeldstad et al., 2012), it is vitally important for organizations to participate in alliance networks where widely distributed partners with the help of epistemic objects leverage the integration of heterogeneous, disparate knowledge for exploiting IT innovation. Third, our emphasis on the independent role of epistemic objects as a trust trigger and a knowledge elicitor reflects a certain practical implication on the role of materiality and human in collaborative knowledge and innovation work, and suggests organizations to reconsider the manager role and the power of artefacts, thereby toning down the managerial control and making epistemic objects and other types of formal managerial control beneficially coexist to coordinate the heterogeneous and disconnected knowledge.

3.6 Conclusion

By adopting a mixed-methods research approach, we find that by acting as a trust trigger and a knowledge elicitor, epistemic objects positively affect inter-firm knowledge acquisition, knowledge integration and knowledge sharing among collaborative organizations, which in turn coordinate the heterogeneity and discontinuity in knowledge that is mobilized during an IT innovation alliance. Thus, we contribute to the current literature by providing novel insights into how epistemic objects are utilized intelligently to maximize the potential of heterogeneous and disconnected knowledge for spurring more IT innovations.

CHAPTER 4 Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation[3]

Abstract

In this study, I explore how activity objects orchestrate knowledge for crowdsourced digital innovation. After reviewing the literature, I develop three hypotheses to investigate the role of activity objects in knowledge sharing, knowledge acquisition and knowledge integration for crowdsourced digital innovation. Adopting a mixed-methods research approach, my quantitative results from 355 questionnaires corroborate the three hypotheses, and my qualitative evidence collected from 48 interviews enriches and adds depth to my explanations. As a result, I found that by acting as a trigger for expansive learning, and a director and motivator of crowdsourcing communities, activity objects serve to facilitate the sharing, acquisition, and integration of knowledge, coordinating knowledge heterogeneity and countering its fragmentation for crowdsourced digital innovation. Hence, my paper makes two contributions: 1) I recognize Zhihu, a Chinese social network platform, as an activity object for orchestrating knowledge, contributing a novel private-collective model for crowdsourced digital innovation through an integration of personal investment and collective action; 2) my focus on the independent role of an activity object as a trigger for expansive learning and, a director and motivator in knowledge orchestration contributes a new understanding of the interacting roles of material artefacts and humans in crowdsourced digital innovation.

[3] Liu, J. (2018), "Knowledge Orchestration and Material Artefacts: The Role of Activity Objects in Crowdsourced Digital Innovation", in *Proceedings of the 11th IADIS International Conference on Information Systems.*

4.1 Introduction

As crowdsourcing communities have increasingly got involved in the process of digital innovation, scholars have paid more significant attention to their innovation networks (Mladenow et al., 2014). Such networks are defined as doubly distributed innovation networks, in which the organizational and technological control over product components is distributed across firms of different kinds, and where the product knowledge is distributed across heterogeneous specialties and communities (Yoo et al., 2010). However, such innovation networks also bring with them their own challenge: the knowledge heterogeneity and fragmentation (Lyytinen et al., 2015). In order to address this challenge, a certain amount of orchestration, influence and direction is needed for the network actors to appropriately transfer, accept, and leverage knowledge without sacrificing flexibility and independence in the processes of innovation. Drawing on a network orchestration model (Dhanaraj & Parkhe, 2006), I identify three purposeful, interrelated knowledge orchestration activities to maximize the output of digital innovation: knowledge sharing, knowledge acquisition, and knowledge integration. As human activity is always mediated by cultural artefacts (Engeström, 1999), scholars suggested that activity objects could be a useful starting point in addressing the knowledge orchestration. According to Miettinen (2005), activity objects are partially emergent, partially fragmented and partially contradictory, as well as under-defined, unfolding objects in collaboration; simultaneously, they maintain the activities around the pursuit of themselves. Although existing studies have recognized the role of cultural artefacts in providing the direction, motivation and meaning for an activity (Kaptelinin & Nardi, 2006), our understanding of how activity objects serve to orchestrate knowledge for crowdsourced digital innovation is still very limited. In order to fill this gap, I aim to explore how activity objects influence the sharing, acquisition and integration of knowledge for crowdsourced digital innovation. Thus, my research question is: how do activity objects orchestrate knowledge to coordinate its heterogeneity and counter its fragmentation in crowdsourced digital innovation?

The rest of the paper is organized as follows: in the next section, I integrate diverse bodies of literature to develop my hypotheses; then I use questionnaires to test these hypotheses, and conduct interviews to enrich the quantitative results. Last, I report

my results and articulate their contributions, including theoretical and practical implications.

4.2 Theoretical Background

4.2.1 Conceptualizing Activity Objects for Crowdsourced Digital Innovation

According to Hutchins (1995), material artefacts play a significant role in the process of collaborative innovation. Hence**,** before conceptualizing activity objects for crowdsourced digital innovation, several other types of objects should first be introduced (Carlile, 2002; Knorr-Cetina, 1997; Nicolini et al., 2012; Rheinberger, 1997). For example, boundary objects serve to make collaboration possible by acting as translation and transformation devices to anchor between different intersecting communities with diverse social and technological worlds, and to meet the information needs of each of them (Carlile, 2002). Epistemic objects are defined as objects of investigation embodying what one does not yet know (Rheinberger, 1997, 2005). It is this lack of completeness that produces energy, and the attempt to fill this void explains the motivation of individuals in their initial search for alignment for collaboration (Nicolini et al., 2012). Infrastructure objects are usually regarded as humble and boring things, often forgotten, involving the taken-for-granted equipment and tools (Star, 1999), but they constitute the foundations of daily work activities (Orlikowski, 2007). Moving on to activity objects, they are, according to cultural historical activity theory, able to mediate any human activity, by enabling purposeful action, connecting agents to their social surroundings, and embedding into the activity the history that they embody (Engeström, 1999; Leont'ev, 1978; Nicolini et al., 2012). Simultaneously, human activity is also oriented toward a cultural artefact, recognized as a prospective outcome that motivates and directs the activity (Kaptelinin & Nardi, 2006). On the basis of current literature, Nicolini et al. (2012) proposed a three-level framework for conceptualizing the role of objects in collaboration, and identified activity objects as "primary objects", with the ability to trigger the collaboration. In this way, the lens of activity objects allows an investigation of the role of cultural artefacts in the accomplishment of a collective human activity, by taking into account the social and practical origins of human productive needs, and the poten-

tially contradictory nature of the object of a collective activity as well as the division of labour (Miettinen, 2005). Thus, a focus on activity objects can give hints as to why the crowdsourced digital innovation activity happens in the first place, and how individuals contribute their knowledge to the construction of the activity object, as well as how they attach their different expectations to this object.

Because an activity's object is recognized as emergent, fragmented, and contradictory, collective human activity is always maintained around the pursuit of a partially emergent, partially fragmented, and partially contradictory object (Nicolini et al., 2012). Hence, an activity object can be viewed as a conflict trigger and a director and motivator of the community that evolves and revolves around itself. Specifically, an activity object can act as a representation for crowdsourced digital innovation from three perspectives. First, because an activity object is inherently multi-faceted, fragmented, and disputed, it can create a socio-material community around itself, into which "a naturally occurring and evolving collection of people" with contradictory interests, orientations and interpretations "engage in particular kinds of activity", and "develop and share ways of doing things as a result of their joint involvement in that activity" (Galagan, 1993, p. 33). As an activity object attracts heterogeneous actors with diverse knowledge boundaries to engage in the process of digital innovation, a crowdsourcing community emerges that absorbs the wisdom of each actor, and triggers reflective learning (Patil & Lee, 2016). Because an activity object can be seen as a trigger of conflict and negotiation due to the potentially contradictory nature of collective activity (Miettinen, 2005; Miettinen & Virkkunen, 2005), the crowdsourcing community, that is composed of actors rooted in heterogeneous worlds with weak ties (Granovetter, 1973), is not an integrated whole in which parts move in harmony, but rather is a "community without unity", in which contradictions and expansive learning abound at the same time (Nicolini et al., 2012).

Second, an activity object is partly predetermined and partly emergent, reflecting the originally embedded, and constantly evolving, interests of the actors involved (Nicolini et al., 2012). Because a cultural artefact serves as an object of a crowdsourced digital innovation activity, it enables the collective action to emerge around it according to a shared goal; simultaneously, it is also the result of the practices and expectations of the crowdsourced communities that gather around it (Miettinen, 2005).

With widely distributed, heterogeneous actors engaging in the process of digital innovation, an activity object is able to help them "find the signal in the noise" while avoiding irrelevant content (Paul et al., 2012). In this way, such an object acts as a moving target that has the capacity to direct the digital innovation activity (Miettinen, 2005).

Third, as Leont'ev (1978, p. 66) emphasized, "the object of an activity is its true motive". An activity object is able to motivate its crowdsourcing communities to continually engage in the process of digital innovation, fuelling the collective activity. Based on the social exchange theory, which suggests that individuals take actions according to their calculated benefits and costs (Lanham, 2006), the motives for actors devoting themselves to crowdsourced activities can either be extrinsic or intrinsic (Choudhury et al., 2014). Actors who contribute high-quality knowledge to crowdsourced digital innovation, expect to improve their reputation as a form of extrinsic reward (Jin et al., 2015). Besides reputation, attention, which has become a scarce resource in the information age, is another significant extrinsic motivator (Lanham, 2006). Drawing on the idea that, in the 'attention economy', information consumes its recipients' attention, Lanham (2006) described how social communities seek to compete for each other's attention. In this way, network actors are extrinsically motivated to exchange their knowledge for reputation and attention, which can also be explained in terms of the concept of desire, drive or struggle for recognition (Hegel, 1977, 1983). Specifically, social recognition is perceived as a primary source of personal identity, which is especially significant in crowdsourced activities where division of labour is a source of individuality (Miettinen, 2005). As social recognition is identified as "esteem achieved in community life", any recognition of individuals' uniqueness is positively related to the future contribution they will make to the collective activity (Miettinen, 2005, p. 62). This is also true in highly distributed, virtual, crowdsourcing communities, where the recognition, acknowledgement and reward for the contributions that members make is important in assigning identity to themselves and maintaining their communities (Lerner & Tirole, 2001). It is noteworthy that this kind of social recognition can be achieved by objectified actions and objects (Kojève, 1969). In other words, actors pursue recognition for their actions and these actions' objectifications both within a cultural activity and in wider communities (Miettinen, 2005). This is because, as actors become increasingly recog-

nized by participating in a collective activity, such participation can be objectified in the products of their actions, with their achievements constituting the objectified demonstration of their capability to contribute to their communities and the target activity (Knorr-Cetina, 1997). Therefore, activity objects are able to realize and demonstrate the unique contributions that members make, which continuously fuels their participation in and contribution to both the activity and their communities (Miettinen, 2005).

With extrinsic benefits providing the main motivations for crowdsourcing communities to initiate the behaviour of knowledge contribution for digital innovation, intrinsic rewards involved in social exchanges that emphasize unspecified obligations, such as social affiliation and feelings of belonging, trust and self-actualization, carry more weight in their motivation of continuous engagement in the community (Sigala & Chalkiti, 2015). Nicolini et al. (2012) pointed out that activity objects can trigger intimate emotional attachment that is not restricted to individuals but is performed as an engine of solidarity, a collective obligation and an emotional affiliation, constituting a morally binding force among community members. In this way, the object of an activity is able to provide a "family of invisible friends" with a "home" in which a sense of loyalty can be engendered in committing to the digital innovation goal (Abrams et al., 2003). Such community affiliation, triggered by the activity object, intrinsically motivates crowdsourcing communities to identify themselves with the communal goal, while putting their self-interests aside, which fuels the impetus for them to commit to the totality.

4.2.2 Knowledge Orchestration for Crowdsourced Digital Innovation

As digital innovation is seen as inherently layered, it increasingly pushes heterogeneous actors to connect with each other across multiple organizational and community boundaries to create new value-in-use, forming a crowdsourced innovation network (Huang et al., 2017). However, such an innovation network has its own challenges. Specifically, the radical reduction of communication and coordination costs makes affordable the participation in the innovation process of otherwise disconnected actors, distributing more widely the coordination of innovation activities (Yoo

et al., 2008). In addition, the loosely coupled layers embedded in the innovation networks trigger high levels of flexibility, resulting in a fragmentation of the knowledge base common to the network actors (Nätti et al., 2006). Furthermore, the convergence of digital technology combines resources and components in unforeseeable ways, which cumulatively expands the cognitive heterogeneity along the 'rolling edge' of the network actors' capability (Yoo et al., 2012). All of these can lead to the knowledge becoming too fragmented and heterogeneous to control (Yoo et al., 2010).

Confronted with this problem, Yoo et al. (2010) identified knowledge orchestration as a solution. Drawing on a network orchestration model (Dhanaraj & Parkhe, 2006), I suggest that a certain amount of coordination, influence and direction is needed for crowdsourcing communities, to transfer, accept and leverage knowledge without sacrificing flexibility in the processes of innovation. More specifically, I identify three inter-related activities for knowledge orchestration: knowledge sharing, knowledge acquisition and knowledge integration.

First, *knowledge sharing* concerns the ease with which knowledge is transferred within a network (Dhanaraj & Parkhe, 2006). Knowledge transfer is predominantly referred to in the network literature as an 'asset' which carries value for a network (Nahapiet & Ghoshal, 1998). Particular emphasis is placed on standardizing or establishing compatible methods of communication to facilitate the sharing of this form of intellectual capital across the 'syntactic' boundaries (Carlile, 2002), from one actor to the next. Because the emergence of new ideas can be diffuse, cascading knowledge through the network and providing access across the syntactic boundaries to a more diverse group of actors can spur more innovations, and the learning effect expands from the level of an individual or an organization to the level of the innovation network, fostering the flow of knowledge and increasing the depth of the synergistic learning among the crowdsourcing communities (Okhuysen & Eisenhardt, 2002).

Second, when the transferred knowledge is complex and there is not clarity of purpose, then the challenge shifts to the *acquisition of knowledge*, where a 'semantic' approach (Carlile, 2002) is needed to recognize the different ways in which each ac-

tor interprets and accepts the disseminated message. With digital technology affording a separation of contents from the network and acting as a generative memory, knowledge flows across the boundaries of diverse mediums on a real-time basis that amplifies the distribution of knowledge across innovation activities (Yoo, 2013). Thus, the efficiency of crowdsourcing communities in assimilating useful knowledge depends on their ability to act as a radar and scan the innovation network quickly to detect the precise knowledge required from a myriad of alternatives (Tsai, 2001).

Third and last, *knowledge integration* occurs- and the full potential of the innovation network can only be realized- if and when the heterogeneous knowledge resources are combined together and transformed into an innovation (Crossan & Inkpen, 1995). Carlile (2002) proposed a 'pragmatic' view of knowledge, and in crowdsourced digital innovation, this poses a challenge for the network actors, namely, fully exploring their unique local context, without losing their ability to interrelate and transform different types of 'hard-won' knowledge into an innovation that spans its customary pragmatic boundaries. As innovations move increasingly toward the network periphery, the knowledge diversity increases exponentially, leading to a situation in which the common cognitive schema is too vulnerable to adequately sustain knowledge integration (Nätti et al., 2006). Simultaneously, digital technology enables a separation of service from device, and enables the network actors to tinker with diverse knowledge in parallel, intensifying the difficulty of coordinating the knowledge heterogeneity for crowdsourced digital innovation (Yoo, 2013). Hence, an efficient knowledge integration mechanism is needed to maximize the variety of contributions stemming from a diversified knowledge base while also creating and maintaining a coherent culture (Tsai, 2001).

4.2.3 Hypothesis Development

Drawing on the literature, I develop three hypotheses to explore how activity objects orchestrate knowledge for crowdsourced digital innovation. Specifically, I examine the impact of activity objects on knowledge sharing, knowledge acquisition and knowledge integration among crowdsourcing communities in their digital innovation networks. The development of these hypotheses can be summarized as follows.

According to Nicolini et al. (2012), activity objects can create a crowdsourcing community, that is not an integrated whole where parts move in harmony, but is rather a community without unity, in which conflicts and contradictions abound. Because a wide collection of conflicting interpretations and contradictory assumptions regarding problems enables community members to search for optimal solutions, evaluate diverse methods, and debate and filter out invalid answers, their group-thinking is decreased and a reflective learning takes place (Scarbrough et al., 2004). Such expansive learning, which involves overcoming heterogeneous boundaries in the transfer and flow of knowledge arising from pre-established cognitive divisions of the community actors involved (Scarbrough et al., 2004), deepens their communication intensity and promotes their information diffusion, thereby increasing their opportunity to share and mobilize widely dispersed pieces of knowledge for crowdsourced innovation (Sigalaa & Chalkiti, 2015). In addition, Boland et al. (2007) highlighted the significance of expansive learning in the transfer of knowledge by proposing the concept of a "trading zone", that is, a cognitive and physical area in which actors with individual innovation trajectories can innovate. Specifically, when crowdsourcing community boundaries overlap or cross during the process of mutually communicating, discussing, negotiating, and innovating (Boland & Tenkasi, 1995), a trading zone may emerge in which a high level of learning flows in multiple directions, and knowledge can travel from one community into another freely, facilitating the mobilization and sharing of knowledge (Boland et al., 2007). Furthermore, as a socially interactive cultural artefact, an activity object can drive socio-emotional forces such as trust, commitment and loyalty, and trigger an ethical community culture, conducive to information diffusion and knowledge mobilization (Tsai, 2001). Specifically, Abrams et al. (2003) emphasized the role of trust in alleviating the fear of risk and creating an atmosphere in which the sources and recipients are less inclined to engage in cost-benefit calculus, and more willing to credit each other's viewpoints and to exchange information with others. Such trust is also significant in the transfer of tacit knowledge that is hard to communicate as readily as information, and this is particularly true in the context where crowdsourcing communities are virtual and widely distributed with consequent difficulties in enforcing, measuring or monitoring their implicit knowledge contributions (Davenport & Perusak, 1998). Hence, I hypothesize that:

H1: Activity objects serve to foster knowledge sharing for crowdsourced digital innovation.

Because an activity object creates a community around itself with the passage of time, knowledge acquisition is facilitated, because the best way to access knowledge is to interact with the community (Mandl et al., 1996). Specifically, from the perspective of communities of practices, knowledge assimilation is not about absorbing information, but rather is about becoming a part of a community, which is a social process built around informed participation (Engeström, 1991). In crowdsourcing communities where learning is identified to be nothing more than accepting socially shared beliefs and practices, activity objects foster the social process of enculturation, promoting the acquisition of knowledge that includes not only procedural and declarative expertise but also social beliefs and values (Lave & Wenger, 1991). In addition, because activity objects act as triggers of negotiation and conflict (Miettinen & Virkkunen, 2005), they serve to spur expansive learning, a powerful driver for the acquisition and assimilation of knowledge. From the perspective of boundaries of different communities of practice, one platform by which expansive learning occurs is through addressing these boundaries of different communities (Lave, 1992). When members of different communities learn from one another, and have to incorporate distributed pieces of knowledge from each member for problem-solving, this process involves the change of their identity, through which expansive learning as well as knowledge acquisition can occur (Merry, 1995). At the same time, friction is likely to happen between heterogeneous actors at the boundaries of different communities of practices, as members as a whole iteratively affect each other by building and modifying the changes in each other's identities (Stamps, 1997). Such inter-community boundaries are the places where knowledge creation and acquisition occur, where diverse actors engage in an expansive learning to compare and contrast their viewpoints with each community, thereby fostering the assimilation of 'knowledge-in-context' in terms of their various requirements (Paul et al., 2012). Hence, by revealing cognitive conflicts and triggering expansive learning among diverse communities, activity objects serve to foster knowledge elicitation and promote intellectual exploration, thereby enhancing their opportunity to generate high-quality knowledge (Rennstam, 2012). Furthermore, activity objects can attach the social desire for recognition and approval to themselves (Miettinen, 2005), which is

perceived as a primary source of motives for the members to make contributions to their communities. As the number of actors motivated to contribute their knowledge to crowdsourced digital innovation increases, activity objects serve to broaden the knowledge that improves the conditions essential for the acquisition of knowledge for innovation (Davenport & Perusak, 1998). Specifically, with a community of practice that revolves and evolves around an activity object, this object acts as a trigger to attract broader communities and thus develop wider (weak) ties (Granovetter, 1973). Such ties, critical for the transmission of novel information, expose the community members to a diversity of external contacts that increases the breadth and depth of their knowledge base, and provides extra opportunities to acquire knowledge (McEvily & Zaheer, 1999). Apart from this extrinsic desire for recognition, activity objects can also trigger intrinsic desire in relation to a common goal (Nicolini et al., 2012). Such desire produces a sense of belonging, commitment and trust among crowdsourcing communities, so that they feel psychologically safe and willing to commit their cognitive resources, learn from each other and nurture the authentic expression of diverse viewpoints, fostering access to and receipt of knowledge (Sigalaa & Chalkiti, 2015). These socio-affective forces are perceived as a prerequisite to knowledge acquisition; as Abrams et al. (2003) suggested, an intimate network lock-in effect enables the information held by an individual to reach others quickly, making the knowledge understood and absorbed more easily. Hence, I hypothesize that:

H2: Activity objects serve to foster knowledge acquisition for crowdsourced digital innovation.

Drawing on the potentially contradictory nature of collective activity (Miettinen & Virkkunen, 2005), activity objects trigger contradictions and conflicts that can spur expansive learning (Engeström, 1987), essential for the coordination and integration of knowledge. Specifically, the cognitive conflicts induced by the object of an activity enable the community members to realize their incomplete ideas, appreciate dissenting views, resolve issues of controversy and create optimal solutions, resulting in a high level of expansive learning (Sockalingam, 2000). Such learning plays a critical role in overcoming pragmatic boundaries to the transfer of knowledge resulting from the divisions in practice associated with differing in political interests (Carlile,

2002). In this way, by revealing contradictions and clarifying interdependencies among crowdsourcing communities (Garrety & Badham, 2000), activity objects engage these communities in the process of expansive learning, in which they can recognize the knowledge needed to accomplish the innovation, elicit each other's expertise, tinker with a variety of knowledge in parallel, inspire critical reflection, question things taken for granted, and develop a novel understanding for shared problem-solving, leading to the integration, coordination, and transformation of heterogeneous knowledge at the interface of community boundaries for crowdsourced innovation (Boland et al., 2007). Furthermore, activity objects can provide the members who pursue reputation improvement with extrinsic motivators for continually contributing to the community. By inducing the desire for recognition among the actors, the object of an activity creates an affective relationship with its actors, with which they are engaging in a collective activity (Miettinen, 2005). As more members are motivated to participate in high-order reflective learning, activity artefacts facilitate the exchange of information and the mobilization of cognitive resources that foster the assembly, combination and recombination of heterogeneous pieces of knowledge for crowdsourced innovation. The additional extrinsic motivator that an activity object can provide is attracting attention, by effectively attaching its community members' goals, motives and expectations to itself to recognize, acknowledge, and reward user contributions (Jin et al., 2015; Miettinen, 2005). By providing such an extrinsic motivator, activity objects serve to get more actors access to a variety of knowledge and thus increase their opportunity to leverage the existing knowledge for the creation of novel associations (McEvily & Zaheer, 1999). Hence, I hypothesize that:

H3: Activity objects serve to foster knowledge integration for crowdsourced digital innovation.

4.3 Research Design

In this research, I used a mixed-methods research approach that began with quantitative surveys to test the hypotheses and followed these with qualitative interviews to enrich and make sense of the hypotheses.

4.3.1 *Zhihu*: A Representative Activity Object

In this study, I selected "*Zhihu*"- a Chinese question-and-answer (Q&A) website, where widely distributed actors across heterogeneous communities create questions, crowd-source the search, and vote for high-quality answers- as a representative object of crowdsourced digital innovation activity for three reasons. First, as a community platform, *Zhihu* is able to attract a number of actors with heterogeneous expertise and potentially contradictory interests to engage in the target activity of asking and answering questions, thus creating a crowdsourcing community around it for digital innovation. Because, as a social network website, *Zhihu* is inherently disputatious, it can also act as a trigger of conflict for its crowdsourcing communities, a place where they can engage in an expansive learning by posting challenging Q&As, searching for topics of interest, voting answers up or down and commenting on controversial content. Second, as highly distributed, heterogeneous online actors engage in the process of asking and answering questions, *Zhihu* is able to help them "find the signal in the noise", while avoiding irrelevant content (Paul et al., 2012). Specifically, *Zhihu* supports a voting service such that more authoritative answers can get up-voted to the top of the answer list, while less helpful answers can get down-voted and eventually filtered out (Patil & Lee, 2016). In this way, *Zhihu* directs the process of separating high-quality answers from ill-formed alternatives on the basis of the numbers of votes received. Because answers produced by primary sources of information with first-hand testimony or direct evidence pertaining to a question are generally perceived as authoritative (Harper et al., 2008), in voting for high-quality content with primary source knowledge, crowdsourcing communities often judge others' reputations according to their online profiles. This information, which may include background expertise, past contribution history, and online popularity, provides a context for *Zhihu* users to verify an answer's validity, thereby helping them vote up valuable answers (Paul et al., 2012). The 'invite' function of *Zhihu* also allows users to tag specific individuals in relation to particular questions to try and ensure that these questions are answered by the most authoritative experts. Hence, *Zhihu* directs the crowdsourced digital innovation activity by leveraging appropriate social connections to help users acquire high-quality answers. Third, *Zhihu* serves to motivate its crowdsourcing communities to continually contribute to the collective activity of asking and answering questions, by providing them with extrinsic and intrinsic in-

centives. In terms of extrinsic incentives, because online users are motivated to exchange their high-quality knowledge for reputation and attention, *Zhihu* is able to recognize, acknowledge and reward the user contributions via its voting mechanism (Jin et al., 2015). Because knowledge contributors desire being deemed valuable to the community, an up-vote provides gratification for their customized answers, which fuels their continued participation in the community. In terms of intrinsic incentives, *Zhihu* provides a place where feelings of belonging, loyalty and trust can be engendered among a 'family' of (invisible) friends. Such community affiliation intrinsically motivates the community to commit to the digital innovation activity.

4.3.2 Quantitative Research

In this study, I used web-based surveys to test the hypotheses. Specifically, I conducted the survey via the *SurveyMonkey*, and measured the items using seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The study population consisted of 500 *Zhihu* users in the groups of digital product innovation, software design and apps use. I distributed 500 questionnaires and deemed 355 usable for the quantitative analysis. To collect reliable data, I asked key informants to respond to the surveys, typically well-known *Zhihu* users with a good reputation and large numbers of up-votes, who frequently use their expertise to provide high-quality answers and leverage their social connections to obtain useful knowledge. Of the response population of 355, 301 had been registered on *Zhihu* for more than three years; those with a PhD numbered 105 (29.6%), while those with industrial experience in digital innovation accounted for 65%.

In terms of measurement, I first measured *Zhihu* as an activity object (ZH) with four items by asking respondents whether, in their crowdsourced digital innovation activity, *Zhihu* had: (1) created a community around the activity where they engaged in expansive learning and crowdsourced to absorb the wisdom of each other (Jin et al., 2015); (2) directed them to find useful answers, while avoiding irrelevant content (Patil & Lee, 2016; Paul et al., 2012); (3) motivated them to ask and answer questions by recognizing and rewarding their unique contributions (Miettinen, 2005); (4) encouraged them to commit to the activity and their community by triggering feelings of belonging and trust (Choudhury et al., 2014). Second, I used four items to

measure knowledge sharing (KS) by asking respondents if they had: (1) developed a compatible communication method to promote the transfer of intellectual capital such as experiences, expertise and creative ideas from one actor to the next (Dhanaraj & Parkhe, 2006); (2) discussed particular technologies with each other, and accessed the knowledge held by the other members (Lynn et al., 2000); (3) created and maintained a certain common ground for communication and interaction (Dodgson, 1993; Nonaka, 1994); (4) promoted mutual transparency, and avoided hiding information from each other during the process of innovation (Dyer & Nobeoka, 2000; Kale et al., 2000). Third, I used three items to measure knowledge acquisition (KA) by asking respondents if they had: (1) recognized and developed the different ways in which each actor interprets and accepts the disseminated message (Weber & Khademian, 2008); (2) adequately received and assimilated the shared knowledge resources, increasing their knowledge base (Gold et al., 2001; Yang, 2005); (3) organized live technology training for the purpose of idea diffusion and solution acquisition (Lynn et al., 2000). Last, I measured knowledge integration (KI) with four items by asking respondents if they had: (1) created a full understanding of each other's expertise and developed an ability to scan, filter and engage relevant network actors for problem-solving (Benkler, 2006); (2) fully explored each member's unique local context, while carefully interrelating their practiced-based expertise with that of others (Carlile, 2002); (3) had maximized the dispersed contributions stemming from a diverse knowledge base while creating a coherent culture (Tsai, 2001); (4) had understood how individuals leverage their diverse domains of expertise for innovation (Crossan & Inkpen, 1995).

4.3.3 Qualitative Research

In this part of the research, I used interviews to gain an insight into how *Zhihu* affects the sharing, acquisition and integration of knowledge, enriching the quantitative results with supplementary evidence. Specifically, I conducted 48 semi-structured interviews, each lasting for 45 minutes. To collect the most reliable data available, I selected those *Zhihu* users with a high number of up-votes for their answers and a good reputation in their communities, suggesting that they can seek and provide high-quality answers, and are able to recognize the elements affecting the process of knowledge-orientated innovation. In terms of their demographic contexts,

22 of these users focused on developing digital games, and 26 focused on designing mobile apps. Of these 48 respondents, 12 held a PhD, and 29 had industrial experience in digital product innovation. Moving to data analysis, I coded the interview transcripts to identify key themes and categories pertaining to each of the questions. By way of example, for one question, I analysed the full transcripts, attempting to find connections between the answers and the motivations. After coding different transcripts, I identified several categories of answers and the corresponding motivations given by various respondents. Then I went back to the transcripts to ascertain how many interviewees' viewpoints belonged to each category. In addition, I also used some initial codes based on the known theoretical concepts in the literature to categorize the transcripts. During the process of recursively moving back and forth between original recordings and transcripts, my appreciation of the link between *Zhihu*, knowledge sharing, knowledge acquisition and knowledge integration emerged progressively. In moving between data and theories, I used N-Vivo software to check whether the emerging themes were supported by the data and whether theories helped make sense of the empirical evidence.

4.4 Research Results

4.4.1 Quantitative Results

In terms of a measurement model (Table 4.1), I first conducted an exploratory factor analysis of the four measures (ZH, KS, KA, KI), by using a principal axis factoring analysis with *Oblimin* oblique rotation with Kaiser normalization rotation. Specifically, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.786, indicating that the data was suitable for factor analysis. In addition, the data showed support for the four factors, which had eigenvalues greater than 1 and explained 96.129% of the variance. Furthermore, the measures suitably represented the four factors whereby all the primary loadings exceeded 0.709. Finally, the Cronbach's alpha was 0.906, implying a high reliability of internal consistency. I also conducted a confirmatory factor analysis to estimate the model using IBM SPSS Amos software, consistent with Anderson and Gerbing's (1988) two-step approach. First, all indexes displayed a good fit with the model: the observed chi-square (CMIN) was 421.15 with 399 degrees of freedom (DF), the normed fit index (NFI) was 0.990, compara-

tive fit index (CFI) was 0.980, and root mean square error of approximation (RMSEA) was 0.021, suggesting a good model fit. Second, I examined the convergent validity by testing the significance of the factor loadings and their gap to the standard error (S.E.) (Koufteros, 1999). All item loadings were above the suggested cut-off of 0.6 (Hair et al., 1998), with a strong significance level. Additionally, all the S.E. values were around 0.1, indicating that all the items had a clear relationship with their own latent variables. Furthermore, all the composite reliability (CR) values of the latent variables were above the criterion of 0.7 (Hair et al., 1998), showing a good convergent validity. Finally, all the square roots of the average variance extracted (AVE) shown on the diagonal of the correlation matrix were greater than the off-diagonal construct correlations, implying a good discriminant validity (Koufteros, 1999). With regard to the structural model (Figure 4.1), I used Amos to test the hypotheses. All the paths were significant, supporting the three hypothesized relationships. The coefficients of *Zhihu* were positive and significant for knowledge sharing (β =.23, $p<.01$), knowledge acquisition (β= .53, $p<.001$), and knowledge integration (β= .19, $p<.01$). This support H1, H2 and H3, indicating that, as an activity object, *Zhihu* fosters the sharing, acquisition, and integration of knowledge for crowdsourced digital innovation.

Constructs	Items	Loading	S.D.	C.R.	KMO	Cronbach's α	ZH	KS	KA	KI
***Zhihu* as an Activity Object**	**ZH1**	.709	.116	.792	.811	.893	**.756***			
	ZH2	.823	.100							
	ZH3	.765	.114							
	ZH4	.754	.115							
Knowledge Sharing	**KS1**	.767	.111	.801	.891	.918	.431	**.827**		
	KS2	.712	.124							
	KS3	.803	.095							
	KS4	.907	.101							
Knowledge Acquisition	**KA1**	.801	.129	.751	.767	.907	.311	.225	**.763**	
	KA2	.822	.135							
	KA3	.711	.092							
Knowledge Integration	**KI1**	.798	.091	.719	.765	.906	.315	.301	.232	**.731**
	KI2	.711	.099							
	KI3	.766	.118							
	KI4	.812	.109							

*Square root of average variance extracted

Table 4.1. Summary results of the measurement model.

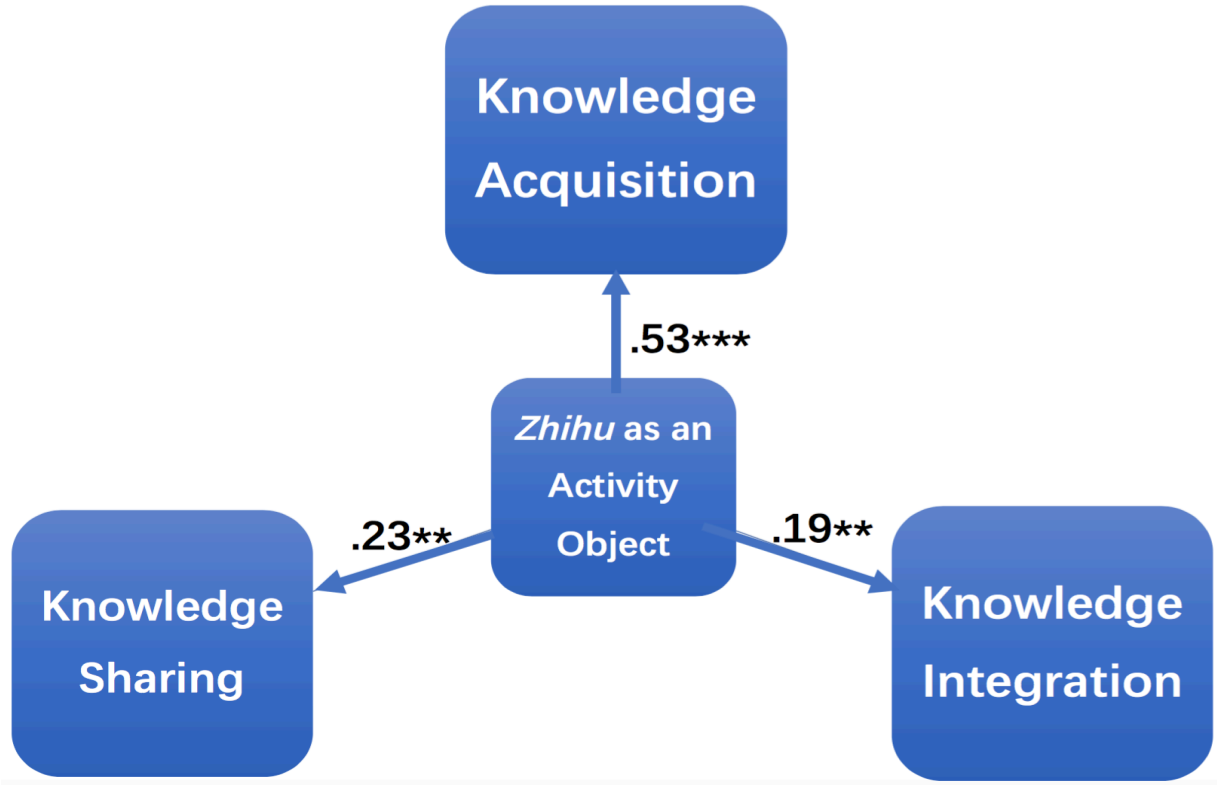

Figure 4.1. Result of the structural model.

4.4.2 Qualitative Results

The quantitative result for hypothesis H1 was corroborated by my interview data. Specifically, I found that *Zhihu* created a crowdsourcing community, whose trajectory was shaped by different knowledge relationships, and where contradictions abounded to trigger expansive learning. As one user mentioned in his interview: "*Usually one question brings us together. We see the question first, then we come to use our expertise to answer the question. We also look at others' answers, compare and contrast their answers with ourselves. It is normal that we have different views and we answer the question from different perspectives. It is these different interpretations that make us evaluate multiple methods, seek optimal solutions, and abandon invalid answers.*" As high degrees of expansive learning overcame heterogeneous barriers to the transfer of knowledge arising from pre-established divisions of crowdsourcing communities, knowledge travelled more freely from one community into another, promoting the mobilization of dispersed pieces of knowledge for innovation. This was reflected in an interview: *"I follow a topic called creative app design, where there are many Q&As concerning the feasibility of novel apps based on iOS 10, like their potentials and problems. There are over 200 persons under this*

topic, who share an interest in digital innovation based on iOS 10. It is normal that we engage in a dialogue to discuss, argue and debate with each other regarding one specific question, and this behaviour can deepen our communication and increase our information diffusion speed. In this way, although we have different expertise, we can quickly develop a shared understanding of optimal problem-solving." In addition, some interviewees believed that *Zhihu* triggered socio-emotional forces among them, which promoted the information flow and fostered the knowledge diffusion. Specifically, one user highlighted how *Zhihu* created an ethical, organic and cohesive culture within his community, in which he was willing to answer questions, credit the others' ideas and openly share valuable answers: "*Because we are all interested in iOS 10.1.1, it is easy for us to discuss the function of this system, its potential and its bugs. So, it is not weird that during the process of asking and answering questions together, we can generate a high degree of trust in each other's willingness and competence to solve problems."* Another interviewee further emphasized the significance of trust in the transfer of tacit knowledge: *"We don't know each other in reality. What holds us together is a common interest in digital innovation. At this time, trust is very important to open our hearts and share our viewpoints, especially the tacit knowhow that is easily lost in the virtual world. When we have a high trust in each other, we are confident that our interests will be fully protected. We will not hoard our knowledge nor keep any information from each other. The implicit knowledge can only be transferred, if and when a cohesive core in-group is developed."*

My qualitative data similarly made further sense of hypothesis H2. Most interviewees highlighted the role of *Zhihu* in separating valuable answers from alternatives in directing them in the acquisition of high-quality knowledge. Specifically, *Zhihu* provides a space where valuable answers generally get up-voted to the top of the answer list, while irrelevant content gets down-voted and eventually filtered out. The 'invite' mechanism of *Zhihu* also leveraged proper social connections to help its users gain authoritative answers from primary information sources, by allowing them to tag persons who have direct evidence on specific questions. As one interviewee highlighted: *"Zhihu is an amazing place where you can approach a diversity of experts who handle the most primary information sources in different domains. For example, when you ask a question about comparing Huawei Mate 9 with iPhone 7, it is possi-*

ble that it will be a designer working within Huawei who provides you with a (very authoritative) answer." Nevertheless, some interviewees argued that an answer from such primary knowledge sources does not necessarily represent a higher quality response. In order to find the "real" signal in the noise, *Zhihu* engages its users in a reflective dialogue, where they are empowered to access a pool of diverse answers, compare and contrast their answers with others, and negotiate their perspectives mutually, fostering the assimilation of 'knowledge-in-context' in terms of their various requirements (Paul et al., 2012). As one user reported: *"Many people up-vote the answers from primary information sources, but I am not one of them. I only respect logic. If the logic of an answer convinces me, I will give it an up-vote. If not, I tend to argue with the answer provider, in order to create a better answer. Vice versa, I like to discuss with those who question my answers, and to conduct some self-reflection."* In addition, some interviewees believed that *Zhihu* propelled them to continually engage in the process of creating questions and formulating answers, by providing them with reputation and attention. Specifically, I found that *Zhihu*'s function of assessing the helpfulness of responses attracted answers from many users pursuing reputation improvement. This was reflected in one interview: *"When I receive up-votes from others, I can really feel their approval of my answer. This gives me more confidence to answer other questions, in order to achieve more up-votes. I want to use my expertise to answer questions and help others solve problems, but I also want social recognition for my contribution. These two requirements don't conflict with each other; on the contradictory, each takes what the other needs."* As increasing knowledge is contributed via the answer posting, *Zhihu* broadens the knowledge available to its users, fostering conditions essential for the acquisition of knowledge for innovation. Meanwhile, *Zhihu* provides its users with attention by using its voting mechanism to recognize and reward their contributions, where more up-votes symbolize more attention. Thus, individuals contributed high-quality content to compete for each other's attention, as one user said: *"I am a new Zhihu user. In order to attract other users' attention, I usually raise the latest, hottest, and most interesting questions. Thus, a vast number of experts with diverse backgrounds will come to post their comments. When the iPhone 7 Plus was released, I asked a question about its camera function. Many Apple fans were attracted to explain me a lot of useful know-how, and simultaneously brought my question even more attention."* When a user posts a creative question, it is a trigger to attract broader communities

and develop wider ties, critical for the diffusion of information, and the acquisition of knowledge. Some interviewees highlighted that *Zhihu* also triggers socio-emotional forces among its users. For example, one interviewee described how *Zhihu*'s 'invite' function helped its members secure exchange relationships with specific users and encouraged them to contribute their answers: "*When I see some questions suitable for my friends, I will invite them to come and answer because I believe that they will give wonderful answers and receive many up-votes. I think this is a win-win. Vice versa, when people send me an invitation to a question, I will try my best to answer it, avoiding letting them down and embarrassing myself. Having developed this kind of exchange relationship with Zhihu users, I feel good in inviting others to answer questions and receiving others' invitations to answer questions*."

The quantitative results for hypothesis H3 were also enriched by my interviews. Most users highlighted that *Zhihu* brought them into contact with cognitive conflicts that encouraged them to realize their incomplete ideas, embrace dissenting views, resolve issues of controversy, and seek optimal solutions. Thus, one interviewee reported: "*Although we share a common interest, we have different experiences, we work in different domains. It is normal that we have various ways of thinking, framing problems and solving problems. It is also normal that we perceive and answer questions differently".* And another stated: *"Conflict is not necessarily a bad thing. It can make me realize what my problem is, and where my idea has gone wrong, so that I have a chance to correct. For the whole community, it can engage us in a reflective, open dialogue, which is also a positive thing."* Hence, these interviewees were empowered to engage in a significant learning critical to overcoming pragmatic barriers to the transfer of knowledge resulting from the divisions in practice, and conducive to the transformation of knowledge for innovation. This was seen in one interview: "*When we group together around one specific question that we all are interested in*, *we can have a full picture of each other's expertise, thereby recognizing the knowledge needed for answering this question, tinkering with various pieces of knowledge in parallel, and developing a shared understanding for problem-solving."* Furthermore, *Zhihu* provides its users with attention as an extrinsic incentive, by using its voting function to recognize and reward user contributions. In order to compete for each other's attention, *Zhihu* users tended to post more challenging questions to attract wider communities to answer them, and to build more ties that help

the users to access a wider variety of knowledge and leverage more existing knowledge for innovation. As one interviewee said: *"Sometimes, I deliberately organize my question in an unexpected way and tag those famous 'big shots', in order to attract their attention and increase my popularity. Vice versa, I always answer selectively and intelligently, attempting to achieve more up-votes and attention." Zhihu* also triggers high degrees of trust among its members, so that they are willing to credit each other's viewpoints in joint problem-solving, essential for the coordination of different pieces of knowledge. This was seen in one interview: *"I feel truly happy when I find my answer is useful to others. If I know the answer, I will provide it without hesitation. In the process of exchanging opinions with each other, we have a high level of trust, which helps us develop a shared understanding of optimal problem-solving."*

4.5 Discussion and Conclusions

In combination, my quantitative and qualitative results demonstrate how activity objects serve to orchestrate knowledge for crowdsourced digital innovation. Therefore, I make two contributions. My first contribution is to recognize *Zhihu* as a trigger for expansive learning, and a director and motivator of crowdsourcing communities in facilitating the sharing, acquisition and integration of knowledge, thereby presenting a novel private-collective model for crowdsourced digital innovation with an integration of personal investment and collective action (Trompette et al., 2008). Specifically, this private-collective model for crowdsourced digital innovation involves an effective coordination between mutually dependent collective action and personal investment (Trompette et al., 2008). With regard to collective action, I identified the ability of *Zhihu* to direct the qualifying process to ensure the attainment of high-quality answers, and even support the shift from highly credible ideas to potential innovation opportunities. This co-evaluation process combines quantitative and qualitative means. For the quantitative measures, the crowd can evaluate an answer's usefulness via voting, with more authoritative answers getting up-voted, and less popular ones getting down-voted and filtered out. By attributing a "like" to an answer to indicate how many users favour it, *Zhihu* directs the process of separating high-quality content from alternatives, which saves significant time and allows crowdsourcing communities to make more accurate decisions. For the qualitative

means, the crowd may offer their various opinions on certain questions, comment on answers given or convert novel ideas into feasible plans. For example, *Zhihu*'s 'invite' mechanism enables the crowd to tag users in relation to certain questions to obtain more useful answers. Thus, I highlighted the capacity of *Zhihu* to shape the collective activity and "find the signal in the noise" for crowdsourced digital innovation (Paul et al., 2012). In terms of personal investment, I recognized the ability of *Zhihu* to encourage the investment of the diverse knowledge resources of intrinsically and extrinsically motivated users in the creation of Q&As, promoting the aggregation of added-value contributions to crowdsourced digital innovation (Trompette et al., 2008). For the extrinsic incentives, I emphasized *Zhihu*'s ability to provide its users with a space to compete for each other's attention and promote their future engagement, by recognizing and rewarding their differing contributions, based on the fact that online communities tend to exchange their knowledge for attention. As Lanham (2006) indicated, social recognition indeed dominates free-riding incentives, and a member with a larger audience size may contribute more to the community. I also highlighted the capacity of *Zhihu* to give its users intrinsic incentives. Whereas crowdsourcing communities are seen as densely interconnected networks of actors, *Zhihu* not only offers a space for knowledge orchestration, but it also encourages reciprocal behaviours by identifying, detailing and highlighting user contributions. Thus, *Zhihu* creates a sense of community, builds a tone of collaboration, and concentrates shared norms of trust, gratitude and respect that members have toward each other to motivate them to contribute without an a priori specified reward in sight. To illustrate, *Zhihu*'s security policy helps its users, who disclose their personal information online, build trust that improves their perceptions of the congruent values within their communities.

For my second contribution, the focus on the independent role of an activity object as a trigger for expansive learning and a director and motivator of knowledge orchestration contributes a novel understanding of the roles of material artefacts and humans in crowdsourced digital innovation. In contexts where digital technology has democratized the communication tools, where product and industry boundaries have become blurred and fluid, and where decentralized crowdsourcing communities have emerged to leverage mutual intelligence for innovation, the danger lies in knowledge being too fragmented and heterogeneous (von Hippel, 2005). Orlikowski (2007) per-

ceived material artefacts as technical objects or managerial instruments, which are generally utilized to sustain and support the daily work in the hands of managers who speak on their behalf. Vázquez (2006) emphasized the active role of managers as the agents of control through supervision or normative means. Drawing on this work, I have highlighted the active role of these material artefacts in enabling networks of actors to freely share, acquire and integrate knowledge, and in mediating dialogue between differing perspectives, maximizing the wisdom of the crowd for digital innovation. In this way, my research provides a new insight into how material artefacts can coexist with other types of formal managerial control in a beneficial manner, geared toward coordinating the fragmented and heterogeneous knowledge for crowdsourced digital innovation. Specifically, I gave prominence to activity objects that have been applied to collaborative development within virtual communities of practice (Hemetsberger & Reinhardt, 2009), and linked crowdsourcing communities to digital innovation. 'Crowdsourcing', combining 'crowd' in terms of 'the wisdom of crowds' and '(out)sourcing' in the sense of opening up the R&D process to a distributed network of heterogeneous actors via an open call, is a key trend that has been studied by many scholars (Bayus, 2013; Howe, 2006). Communities, seen as the basic organic force, are essential for achieving network effects (Surowiecki, 2004). By viewing crowdsourced digital innovation as an object-oriented, culturally mediated and collective human activity (Engeström, 1999), I presented the ability of activity objects to orchestrate knowledge by providing expansive learning, direction, and motivation for the crowdsourced digital innovation activity. To be more specific, I demonstrated how an activity object creates a crowdsourcing community around it, and how contradictions abound to trigger expansive learning, conducive to the absorption of collective wisdom for digital innovation (Nicolini et al., 2012). In addition, I highlighted an activity object's ability to motivate the members of its community, by recognizing their desire for social recognition and a struggle for personal identity (Hegel, 1977), by attaching "esteem achieved in community life" (Miettinen, 2005, p. 62) to it and by objectifying community members' participation in the products of their actions, whereby their achievement constitutes the objectified demonstration of their capability to contribute to their community and the target activity (Miettinen, 2005). Thus, activity objects are able to recognize, acknowledge and reward the contributions of community members, continuously fuelling their participation in and contribution to the activity and their communities. This is especially true

in highly distributed, virtual crowdsourcing activities, where division of labour is a source of individuality (Miettinen, 2005). Apart from social recognition, I also emphasized the capacity of an activity object to trigger emotional attachment and intrinsic obligations- such as social affiliation, feelings of belonging, trust and self-actualization- that are not restricted to individuals but operate as an engine of solidarity among the members of its community (Nicolini et al., 2012). In this way, the activity object provides a "family of invisible friends" with a "home", where they are committed to crowdsourced digital innovation (Abrams et al., 2003).

In terms of theoretical implications, by treating *Zhihu* as an activity object that creates crowdsourcing communities around it for digital innovation, I add to the work of Mladenow et al. (2014) and Trompette et al. (2008), who linked crowdsourcing to open innovation and recognized a community platform as an "interesting" subject for scholars. My focus on *Zhihu*'s role as a director and motivator presents a novel private-collective model for crowdsourced digital innovation, with the integration of collective action in distinguishing high-quality content from alternatives, and the personal investment of fragmented and heterogeneous knowledge resources. Such a cultural artefact reveals a trade-off, between a control by itself to direct its community to find valuable knowledge, and a delegation to motivate its community to contribute their cognitive resources. From an interdependency perspective, this activity object and its crowdsourcing community waver between centralization and distribution of power in the control of the collective activity (Trompette et al., 2008). Thus, my study has a theoretical implication for the development of new collaboration rules among virtual crowdsourcing communities, for managing tensions to trigger expansive learning, for identifying extrinsic and intrinsic incentives to enhance individual involvement, and for establishing the collective brain to direct the innovation activity. Simultaneously, my focus on strategic decomposition, modular problem-solving, and the way in which the locus of knowledge pushes the locus of innovation beyond the organization offers some research implications for the design of organizational identity, culture, boundaries, control and incentives (Smith & Lewis, 2011).

I also furnish two practical suggestions. First, my focus on *Zhihu*'s director role has a practical implication for the design of such a Q&A website. By emphasizing *Zhihu*'s capacity to select the best answers, generally from primary information sources, I

suggest that such community platforms should promote the creation of social networks based on a real-name registration policy, which provides users with improved credibility when judging others' authoritativeness (Paul et al., 2012). I also found that users tend to judge others' reputation according to their past actions and contributions; thus, I suggest such Q&A sites to make users' online histories easier to discover, which is especially significant for those websites without complex algorithmic mechanisms for signalling user reputation (Paul et al., 2012). Second, for those firms aiming to cooperate with crowdsourcing communities to leverage differentiated cognitive resources into something that creates novel meaning, my study provides a practical implication for the identification of motivation to encourage involved actors to contribute to crowdsourced activities. Specifically, as online users tend to exchange their knowledge for attention, I suggest those senior managers to promote such social websites as a marketplace, which connects users' needs for attention and knowledge, thereby motivating their involvement. For example, it is a good idea to leverage the response mechanisms of such social platforms to recognize user contributions and visualize free-riders' acknowledgement toward knowledge contributors (Wasko & Faraj, 2005). I also suggest those leaders to develop a network macroculture, which could be seen as a governance mechanism, to align the efforts of crowdsourcing users and support the safeguards against potential actor malfeasance.

CHAPTER 5 When *Guanxi* Meets Structural Holes: The Role of Social Networks in Knowledge Orchestration among Chinese Digital Entrepreneurs[4]

Abstract

In this study, we explore how Chinese digital entrepreneurs interact and leverage guanxi - a system of influential relationships and social network dynamics in Chinese culture - to buffer the negative impacts of structural holes on knowledge orchestration and to add value to their innovation networks. After drawing on the existing literature to build our research model, we develop ten hypotheses. We adopt a mixed-methods research approach where we use a quantitative survey to test the hypotheses grounded on our theoretical framework, and qualitative interview data to explain and uncover further the mechanisms that underlie our quantitative results. Our paper makes four contributions: 1) it recognizes guanxi as a 'shock absorber' that lessens the adverse effects of structural holes among Chinese digital entrepreneurs; 2) uncovers the unique value that Chinese 'integrators' bring to their innovation networks; 3) presents how 'knowledge orchestrators' purposefully and deliberately promote the mobilization and coordination of knowledge to maximize the value in innovation networks; 4) and uncovers evidence of what type of guanxi is utilized the most among Chinese digital entrepreneurs and when, thus, identifying the dynamics of guanxi in entrepreneurial network relationships.

[4] Liu, J., Nandhakumar, J. and Zachariadis, M. (2017), "'*Guanxi*' as a Shock Absorber: Lessening the Detrimental Effect of Structural Holes on the Acquisition and Integration of Knowledge", in *Proceedings of the 25th European Conference on Information Systems (ECIS)*, Guimarães, Portugal, June 5-10, 2017 (pp. 1600-1618).

5.1 Introduction

China's leading digital entrepreneurs have increasingly made an impact on the global landscape (Leavy, 2016) attracting attention to their business networks and unique culture. With digital innovation pushing heterogeneous actors to connect across multiple organizational and community boundaries, doubly distributed innovation networks often emerge, where the organizational and technological control on product components is distributed across firms of different kinds, and where the knowledge is distributed across heterogeneous communities and specialties (Yoo et al., 2010). Digital entrepreneurs drawing on such a network are likely to encounter a serious challenge in coordinating this heterogeneity of knowledge and countering its fragmentation. Hence, a certain amount of orchestration, influence and direction is needed to appropriately mobilize and coordinate knowledge without sacrificing flexibility and independence in the processes of innovation.

Drawing on a network orchestration model (Dhanaraj & Parkhe, 2006), we endorse the view of "a hub in networks" (Heikkinen & Tähtinen, 2006, p. 273), suggesting that an individual who holds a nodal position in their innovation network tends to use prominence (Wasserman & Galaskiewicz, 1994) and power (Brass & Burkhardt, 1993) to perform a 'prime mover' role in knowledge orchestration. Thus, structural holes theory attests that a hub actor who connects two or more otherwise disconnected individuals in a network, each with access to complementary information, has more advantages than an actor who does not occupy such a central position (Burt, 1992). Most studies highlighting the benefits that accrue to the 'brokers' occupying structural holes have restricted their scope to Western contexts (Burt, 1997, 2000, 2005), but Xiao and Tsui (2007) highlighted that the collectivistic values of China undermine the ways in which Chinese brokers gain their control and information benefits. Being embedded in Confucian culture, the Chinese perceive these brokers as unethical, selfish and opportunistic, because they manipulate "accurate, ambiguous, or distorted information" strategically between the two sides to have a "disproportionate say in whose interests are served" (Burt, 2000, p. 354). Thus, structural holes may expose the intermediary actors to conflicting allegiances (Podolny & Baron, 1997), increasing their risk of diminishing collective interest and tarnishing personal reputation. Besides attenuated control benefits, Chinese brokers cannot fully

realize their personal information benefit either, as the communal-sharing values oblige them to attribute a more significant share of the pie to the group contribution and a smaller proportion to that of the broker (Xiao & Tsui, 2007).

Having said that, it is not clear that whether or not such disadvantages can be mitigated given that '*guanxi*', a system of influential relationships and social network dynamics in Chinese culture, is certain to have a unique influence on structural holes. In China, every person is expected to observe *guanxi*, regardless of their age or profession, because it acts as the social standard when developing and maintaining a relationship among the Chinese (Nguyen & De Cremer, 2016). Scholars have studied the constraining effect of the Chinese culture on structural holes (Batjargal, 2005, 2010; Xiao & Tsui, 2007), but, thus far, how *guanxi* moderates the negative impacts of structural holes on the orchestration of knowledge among Chinese digital entrepreneurs at different entrepreneurial stages remains largely unexplored.

Because *guanxi* is a means by which people can accomplish their personal, family or business goals (Bell, 2000), it involves family-or-friend *guanxi*, where members are related by blood or are emotionally close, with a high degree of intimacy, obligation and expectation (Fan, 2002), and business *guanxi*, which involves seeking business solutions via personal ties, and which can often be unstable because of sparse interconnections and low levels of trust (Yang, 1994). The distinctive roles of these two kinds of *guanxi* have been ignored in terms of their effect on the relationship between structural holes and knowledge orchestration. Different types of *guanxi* can affect the extent to which the negative impacts of structural holes are mitigated, especially business *guanxi* that pursues resource mobilization by exchanging favours, accumulating *renqing* (i.e. reciprocal favours in Chinese culture) and preserving *mianzi* (face) (i.e. not showing disrespect in Chinese culture) (Chen et al., 2004; Hwang, 1987; Wang, 2007). Developing business *guanxi* is a dynamic process, through which a gradual transition occurs from being treated as an outsider to becoming a part of the in-group. During this process, hub actors tend to act as integrators who fill their structural holes and pull previously disconnected individuals together into a buffer zone, "a sphere of morality and human feeling" (Nguyen & De Cremer, 2016), within a highly competitive and chaotic business environment, such

that valuable personal connections emerge that oil the wheels of business transactions (Guthrie, 1998), and alleviate the negative effects created by structural holes.

While the collectivist values of China might cause brokers to lose their control and information benefits from filling structural holes, *guanxi* is likely to mitigate such disadvantages. In this research, we aim to explore how structural holes and *guanxi* influence knowledge mobilization and knowledge coordination among Chinese digital entrepreneurs in their innovation networks at different entrepreneurial stages. Thus, our research question is: how do Chinese digital entrepreneurs interact and leverage *guanxi* to orchestrate knowledge and add value to their innovation networks?

The rest of the paper is organized as follows: in the next section, we integrate diverse bodies of literature to build our research model and develop our hypotheses. Then we use questionnaires to test the hypotheses, and conduct interviews to gather qualitative evidence to explain and uncover further the mechanisms that underlie our quantitative results. Last, we report our results and articulate their contributions, including the associated theoretical and practical implications.

5.2 Literature Review

In this study, we refer to digital entrepreneurs as entrepreneurs who search for change and pursue opportunities "based on the use of digital media and other information and communication technologies" (Davidson & Vaast, 2010, p. 1531). Specifically, as digital media and IT have created new conditions for communication and new opportunities for business models, a tremendous level of ambiguity regarding the interpretation of the future arises in this digital world. In this study, we focus on those entrepreneurs who have "abilities to deal with such ambiguity", by "supporting a new but disruptive technology" (Joshi & Yermish, 2000, p. 9). During the process of seizing such opportunities, these entrepreneurs amplify changes in the competitive landscape that "potentially further the creative destruction process of the digital economy" (Davidson & Vaast, 2010, p. 1531).

As digital innovation is identified to be inherently layered (Yoo et al., 2010), a doubly distributed innovation network may emerge, bringing its own challenges (Lyytinen et al., 2015; Nätti et al., 2006; Yoo et al., 2010). Specifically, the radical reduction of communication and coordination costs makes affordable the participation in the innovation process of otherwise disconnected actors, distributing the coordination of innovation activities more widely (Yoo et al., 2008). In addition, the loosely coupled layers embedded in these innovation networks enable high levels of flexibility but result in greater fragmentation of the knowledge base common to the network actors (Nätti et al., 2006). Furthermore, the convergence of digital technology combines resources and components in unforeseeable ways, which cumulatively expands the cognitive heterogeneity along the 'rolling edge' of the network actors' capabilities (Yoo et al., 2012). All of this can lead to the knowledge becoming too fragmented and heterogeneous to control. Confronted with this problem, Yoo et al. (2008, 2010) suggested that knowledge orchestration could be a useful solution. Drawing on this network orchestration model (Dhanaraj & Parkhe, 2006), we identify k*nowledge mobilization* and *knowledge coordination* as the essential ingredients that constitute it.

Knowledge mobilization concerns the ease with which knowledge is transferred and accepted within a network (Dhanaraj & Parkhe, 2006). More specifically, knowledge transfer is predominantly referred to in the network literature as an 'asset' that carries value for a network (Nahapiet & Ghoshal, 1998). Particular emphasis is placed on standardizing or establishing compatible methods of communication to facilitate the sharing of this form of intellectual capital across the 'syntactic' boundaries (Carlile, 2002; Weber & Khademian, 2008). When the transferred knowledge is complex and there is not clarity of purpose, the challenge shifts to the receipt of the knowledge, where a 'semantic' approach (Carlile, 2002) is needed to recognize the different ways with which each actor interprets and accepts the disseminated message.

Knowledge coordination occurs - and the full potential of the innovation network is only realized - if and when the heterogeneous knowledge resources of independent actors are combined together and transformed into an innovation (Crossan & Inkpen, 1995; Kogut & Zander, 1996). By definition, knowledge coordination concerns the extent to which the network members leverage and integrate their diverse domains of

expertise (Gold et al., 2001; Schutz et al., 2009). In doubly distributed innovation networks, a 'pragmatic' approach (Carlile, 2002) is needed for the network actors to fully explore their unique local context without losing their ability to interrelate and transform different types of 'hard-won', practice-based knowledge into a novel innovation that transcends its customary pragmatic boundaries (Yoo et al., 2012).

Moving to social network structures, we first focus on structural holes, which are defined as the gaps, or absence of connection, between two contacts who are both, nevertheless, linked to a common actor (Burt, 1992). Second, we place an emphasis on *guanxi*, defined as "the exchange of favours; the cultivation of personal relationships; and the manufacturing of obligation" (Yang, 1994, p. 6). As a highly particularistic tie between two persons bonded by an implicit psychological contract (King, 1991), *guanxi* involves a mechanism that governs different types of relationships with different degrees of social norms and role obligations. In this research, we divide *guanxi* into family-or-friend *guanxi* and business *guanxi*. Such a distinction is also made by Yan (1996), who conducted his research in a village setting and divided *guanxi* into a 'primary form' and an 'extended form'. Specifically, the villagers perceived their *guanxi* networks as the local moral society in which they lived. Within this society, they had the 'primary form' of *guanxi,* which involved close fellow villagers with whom one has primary social relationships and moral obligations to provide social support for mutual aid when it is needed. Beyond this *guanxi*, they instrumentally and pragmatically developed an 'extended form' of *guanxi* as well, which referred to the relationships established with strangers in pursuit of their personal benefits. Even though the villagers were clever at 'pulling' or leveraging such *guanxi* by exchanging suitable gifts on different ritual occasions, they did not have to take the same moral force and obligations as those in their primary *guanxi* networks (Yan, 1996).

Figure 5.1 presents our research model. Before discussing in more detail how *guanxi* and structural holes influence knowledge mobilization and knowledge coordination, we make one additional distinction. In this research, we divide Chinese digital entrepreneurs into two types: entrepreneurs of start-ups and those of growing ventures. Thus, while acknowledging the significance of the initial entrepreneurial stage, our research model recognizes the two stages that Chinese digital entrepreneurs experi-

ence, and investigates the roles of family-or-friend *guanxi*, business *guanxi* and structural holes in knowledge mobilization and knowledge coordination. In addition, our model explores further the moderating effect of *guanxi* on the relationship between structural holes and knowledge orchestration at both entrepreneurial stages.

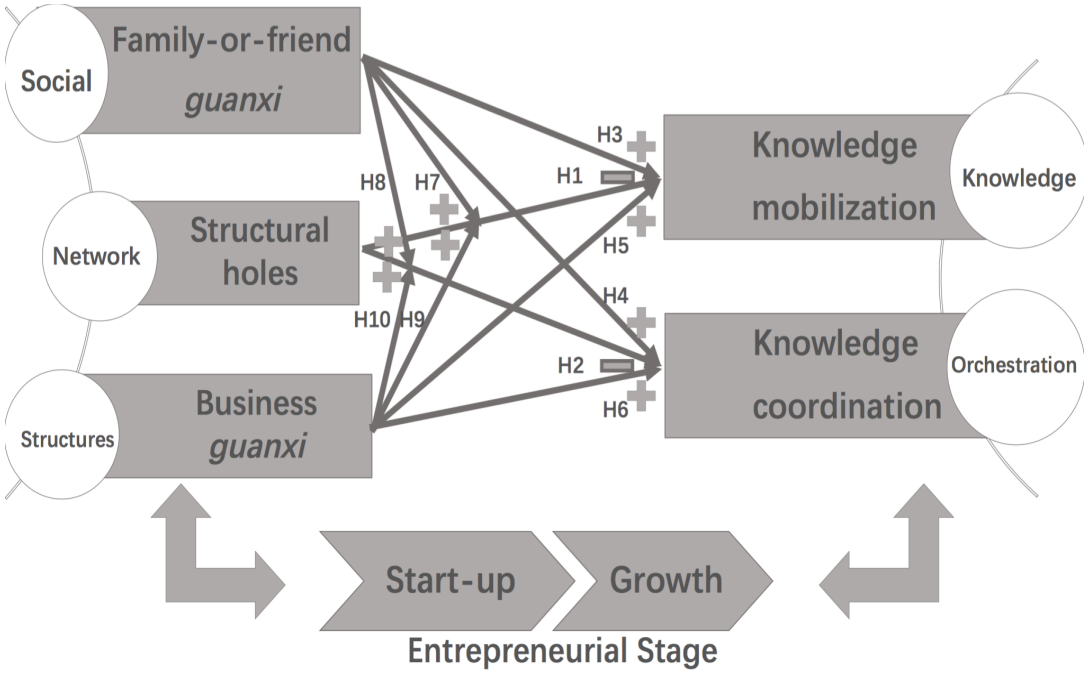

Figure 5.1. Research Model.

5.2.1 Structural Holes

Although structural holes theory has its roots in Western contexts (Burt, 1992, 1997, 1999, 2000, 2002), scholars have previously tested its validity in Chinese culture whose institutional mechanisms and cultural norms are substantially different from those of Western culture (Xiao & Tsui, 2007; Batjargal, 2004, 2005, 2007, 2010). According to their work, the Chinese do not benefit from spanning structural holes because the cost is higher than its return. Structural holes may generate three issues among Chinese digital entrepreneurs: first, structural holes in innovation networks may slow down the communication process amongst distributed actors who barely know each other (Batjargal, 2005). Secondly, structural holes are likely to trigger the creation of boundaries in the flow of information, leading to a bottleneck in knowledge diffusion (Batjargal, 2010) and decreasing innovation efficiency because the quality of information deteriorates as it transfers from one actor to the next in a chain of intermediaries (Baker, 1984). Thirdly, a mismatch of strategies may also be

created as a reflection of dispersed, vague and distorted information (Batjargal, 2004, 2007). As already discussed, these issues may amplify the knowledge fragmentation that exacerbates entrepreneurs' difficulty in sharing and acquiring fine-grained knowledge across structural holes. More specifically, according to transactive memory theory (Wegner, 1986), the knowledge of "who knows what" is essential for the development of collective intellectual capital for innovation, but dispersed communication may maximize the silo effect and minimize the collective learning, increasing the efforts needed for adequate knowledge mobilization, which entrepreneurs cannot afford (Gulati, 1999). In addition, knowledge mobilization is not just a matter of copy-and-paste from the sources to the recipients but is a generative process, where trust is highly vital in removing barriers to the transfer of tacit knowledge, and unsmoothed information mobilization may hinder trust-building, increasing the sluggishness of knowledge flow around structural holes (Szulanski, 1995). Furthermore, as Obstfeld (2005) highlighted, a large firm can maximize its benefit from a network of small enterprises who are too vulnerable in themselves to protect their core techniques, and unfocused strategies created by structural holes aggravate the exposure of small enterprises to unethical brokerage and potential malfeasance (Bizzi, 2013).

Taking another perspective, structural holes are also likely to amplify the incompatibility of personal values and behaviours of heterogeneous entrepreneurs (Bizzi, 2013). Brokers embracing a cost-benefit calculus tend to manipulate information to exploit personal power, while those valuing social obligation are inclined to pass on information in the collective interest (Marks et al., 2001). As members uncover conflicting beliefs and behaviours, it may give rise to negative attitudes, because when brokers control information for personal gain, the remaining isolated actors have to pay for it, creating their resentment toward the brokers (Bizzi, 2013). At the same time, brokers deriving personal benefits from structural holes decrease the benefits available to other brokers, so that all brokers may perceive each other as competitors and adopt mutually hostile attitudes; the shared perception of potentially opportunistic behaviours further deepens mutual monitoring and dependence, preventing brokers from relinquishing control and heightening their risk of becoming overloaded (Costa & Bijlsma-Frankema, 2007). All of these issues may reduce the network actors' motivation to integrate knowledge. Furthermore, increased dissimilarity in en-

trepreneurs' social and technical worlds, exacerbated by diverse structural holes, prevents them from building shared understanding (Obstfeld, 2005), which further exacerbates the knowledge heterogeneity, and hinders the coordination of knowledge for innovation. As Sandström (2004) pointed out, a greater number of structural holes triggers a higher degree of heterogeneity of knowledge.

Hence, we hypothesize that:
Hypothesis 1 (H1): Structural holes impede knowledge mobilization in doubly distributed innovation networks among Chinese digital entrepreneurs.
Hypothesis 2 (H2): Structural holes impede knowledge coordination in doubly distributed innovation networks among Chinese digital entrepreneurs.

5.2.2 Family-or-Friend *Guanxi*

Involving a high level of relational capital, family-or-friend *guanxi* can confer on Chinese digital entrepreneurs a commitment advantage (Anderson, 2008), which provides them with emotional support and access to resources, mitigates their negative attitude to brokerage, and shelters them from the worst effects of opportunism (Chen et al., 2013; Hite & Hesterly, 2001; Pollack et al., 2012). Many scholars have studied the role of relational proximity in the transfer, acquisition and integration of knowledge. For example, Yli-Renko et al. (2001) pointed out that a high degree of relational cohesiveness makes entrepreneurs less willing to withhold resources and more inclined to credit each other's perspectives. Hansen (2002) highlighted that the lock-in effect produced by an intimate network increases members' motivation to commit their intelligence resources, fostering the assimilation and integration of knowledge. Dhanaraj and Parkhe (2006) found that a high degree of relational proximity reinforces "a common identity", seen as a prerequisite to knowledge mobility, which provides a "cohesive force" (Orton & Weick, 1990) and develops the "logic of confidence and good faith" (Meyer & Rowan, 1977) among network actors, essential for the sharing of valuable knowledge with each other (Dyer & Nobeoka, 2000). As a result, the high level of relational capital embedded in family-or-friend *guanxi* serves to facilitate the flow of cognitive resources throughout the innovation network, thereby increasing the efficiency of the network entrepreneurs in disseminat-

ing, acquiring and leveraging knowledge across structural holes (Benkler, 2006; Nambisan, 2013; Yoo, 2013).

From the above discussion of the relevant theory and literature, we hypothesize that:
Hypothesis 3 (H3): For knowledge mobilization in doubly distributed innovation networks, Chinese digital entrepreneurs primarily rely on family-or-friend guanxi.

Hypothesis 4 (H4): For knowledge coordination in doubly distributed innovation networks, Chinese digital entrepreneurs primarily rely on family-or-friend guanxi.

5.2.3 Business *Guanxi*

Business *guanxi*, which is grounded on the traditional Confucian philosophy (Chen et al., 2004), values *renqing* and *mianzi*. Specifically, *renqing*, which highlights the social exchange nature of *guanxi*, is a lubricant for the emotional and economic exchange of favours in the pursuit of relational longevity (Wang, 2007). By definition, the word '*renqing*' combines '*ren*', or human being, and '*qing*', or feeling, affection and sentiment, and concerns the informal social obligation to exchange favours with another person (Nguyen & De Cremer, 2016). It highlights the obligation to nurture a reciprocal relationship through highly symbolic interactions, where many signals are silently embedded in a mutual understanding between the two parties (Wang, 2007), and this reciprocity shapes how favours should be mobilized to perpetuate *guanxi* (Nguyen & De Cremer, 2016). In this way, *renqing* is a form of social capital that provides leverage in interpersonal exchange, and when developing and maintaining a *guanxi* relationship, reciprocal *renqing* returning is obligatory (Nguyen & De Cremer, 2016). As Yang (1994) noted, once *renqing* is established, a person can ask a favour from someone and has an obligation to return this favour in the future. Such an arrangement of taking turns to give favours is therefore significant in facilitating social bonding and maintaining *guanxi* in highly uncertain innovation networks (Luo, 2005). In addition to *renqing*, *mianzi* also serves as a social currency with an absolute value in China: giving or saving *mianzi* (face, respect) symbolizes the social rituals in Chinese culture, while losing *mianzi* may degrade or dissolve the *guanxi* (Hwang, 1987). Seen from the perspective of hierarchical ties, the underlying social status of *mianzi* is a fundamental aspect of favour exchange. Between two en-

trepreneurs with dramatic differences in social power, saving the senior entrepreneur's *mianzi* represents a significant favour given, which may lead to a greater favour in return for the junior entrepreneur (Zhang & Zhang, 2006).

Because business *guanxi* involves an implicit rule of favour exchange among network entrepreneurs whose social status is asymmetric (Peng, 2003), it can enhance socialization, which is defined as "formal and informal linkages among network members" and is recognized as a prerequisite to knowledge mobility (Dhanaraj & Parkhe, 2006, p. 662). Given such favour mobilization, heterogeneous cognitive and social resources can then flow more freely through the innovation networks, enabling actors to tinker flexibly in order to inspire critical reflection, question things taken for granted, and promote perspective-taking and enhance sense-making of the diversity of knowledge (Boland & Tenkasi, 1995; Yoo et al., 2010). Such strong accommodation between one another's perspectives serves to homogenizes mindsets and increase cognitive proximity between independent entrepreneurs (Lin, 2001); Boschma (2005) found that, among relatives, friends and business partners, it is business partners that have the closest cognitive proximity with entrepreneurs. This 'optimal cognitive distance', at which the network actors' knowledge bases demonstrate sufficient complementarity to learn from each other, while also maintaining fluent communication throughout reciprocal understanding (Cantner et al., 2010; Nooteboom et al., 2007), can enhance their capacity to leverage diverse domains of expertise, fostering the transformation of knowledge into innovation (Schutz et al., 2009). This view is supported by many scholars (Dyer & Singh, 1998; Robert et al., 2008). For example, Buttner (1992) found that individuals with better-matching cognitive modes can more readily assimilate and deploy each other's tacit knowledge.

Based on the above, we can hypothesize that:
Hypothesis 5 (H5): For knowledge mobilization in doubly distributed innovation networks, Chinese digital entrepreneurs rely on their business guanxi.

Hypothesis 6 (H6): For knowledge coordination in doubly distributed innovation networks, Chinese digital entrepreneurs rely on their business guanxi.

5.2.4 Moderating Effects of *Guanxi* on Structural Holes

With the influence of *guanxi*, Chinese entrepreneurs tend to fill structural holes and pull otherwise disconnected individuals together into an in-group to inhibit personal controlling behaviours and enhance collective intelligence benefits (Xiao & Tsui, 2007). Specifically, trust-building among Chinese entrepreneurs is very challenging, because they do not make any assumptions about other's goodwill besides that of their relatives or close friends. Thus, most business dealings are highly dependent on personal and entrepreneurial trustworthiness (Redding, 1990). Within an interwoven business network, where prestige flows via word-of-mouth dissemination and where the Chinese view the brokerage as unethical, those who frequently leverage their business *guanxi* with a higher concern for *renqing* and *mianzi* are less inclined to profit from the brokerage, a behavior otherwise regarded as "standing on two boats" (a Chinese proverb) and socially distasteful (Batjargal, 2005). Instead, they are more willing to cultivate a social exchange relationship and develop a form of social capital to create a cohesive *guanxi* network, utilizing this network to reap business advantages (Nguyen & De Cremer, 2016). In addition, the collectivistic values of China encourage those who sit at the boundary of two in-groups to fill the hole and act as the 'real' bridges to promote the flow of information and foster the integration of dispersed knowledge, so that the whole in-group can share the intelligence benefit that would otherwise have belonged primarily to the brokers (Xiao & Tsui, 2007). By providing the favour of introducing unknown contacts to one another, integrators invest their *renqing*, which can extend through the network quickly, leading to a greater return because the Chinese tend to trust those who are introduced by their trustworthy sources (Batjargal, 2005). As for those who receive a favour, they tend to pull more individuals together in order to return this favour because they respect the unwritten code of reciprocity that emphasizes taking turns to give favours; if they refuse to reciprocate a previously granted favour, they will be excluded from any further development and maintenance of business *guanxi,* resulting in a humiliating loss of mianzi (Nguyen & De Cremer, 2016).

The situation in which personal controlling behaviours are inhibited and collective intelligence benefits are enhanced also applies, if and when family-or-friend *guanxi* plays a prominent role. As the controlling behaviour is perceived as opportunistic

(Frye, 2000), those who value their family-or-friend *guanxi* rarely favour the manipulation of information between two parties at the expense of hurting their relatives or close friends (Gu et al., 2008). This view is supported by Yan (1996), who argues that acting toward one's family in a manner that is more suitable to dealing with strangers is perceived as unethical, demonstrating a lack of *renqing* and leading to a loss of *mianzi*. At the same time, rather than acting as a controller, those who rely primarily on their family-or-friend *guanxi* tend to play the role of integrator in brokering situations (Xiao & Tsui, 2007), pulling unconnected entrepreneurs together and turning indirect ties into direct ties, enabling the whole network to share the broker benefits for innovation (Verona et al., 2006; Xiao & Tsui, 2007).

In this way, a 'buffer zone' appears, around which an abundance of cognitive and social resources flow in the form of favour exchange, *renqing* accumulation, and *mianzi* preservation, smoothly alleviating the negative issues that structural holes can create. This concept of a buffer zone was first proposed by Yang (2016), who reported that the Chinese require a "private sphere" of kinship, friendship and *guanxi* networks around them to act as a form of buffer against dysfunctional legal systems and the increasing surveillance power of the communist state (Haveman et al., 2016). In this buffer zone valuable personal connections serve to oil the wheels of official procedures, and even override formal legal systems to get things done (Guthrie, 1998). In this research, we focus on the affective side of *guanxi*, identifying a buffer zone as a space where close-knit connections among networks of entrepreneurs are developed around mutual commitment, bonding and empathy to mobilize and secure favours in business transactions (Nguyen & De Cremer, 2016). In such a buffer zone, an individual who occupies diverse structural holes tends to perform as an 'honest' middleman or transferable medium by establishing *guanxi* on behalf of the two parties, linking multiple entities together, and smoothing out potential issues that may arise during intense business transactions (Nguyen & De Cremer, 2016). As a result, connections between previously isolated actors are established. As existing ideas are linked across multiple boundaries to satisfy the requirements of network actors, the distributed knowledge resources can be effectively mobilized and deployed for problem-solving (Dhanaraj & Parkhe, 2006; Hargadon & Sutton, 1997). Furthermore, when those otherwise disconnected entrepreneurs get access to the buffer zone, by "taking in outside perspectives" (Schutz et al., 2009), they cross pragmatic bounda-

ries to reflexively negotiate their perspectives and transform their 'hard-won' knowledge into increased "waves of innovation" (Boland et al., 2007; Carlile, 2002; Kellogg et al., 2006).

Hence, we hypothesize that:
Hypothesis 7 (H7): Family-or-friend guanxi moderates the effect of structural holes on knowledge mobilization in doubly distributed innovation networks.

Hypothesis 8 (H8): Family-or-friend guanxi moderates the effect of structural holes on knowledge coordination in doubly distributed innovation networks.

Hypothesis 9 (H9): Business guanxi moderates the effect of structural holes on knowledge mobilization in doubly distributed innovation networks.

Hypothesis 10 (H10): Business guanxi moderates the effect of structural holes on knowledge coordination in doubly distributed innovation networks.

5.3 METHODS

In this research, we use a mixed-methods research approach that begins with a quantitative method to test the hypotheses and follows up with a qualitative method to explain further the quantitative results and identify the underlying mechanisms that lead to the emergence of the above phenomena. In general, mixed-methods research is used to establish a more systematic account of a phenomenon (Zachariadis et al., 2013). Specifically, quantitative methods are usually better at identifying non-obvious regularities in larger, often numerical, samples where qualitative methods would not have been effective. On the other hand, qualitative methods are able not only to explain propositions but can also identify the mechanisms through which complex phenomena interact and the various contingencies that affect them. In our research, we used quantitative surveys to test the hypotheses and estimate their impacts, which were then discussed in conjunction with our qualitative results and existing theory. In parallel, our qualitative analysis of the interviews allowed us not only to explain these relationships but also to make better sense of the quantitative results by revisiting our interview data.

In the quantitative part of the research, we used a stratified random sampling approach to select 450 digital ventures listed in the China Credit Information Service Incorporation Yearbook. Our sampling frame included entrepreneurs in the digital industry, covering digital products, software and mobile apps. On the basis of Petch (2017), who divided the business lifecycle into five stages, we classified these digital entrepreneurs into two types: the first being the nascent entrepreneur who has thoroughly tested their business ideas, and decided to launch their start-up, which is less than three years old; the second being the entrepreneur with a company aged three years old or more, whose business has generated a consistent source of income and regularly taken on new customers. We distributed a total of 450 questionnaires and deemed 325 of the responses usable for the quantitative analysis (the remaining 125 deemed unusable for miscellaneous reasons such as incomplete responses), representing a response rate of 72%.

To collect the most reliable data available, we requested those key informants who were founders of digital ventures with large innovation networks to respond to the surveys; they frequently leveraged their personal connections to obtain valuable social and cognitive resources, and could be expected to be able to comment on the survey variables emerging in the process of knowledge-orientated innovation. Table 5.1 depicts the demographic profiles of the two types of respondent, allowing us to compare across several dimensions. Specifically, of the 325 respondents, 150 (46%) were entrepreneurs of digital start-ups that were founded between 2013 and 2016 with a mean age of 2.2 years; while the other 175 (54%) were entrepreneurs of growing ventures with a mean age of 11 years, of which the oldest company was 27 and the youngest 4.5 years old. With regard to company size, those entrepreneurs with start-ups had an average of 16 employees, while those who operated growing ventures had an average of 151 employees, of which the largest workforce numbered 950. In addition, according to the data, 90 (60%) start-up entrepreneurs held a PhD, while those of growing ventures with a PhD accounted for 63%. Entrepreneurs of start-ups with industrial experience numbered 30 (20%), while 67% of the entrepreneurs operating growing ventures had industrial experience. Finally, the data presents that both groups consisted of digital entrepreneurs conducting R&D activities,

where 33% of the start-ups were R&D-intensive firms, while the growing ventures with R&D activities numbered 125 (71%).

Characteristic	Entrepreneurs of start-ups (N = 150)	Entrepreneurs of growing ventures (N = 175)
Average company age (from 2016)	2.2 (min = 0.7; max = 3)	11 (min = 4.5; max = 27)
Average company size (no. employees)	16 (min = 2; max = 36)	151 (min = 32; max = 950)
Entrepreneurs with a PhD (no.)	90	110
Entrepreneurs with industrial experience (no.)	30	117
Entrepreneurs with R&D activities (no.)	50	125

Table 5.1. Demographic profiles of the two types of survey respondents.

In the qualitative part of the research, we conducted semi-structured interviews to make sense of the quantitative results with supplementary evidence. The general theme of the interviews was "how *guanxi* and structural holes influence knowledge mobilization and knowledge coordination". Each interview typically lasted for about 45 minutes. From all the survey respondents, we selected 48 entrepreneurs who established their digital ventures between 1996 and 2014 in *Zhongguancun*, a typical high-tech district in Beijing. Table 5.2 presents the demographic characteristics of the interviewees. Specifically, the data shows that 25 (52%) entrepreneurs had operated their companies for more than three years. Of the 48 interviewees, four had fewer than ten employees, and 41 had between ten to 500 employees. In terms of functional background, 29% were in digital games, 31% were in video software, and 40% were in mobile apps. Finally, of the entrepreneurs interviewed, 32 held a PhD, ten held Master's degrees, and the remaining six had Bachelor's degrees.

Characteristic		Number (no.)	Percent (%)
Company age	**Less than three years old**	**23**	**48**
	Three years or more	**25**	**52**
Company size	**Less than ten employees**	**4**	**8**
	Between ten and 500 employees	**41**	**86**
	More than 500 employees	**3**	**6**
Company function	**Digital games**	**14**	**29**
	Video software	**15**	**31**
	Mobile apps	**19**	**40**
Education background	**Doctor**	**32**	**67**
	Master	**10**	**21**
	Bachelor	**6**	**12**

Table 5.2. Demographic characteristics of the participating interviewees.

Our qualitative analysis involved coding the interview transcripts to identify key themes and categories. Specifically, we used some initial codes, based on the recognized theoretical concepts in the literature as a guide (Walsham, 1995) to categorize the transcripts such as favour exchange, personal controlling behaviours and collective intelligence benefits as well as knowledge sharing, knowledge acquisition and knowledge integration by using N-Vivo analytical software. During the process of recursively moving back and forth between original recordings and transcripts, our appreciation of the link between *guanxi* and structural holes, as well as knowledge mobilization and knowledge coordination, progressively emerged. Then we analysed the potential theoretical implications and used them to enrich our quantitative results with supplementary evidence (Nandhakumar & Jones, 1997). In moving back and forth between data and theories, we checked whether the emerging themes were supported by the data and whether theories helped make sense of the empirical evidence.

5.3.1 Measures

Structural holes. Based on the literature, we measured structural holes (SH) with six items by asking respondents to what extent (on a Likert scale with 1 - 7 responses) in their innovation networks they: (1) perceived the controlling behaviour as unethical, selfish, or opportunistic (Frye, 2000; Xiao & Tsui, 2007); (2) believed that brokerage could slow down the communication progress among network actors who barely knew each other (Batjargal, 2005; Davison & Ou, 2008); (3) believed that brokerage could block information flow and downgrade information quality (Batjargal, 2004, 2007, 2010; Baker, 1984); (4) believed that the controlling behaviour could create a mismatch of strategies by intentionally manipulating information between two parties (Burt, 2000; Cheon et al., 2015); (5) believed that brokerage could amplify the incompatibility of personal values and behaviours of diverse network actors (Bizzi, 2013; Podolny & Baron, 1997); (6) believed that brokerage could increase dissimilarity in network actors' social and cognitive worlds (Brown & Duguid, 2000; Obstfeld, 2005).

Family-or-friend *guanxi.* We identified five items by which to measure family-or-friend *guanxi* (FG) by asking respondents to what extent in their innovation networks they: (1) held a strong belief and a high level of confidence that they could count on their network members when they were in trouble (Anderson, 2008; Fan, 2002; Lee et al., 2001); (2) provided their network members with emotional support and resource access when they were in need (Chan et al., 2002; Chen et al., 2002); (3) were concerned about their network members' feelings before making a decision, and sought to mitigate negative attitudes among members of their network (Chen et al., 2013; Pollack et al., 2012); (4) felt a brotherly affection toward their network members and protected them from the opportunism of others (Hite & Hesterly, 2001; Tsui & Farh, 1997; Zhang & Zhang, 2006); (5) experienced a high degree of relational proximity and dealt frankly with their network members (Dhanaraj & Parkhe, 2006; Meyer & Rowan, 1977; Orton & Weick, 1990).

Business *guanxi.* We measured business *guanxi* (BG) through six items by asking respondents to what extent in their innovation networks they felt: (1) happy to give a favour to network actors with different social status who were in need (Peng, 2003;

Yan, 1996); (2) obliged to return a favour to those network actors who had given them a favour (Lin, 2001; Yang, 1994); (3) '*you mianzi'* (honoured) when they developed *renqing* with network actors (Luo, 2005, 2007); (4) '*mei mianzi*' (loss of face) if they did not return a received favour to favour providers (Hwang, 1987; Wang, 2007); (5) embarrassment if they damaged network actors' benefits and *renqing* (Nguyen & De Cremer, 2016; Yen et al. 2011); (6) they had a more similar way of thinking to the other actors in the network (Boschma, 2005; Buttner, 1992; Nooteboom et al., 2007).

Family-or-friend *guanxi* × Structural holes. We used three items to measure the interaction between family-or-friend *guanxi* and structural holes (FG×SH**)** by asking respondents, to what extent, in their innovation networks they: (1) tended to avoid brokerage for fear of hurting their relatives or close friends (Gu et al., 2008; Yan, 1996); (2) tended to pull their relatives or close friends together into an in-group to enhance the collective benefit (Verona et al., 2006; Xiao & Tsui, 2007); (3) believed that such *guanxi* could provide a 'private sphere' of kinship, friendship and social networks around them to mitigate negative feelings and strengthen their commitment (Nguyen & De Cremer, 2016; Yang, 1994).

Business *guanxi* × Structural holes. Based on the literature, we measured the moderating effect of business *guanxi* on structural holes (BG × SH**)** through six items by asking respondents, to what extent in their innovation networks they: (1) avoided profiting from brokerage for fear of damaging *renqing* and losing their future benefit (Batjargal, 2005; Gargiulo & Benassi, 2000); (2) avoided profiting from brokerage for fear of losing *mianzi* and tarnishing their personal reputation (Chen & Chen, 2004; Tan et al., 2015); (3) remained willing to introduce unknown contacts to one another and cultivate a social exchange relationship as a form of *renqing* investment (Reve & Lu, 2011; Xiao & Tsui, 2007); (4) remained willing, after receiving a favour from other network actors, to connect more separate individuals with one another for *renqing* accumulation and *mianzi* saving (Guthrie, 1998; Haveman et al., 2016; Nguyen & De Cremer, 2016); (5) believed that such *guanxi* could provide a 'buffer zone' of favour exchange, *renqing* accumulation and *mianzi* preservation around them, oiling the wheels of official procedures to get things done (Guthrie, 1998; Yang, 1994, 2016); (6) believed that such *guanxi* could provide a 'buffer zone' of favour ex-

change, *renqing* accumulation and *mianzi* preservation around them, where they were more inclined to establish *guanxi* on behalf of two parties, turning indirect ties into direct ties and smoothing out potential issues that could arise during intense business transactions (Nguyen & De Cremer, 2016; Yang, 1994, 2016).

Knowledge mobilization. We used six items to measure knowledge mobilization (KM) by asking respondents to what extent in their innovation networks, they: (1) established a compatible communication method to promote the sharing and dissemination of tacit intellectual capital, such as experiences and expertise, horizontally and vertically throughout the network (Argyris & Schön, 1996; Carlile, 2002; De Leo, 1994; Dhanaraj & Parkhe, 2006); (2) transformed technical information into knowledge that could be easily articulated in documents, and made, written, transferred and followed by the other network members either orally or via computer programs, patents, diagrams and information technologies (Day, 1994; Lynn et al., 2000; Sinkula, 1994); (3) recognized and accommodated the different ways in which each actor interprets and accepts the disseminated message (Carlile, 2002; Podolny & Page, 1998; Weber & Khademian, 2008); (4) adequately received and assimilated the shared information and knowledge resources, increasing their existing knowledge base such as the diversity of knowledge disciplines (Ravasi & Verona, 2001; Yli-Renko et al., 2001); (5) created and maintained a certain common ground for communication and interaction (Doz, 1996; Nonaka, 1994; Parolini, 1999); (6) promoted mutual transparency, fostered trust-building and facilitated conflict resolution among network actors (Dyer & Nobeoka, 2000; Kale et al., 2000; Pittaway et al., 2004).

Knowledge coordination. We measured knowledge coordination (KC) through four items by asking respondents to what extent in their innovation networks they: (1) established a full understanding of each other's expertise as well as developing and utilizing relevant skills and routines to achieve technology integration for higher R&D productivity (Bacheldor, 2003; Benkler, 2006; Iansiti, 1996; Tsai, 2001); (2) fully understood each network actor's unique local context, while interrelating their practiced-based expertise with one another for effective managerial decision-making and strategic responses to changes in the external environment (Carlile, 2002; Lessard & Zaheer, 1996; Weber & Khademian, 2008); (3) maximized the variety of con-

tributions stemming from a diversified knowledge base while creating a coherent culture to achieve high product performance (Takeishi, 2002; Tiwana & McLean, 2005; Yang, 2005); (4) established a clear understanding of how the network members integrated their diverse expertise into innovative products and a high number of patent citations (Crossan & Inkpen, 1995; Schutz et al., 2009; Singh, 2008).

5.4 RESULTS

Table 5.3 presents the measurement results for the two samples of entrepreneurs (start-ups and growing ventures). We first conducted an exploratory factor analysis of the seven measures (FG, BG, SH, FG × SH, BG × SH, KM and KC), by using a principal axis factoring analysis with *Oblimin* oblique rotation with Kaiser normalization rotation. Specifically, the Kaiser-Meyer-Olkin (KMO) measures of the two samples of start-ups and growing ventures were 0.766 and 0.751, indicating that the data was suitable for factor analysis. In addition, the data showed support for the seven factors, which had eigenvalues greater than 1 and that explained 94.505% and 91.535% of the variance respectively. Furthermore, the measures suitably represented the seven factors, whereby all the primary loadings of the two samples exceeded 0.692 and 0.622, respectively. Finally, the Cronbach's alpha for the two samples were 0.914 and 0.902, implying a high degree of reliability in internal consistency of the measures for the seven factors.

We also carried out a confirmatory factor analysis to estimate the model using IBM SPSS Amos software, which is consistent with the two-step approach proposed by Anderson and Gerbing (1988). First, all indexes displayed a good fit with the model: for the two samples (start-ups and growing ventures) respectively, the observed chi-squares (CMINs) were 487.155 with 394 degrees of freedom (DF), and 734.155 with 398 DF. Respectively, the normal fit indexes (NFIs) were 0.991 and 0.901, comparative fit indexes (CFIs) were 0.990 and 0.913, and root mean square errors of approximation (RMSEAs) were 0.019 and 0.031, suggesting a good model fit. Second, we examined the convergent validity by testing the significance of the factor loadings and their gap to the standard error (SE), based on the work of Koufteros (1999). As illustrated in Table 3, all item loadings for both samples were above the suggested cut-off of 0.6 (Hair et al., 1998), with a strong significance level. Additionally, all the

SE values were around 0.1, indicating that all the items had a significant and clear relationship with their own latent variables. Furthermore, all the composite reliability (CR) values of the latent variables were above the criterion of 0.7 (Hair et al., 1998), displaying good convergent validity. Finally, according to the criterion established by Koufteros (1999), when the average variance extracted (AVE) between items and their underlying latent variable is greater than that between this latent variable and other latent variables, this measurement model has good discriminant validity. In this study, we used the square root of the AVE to examine the discriminant validity. Table 3 illustrates the inter-factor correlations matrix for the research variables. It can be seen that for each sample all the square roots of the AVE shown on the diagonal of the correlation matrix were greater than the off-diagonal construct correlations, implying distinctness in its discriminant validity (Koufteros, 1999).

Items	Loading		SD		CR		Cronbach's α		SH		FG		BG		FG*SH		BG*SH		KM		KC	
SH1	.713	.709*	.116	.106*	.874	.807*	.934	.893*	**.816**	**.756***												
SH2	.709	.713*	.100	.110*																		
SH3	.728	.701*	.114	.112*																		
SH4	.705	.754*	.115	.105*																		
SH5	.726	.716*	.102	.112*																		
SH6	.801	.811*	.109	.119*																		
FG1	.811	.741*	.129	.121*	.812	.751*	.877	.823*	.306	.256*	**.806**	**.767***										
FG2	.717	.781*	.135	.129*																		
FG3	.767	.638*	.134	.114*																		
FG4	.739	.654*	.124	.121*																		
FG5	.692	.622*	.133	.118*																		
BG1	.693	.801*	.115	.103*	.745	.791*	.745	.907*	.201	.401*	.305	.205*	**.755**	**.826***								
BG2	.712	.822*	.102	.105*																		
BG3	.734	.767*	.124	.114*																		
BG4	.866	.712*	.126	.124*																		
BG5	.832	.692*	.109	.113*																		
BG6	.812	.622*	.117	.101*																		
FGSH1	.714	.634*	.113	.125*	.801	.781*	.899	.793*	.421	-.331*	.388	.488*	-.315	.215*	**.809**	**.712***						
FGSH2	.698	.671*	.108	.128*																		
FGSH3	.702	.744*	.121	.119*																		
BGSH1	.709	.879*	.121	.102*	.724	.826*	.785	.873*	.322	.358*	.271	.312*	.401	.201*	.212	.356*	**.781**	**.881***				
BGSH2	.712	.882*	.119	.110*																		
BGSH3	.745	.792*	.111	.101*																		
BGSH4	.801	.856*	.125	.119*																		
BGSH5	.785	.834*	.132	.121*																		
BGSH6	.712	.903*	.118	.105*																		
KM1	.742	.722*	.119	.111*	.739	.721*	.931	.876*	.261	.361*	-.355	-.298*	-.342	.221*	.298	.234*	.481	.281*	**.815**	**.701***		
KM2	.766	.716*	.118	.107*																		
KM3	.788	.717*	.109	.118*																		
KM4	.742	.738*	.108	.101*																		
KM5	.695	.701*	.112	.103*																		
KM6	.802	.789*	.121	.131*																		
KC1	.694	.711*	.104	.119*	.767	.739*	.934	.906*	.391	.217*	.289	.383*	.362	.492*	-.217	.417*	.501	.361*	.392	-.392*	**.816**	**.717***
KC2	.781	.766*	.109	.118*																		
KC3	.785	.812*	.111	.109*																		
KC4	.734	.787*	.126	.124*																		

*The sample of entrepreneurs of growing ventures

Table 5.3. Summary of the measurement model results of the two samples.

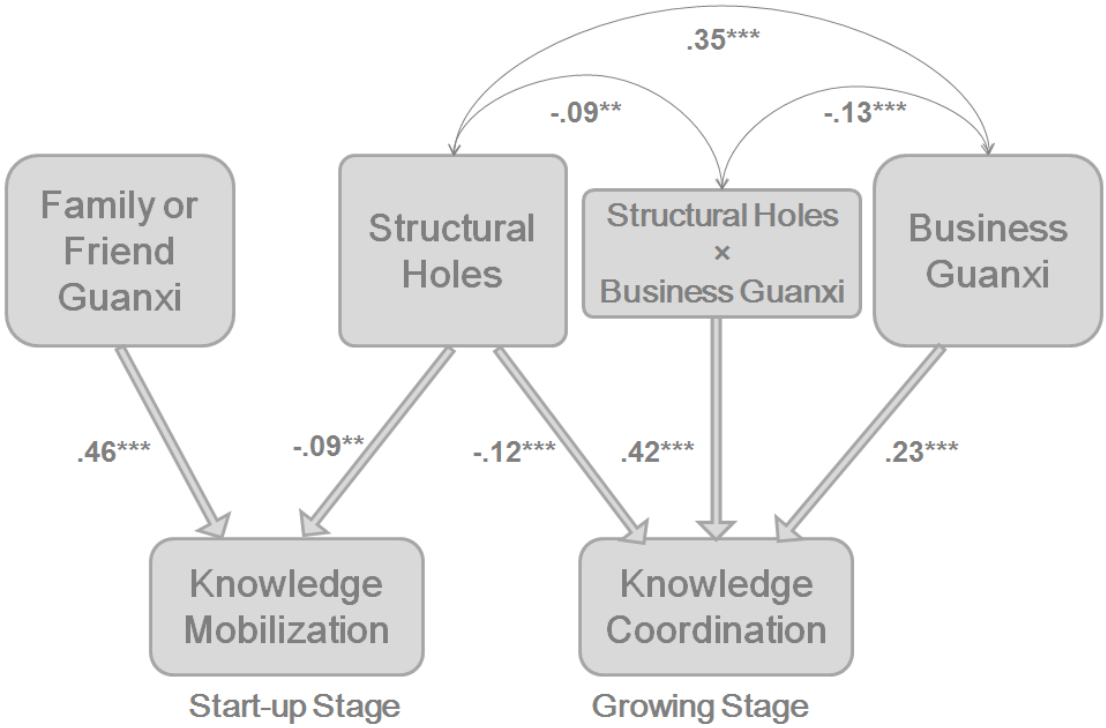

Figure 5.2. Summary of the significant results of hypothesis testing for the two samples.

In terms of the structural model, we used Amos software to test the hypotheses. Figure 5.2 summarizes the significant results of the hypothesis testing of the two samples. It can be seen that, of the 20 potential connections, five were significant, supporting five of the hypothesized relationships. Specifically, for the sample of entrepreneurs of start-ups, the coefficient of structural holes was negative and moderately significant in knowledge mobilization ($\beta = -.09$, $p < .01$), which supports H1 and suggests that at the entrepreneurial start-up stage structural holes impede knowledge mobilization in doubly distributed innovation networks among Chinese digital entrepreneurs. In addition, the coefficient of family-or-friend *guanxi* was positive and significant in knowledge mobilization ($\beta = .46$, $p < .001$) supporting H3 and indicating that, for knowledge mobilization, Chinese digital entrepreneurs primarily rely on family-or-friend *guanxi* in the start-up stage of their enterprises. For the sample of entrepreneurs of growing ventures, the coefficient of structural holes was negative and significant in knowledge coordination ($\beta = -.12$, $p < .001$), which is in line with H2, implying that structural holes hinder knowledge coordination at the entrepreneurial growth stages. Further, the coefficient of business *guanxi* was positive and

significant in knowledge coordination (β = .23, p < .001), which supports H6 and implies that in the growth phase of their enterprises, Chinese digital entrepreneurs rely on their business *guanxi* to promote knowledge coordination. Finally, the interaction coefficient for business *guanxi* and structural holes was positive and highly significant in knowledge coordination (β = .42, p < .001) at the entrepreneurial growth stage, supporting H10. Plotting this interaction, as illustrated in Figure 5.3, shows that the negative relationship between structural holes and knowledge coordination is mitigated when business *guanxi* is high, suggesting that business *guanxi* can moderate the detrimental effect of structural holes on knowledge coordination at the entrepreneurial growth stage.

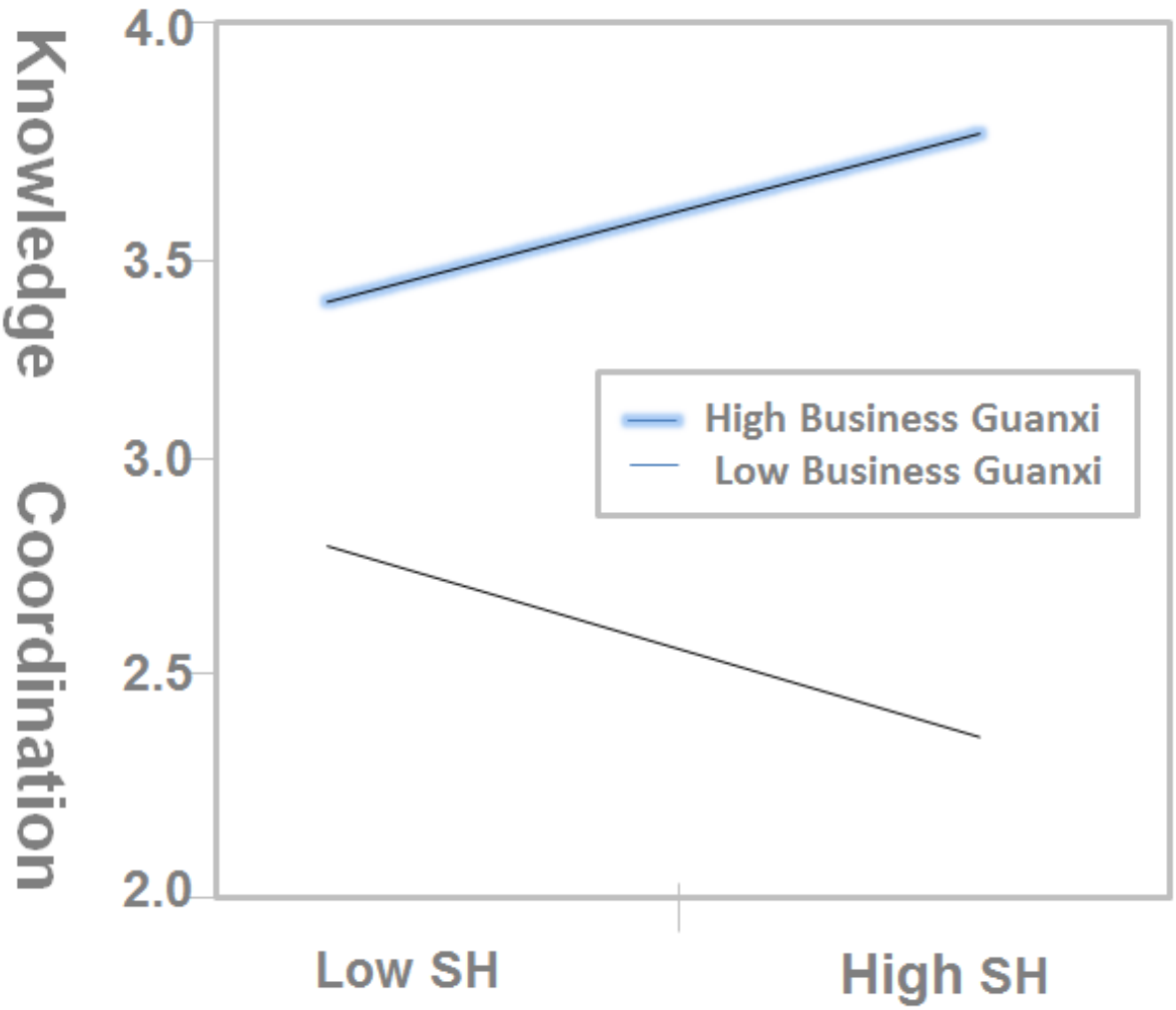

Figure 5.3. The moderating effect of business *guanxi* on the relation between structural holes and knowledge coordination

5.4.1 Qualitative Results: When *Guanxi* Meets Structural Holes

Our quantitative results in relation to hypotheses H3, H6 and H10 were corroborated, explained and enriched by the qualitative evidence collected from our interviews, as described below.

Family-or-friend *guanxi*. Our analysis of interview data suggests that when entrepreneurs started to establish their companies, they were unformed and vulnerable, with restricted resources. At this time, they indicated that they were highly dependent on their family-or-friend *guanxi* to share or acquire the resources necessary for survival in an uncertain and highly competitive business environment. As one entrepreneur said: "*When I started my firm, it was tough to gain an initial user base, which made me very stressed. My friend pulled me into a mobile media in-group and introduced me to the CEO of a mobile operator firm, who had a very high status in this circle. He allowed me to share his digital product platform, and provided me with exclusive and accurate information about the affordability of the platform so that I had more opportunities to design innovative and attractive apps based on his platform. I knew he was not a person with whom I could easily develop guanxi. This favour from my friend was priceless. He gave me hope and encouragement to make me realize I was not alone when I struggled with the pressures of a start-up*." Similarly, another interviewee told us that, during his start-up stage, a friend provided him with selfless help, including all kinds of information about market trends, user tastes, user requirements and user distribution, as well as a variety of advice on the app design: *"He is my 'firm saver'. When I started my firm, he told me that video software is a very hot field with a large audience. But most of the video apps were very boring. He suggested that I develop a video app with a 'kuso' function. Based on his advice, my team developed an app named 'Xiaokaxiu' with huge success. Xiaokaxiu was officially launched in the app store in May 2015, and ranked the first on the list of apps in the app store after only two months. I do believe that my friend who gave me this idea should take credit for this huge success."* In this way, these interviewees emphasized how their families or close friends created a cohesive sphere of trust, commitment and loyalty around them. For example, one entrepreneur highlighted the significance of trust-based connections for the transfer and receipt of

tacit knowledge: *"When we have a high level of trust in one another, we are confident that our interests will be fully protected. As a result, we will not hoard our social and knowledge resources nor keep any information from each other. We will not do anything to hurt our group members. Such a coherent atmosphere helps us share and assimilate tacit know-how."*

Business *guanxi*. As digital ventures gradually expand, the focus shifts to the integration of heterogeneous knowledge, where Chinese entrepreneurs increase their reliance on business *guanxi*. Specifically, all the interviewees acknowledged the significance of business *guanxi* for their further entrepreneurial development and highlighted that such *guanxi* had an implicit rule of favour exchange among persons with asymmetric social status. From the affective perspective of *renqing*, these Chinese entrepreneurs expressed their willingness to give favours to those persons who were in need, in order to develop and accumulate *renqing*, which was essential for their own future business development in this collectivist society. At the same time, this *renqing* was mutual. When they granted a favour first, they believed that it would automatically oblige the receiver of the favour to repay them in the future. For example, one entrepreneur operating a digital firm with more than 400 employees said: *"Developing renqing is extremely significant in China. Many things, such as whether I can obtain a resource, how fast I can obtain it, whether I have the chance to speak to the person in charge, and whether I can get accurate information in advance, depend on the renqing that I have hold. With renqing in hand, I can expand my business more easily. At the same time, developing renqing is a two-way or even multiple-way process. This means that when I develop renqing at one point in the guanxi network, this renqing can extend to the other points in the network, instead of staying in one place forever. It is a good thing, because renqing can help me expand my business guanxi network for my further development of my business."* Another entrepreneur also pointed out that *"Building good guanxi with your business partners is very important for you in expanding your business. In this business society, highlighting that time is money and maintaining a good relationship with your partners, colleagues and potential customers can help you gain a deep understanding of their ways of thinking, their habits, their favourite things and their 'mine field'. All this information is a huge plus for you in growing your business, while saving your time and effort."*

From the hierarchical perspective of *mianzi*, most of the interviewees believed that the underlying asymmetric social status of *mianzi* was critical to favour exchange: "*Gei mianzi [giving someone respect] is particularly significant in China. The Chinese care about their mianzi, especially those who have stronger social power and a higher social status. Thus, saving the face of the big shots can help you develop renqing with them, which may return you a bigger favour in the future. Taken from a long-run viewpoint, saving the face of other business partners is very helpful for your future business development and growth."*

With a large amount of favour mobilization, heterogeneous cognitive and social resources flowed throughout the networks, essential for the coordination of knowledge. As presented in several interviews: "*We have an alliance for digital innovation where all the members have similar experiences and backgrounds of expertise in creating and designing digital products. As we exchange favours with each other and mobilize resources, we come to know every member, such that we can maintain fluent communication throughout the innovation process. Sometimes, they can give me suggestions that are exactly what I needed. On the other hand, we have different ways of thinking so that we have enough space to learn from and complement with each other, increasing our chances of integrating diverse ideas into something that gives novel value."*

The Creation of a Buffer Zone: When Business *Guanxi* Meets Structural Holes. Our qualitative findings suggest that business *guanxi* does moderate the negative effect of structural holes on knowledge coordination in the growth stage of digital entrepreneurship. Being embedded in Confucian culture, most of the interviewees did not appreciate the role of brokerage, because it is *"incongruent with the collectivistic value of the Confucian philosophy"*. These interviewees perceived the controlling behaviour associated with brokerage as "selfish" and they were thus wary of those who had taken advantage of their central position in innovation networks to maximize their personal interests. For example, one entrepreneur commented on those brokers who profited from their hub position: "*I established my firm in 2009. So far, I have more than 100 employees. In my firm, the group interest should always come first. Therefore, I don't appreciate those brokers who frequently manipulate infor-*

mation between isolated persons for exploiting their personal benefits. In their minds, there is no cooperation. It is unfair. When they [brokers] control relations, innocent members have to pay for it, and get cut down like stupid animals. Those brokers also compete with one another. They hold each other in play. I don't think they [brokers] are smart. Rather they are short-sighted. Their brokerage ruins their reputation." It is therefore not surprising that most of the interviewees tended to avoid the brokerage to protect their reputation within their innovation networks. This was reflected in one interview with one entrepreneur who focused on expanding his mobile app company: "*In China, we believe that the flames rise higher when more persons add fuel to it. We live in a collectivist society from which we cannot escape. Therefore, in our culture cooperation is a very important thing. If you are good at cooperating with the others, you will get a very good evaluation from them, which will positively influence your renqing accumulation for further business development. On the other hand, if you want to be the leading sheep, when you try to control the relationship between two separate sides but get caught, you screw up! If you hold others down, you will have to pay for it. The price is that people will not trust you any longer. Everyone will resent you, and abandon you. You will lose mianzi that you can never get back.*" Another entrepreneur also remarked that *"I don't think any information can be hidden by only one person or one group. When you tell someone a secret, and ask this person to keep this secret from others, even though he makes a promise to you, this secret will eventually be spread to everyone anyway. You don't need to feel surprised as to why it happened. It is human nature. In our culture, much personal guanxi is under the table, and you cannot evaluate it on the surface. So, it is stupid to manipulate the relationships to pursue personal interest."*

On the contrary, compared with those brokers who deliberately preserve their central position to profit from the others' disconnection, it is interesting that 41 out of 48 interviewees who operated at the boundaries with non-connected actors preferred to fill these structural holes the first time they saw them and act as 'integrators', who were defined by Xiao and Tsui (2007) as people who have a large and dense ego-centered network with few structural holes. These integrators give up their advantage of "having a hand in distribution" (Xiao & Tsui, 2007) and pull separated entrepreneurs together into an in-group in the interest of the whole innovation network. Being embedded in Confucian culture, where *renqing*, reciprocity and *mianzi* play a

prominent role, when Chinese entrepreneurs act as integrators to create value for the collective network, other network members recognize their contributions and reward them for their structural hole-filling behaviour in return. Our interviewees corroborated this view. For example, one entrepreneur pointed out that, in China, it is commonplace for the entrepreneurs to introduce new contacts to their friends or business partners to realize common entrepreneurial development and win-win outcomes, because the Chinese are more inclined to trust those persons who are introduced by sources they already regard as trustworthy (Reve & Lu, 2011): "*Zhu introduced Li to me and asked me to bring Li into an in-group of a digital innovation information summit. This in-group is very private, and extremely difficult to join. Li would not be accepted unless a member of this group offers him a reference. Zhu had always helped me when I was in trouble, so I trust him very much. When I verified Li with Zhu, I trusted Li as well and brought Li into that private circle. From my perspective, creating a network of personal connections is important, but we cannot create a connection for the sole purpose of connection. We connect with each other in order to add value and make a contribution rather than to act as an information receiver, or a mere point in the network. I have no doubt that Zhu and Li will return this favour to me in the future. This is a good thing for Zhu, Li and me. It is a win-win-win situation. In our society, renqing is like money that can be banked and retrieved later. However, once I break the deal or refuse to return a previously received favour to the favour provider, I damage renqing and lose personal credibility. People will judge me. In this situation, it is very difficult for me to run a business in China.*"

When these integrators filled in structural holes in their innovation networks, a buffer zone developed around which valuable resources mobilized in the form of favour exchange, *renqing* accumulation, and *mianzi* preservation, protecting against the negative impacts created by the manipulation of structural holes. As a result, when those otherwise disconnected entrepreneurs were pulled together into the buffer zone, a high degree of trust, commitment, and obligation was developed to exchange and secure favours in business transactions (Nguyen & De Cremer, 2016), accelerating the flow of information and promoting the integration of knowledge. As one interviewee said: *"My friend brought me to this circle. It was a private in-group where we gradually developed a high level of loyalty, bonding and empathy toward each other. We trusted each other, not only our personalities, but also our competence to*

carry out our share of the task. We brought diverse domains of expertise to collaborative problem-solving. During this process, I learned how big shots use their ways of thinking to solve problems. I formed a full picture of everybody else's expertise and clearly observed how they put each piece of thinking together, how they transformed these fragments into a plan, and how they made this plan work. In this story, my friend functioned as a glue holding us together."

5.5 DISCUSSION AND CONCLUSION

Our combinative quantitative and qualitative results have managed to address how Chinese digital entrepreneurs interact and leverage *guanxi* to orchestrate knowledge and add value to their innovation networks, and we have made four key contributions in this context, as set out below.

The Creation of Buffer Zones. Our primary contribution is the recognition of *guanxi* as a 'shock absorber' that lessens the detrimental impacts of structural holes by providing a 'buffer zone' for Chinese digital entrepreneurs in their innovation networks, around which an abundance of cognitive and social resources flow in the form of favour exchange, *renqing* accumulation, and *mianzi* preservation. Specifically, our results confirm that structural holes create adverse impacts among a network of entrepreneurs, including poor communication and coordination, restricted information mobilization, a mismatch of strategies, an amplification of incompatibility in personal values and behaviours, and an intensification of the dissimilarity in their capacities and expertise, thereby hindering the mobilization and coordination of knowledge. Meanwhile, the negative image of brokers actually becomes a liability for Chinese digital entrepreneurs in the mobilization of resources, which exacerbates this knowledge fragmentation and heterogeneity. Within a collectivist society built on interwoven networks of social relations (Xiao & Tsui, 2007), *guanxi* pulls previously non-connected entrepreneurs together and constructs buffer zones within a highly competitive and turbulent business environment, moderating the adverse effects generated by the existence and manipulation of structural holes.

More specifically, in a buffer zone, those entrepreneurs who frequently leverage their business *guanxi* show respect for and comply with a tacit, subtle and everybody-

does-it rule of reciprocal favour exchange to oil the wheels of resource mobilization and get things done. Refusing to return a previously received favour will severely damage personal creditability, resulting in a humiliating loss of *mianzi* and exclusion from ongoing *guanxi* maintenance (Nguyen & De Cremer, 2016). As entrepreneurs take turns to give and receive favours among one another, their *renqing* is developed and gradually accumulated, which is seen as a form of relational capital that provides leverage in social exchanges to facilitate social bonding and obtain access to otherwise unavailable resources (Yang, 1994). Using favour mobilization and *renqing* development within the network, entrepreneurs create a harmonious atmosphere in which they share a high level of emotional understanding with each other, reducing personal disagreement and potential conflict so that their *mianzi* is fully protected and preserved. When the entrepreneurs respect each other's commitment to reciprocate, they have opportunities to obtain 'insider' information, circumvent institutional barriers, and decode the intent of official government policy in order to spur more innovation (Nguyen & De Cremer, 2016). In this way, we demonstrate how business *guanxi* and structural holes coexist in a beneficial manner geared toward the coordination of heterogeneous knowledge and countering its fragmentation in support of digital innovation, adding to the work of Xiao and Tsui (2007) and Batjargal (2005, 2010), who first highlighted the constraining impact of the collectivistic values of the Chinese culture on structural holes. We thus contribute a novel network configuration for Chinese digital entrepreneurs, which meshes *guanxi* and structural holes in a complementary way to promote the mobilization and coordination of knowledge, orchestrating their innovation networks.

Integrators not Brokers. Even though our results demonstrate that structural holes are detrimental to the mobilization and coordination of knowledge, we do not deny the significance of those associated hub actors who occupy a prestigious and advantageous position in their innovation networks. Thus, our second contribution is to complement the extant literature by systematically presenting how these 'structural hole fillers' promote the sharing, acquisition and leverage of knowledge to maximize the value of the whole network. Specifically, we tease out the unique value that 'integrators' add to their innovation networks by highlighting their pivotal role in influencing the relationships between other actors. As we have already highlighted, *guanxi* affords the creation of a buffer zone that is initiated by a collection of integrators

who are sitting at the centre of diverse structural holes and are willing to fill these holes. Unlike those typical brokers who act as 'gatekeepers', controlling information inflow and outflow, Chinese integrators tend to serve as the 'honest' brokers (Obstfeld, 2005) and 'pathfinders' (Xiao & Tsui, 2007). By opening the gate and bringing outsiders into a buffer zone, the otherwise isolated entrepreneurs around structural holes are pulled together, and those widely dispersed, heterogeneous social and cognitive resources are connected to benefit the innovation network as a whole (Grandori & Kogut, 2002). In this way, we contradict the view of many Western scholars who have perceived a middleman solely as an opportunistic broker who takes advantage of their position to reap personal benefit (Burt, 1992, 1997, 1999, 2002).

Knowledge Orchestrator. Our focus on how these structural hole fillers purposefully and deliberately orchestrate knowledge to maximize the output of digital innovation and coordinate fragmented and heterogeneous knowledge represents our third contribution to identifying the underexplored value that 'knowledge orchestrators' bring to their innovation networks. Drawing on the network orchestration model of Dhanaraj and Parkhe (2006), we endorse the notion of a hub in a network (Heikkinen & Tähtinen, 2006) and extend it from single-hub innovation networks to multi-hub innovation networks (Gnyawali & Madhavan, 2001). Specifically, we recognize those hub actors who hold a central position in their networks as knowledge orchestrators, who are not only willing to act as the glue holding the network together, but are also able to effectively mediate and manage the network members' knowledge, thereby facilitating the mobilization and coordination of that knowledge. In this way, we highlight the leading role that knowledge orchestrators play in transferring, acquiring and integrating knowledge resources through their individual action; as Burt (1992) argued, a hub position can only produce value when and if the position holder takes real action.

Relationship Control. As we uncover evidence of what type of *guanxi* is most used among Chinese digital entrepreneurs and when, we add to the current literature on network theory (Ebers & Grandori, 1999; Kenis & Knoke, 2002). By making a distinction between family-or-friend *guanxi* and business *guanxi*, and identifying the role each plays in entrepreneurial start-up and growth stages, we capture the dynam-

ics of *guanxi*, recognize the reality of change in entrepreneurial network relationships, and highlight the significance of relationship control among different Chinese digital entrepreneurs (Kenis & Knoke, 2002; Madhavan et al., 1998). Specifically, given a layered modular architecture (Yoo et al., 2010), the distinctiveness of those entrepreneurs with established digital ventures depends on their capacity to build a digital product platform encompassing loosely coupled layers of device, network, service and content that will attract heterogeneous start-up entrepreneurs to remix digital components in support of digital innovation (Yoo, 2013). It is therefore vital for these mature entrepreneurs to utilize their business *guanxi* strategically to develop appropriate incentives to attract nascent entrepreneurs to join their innovation network, while continuing to control the core components (Henfridsson & Yoo, 2014). However, for those start-up entrepreneurs who cannot afford a digital product platform and who seek to create novel components across multiple layers outside the digital platform, we found that they have no choice but to rely on their family-or-friend *guanxi*. This finding represents a significant contribution to *guanxi* identification in knowledge orchestration for digital innovation, suggesting that Chinese digital entrepreneurs should recognize the comparative advantages of family-or-friend *guanxi* and business *guanxi* with a view to engaging the right *guanxi* at the right time in the right context.

Theoretical and Practical Implications

Our study has a range of theoretical implications. First, our focus on the role of *guanxi* as a shock absorber in creating a buffer zone for Chinese digital entrepreneurs to mobilize network resources and reconcile the personal conflict between different voices of a network of entrepreneurs, produces several theoretical implications for the management of tensions among diverse actors in the process of negotiation, sense-making and sense-giving in the Chinese entrepreneurial context (Boland & Tenkasi, 1995), and also for the coordination of heterogeneous knowledge resources within doubly distributed innovation networks (Lyytinen et al., 2015). Specifically, digital innovation involves social translations that occur at the boundaries of different communities in a "digitally enabled trading zone" (Yoo et al., 2010), where actors cross pragmatic boundaries (Carlile, 2002) to mutually negotiate and adjust to each other's perspectives, and/or in an "innovation sweet spot", where there is a delicate balance between known and novel knowledge among heterogeneous actors

(Carlile & Lakhani, 2011). Drawing on these ideas, we further extend the concepts of the "trading zone" (Boland et al., 2007; Galison, 1997) and the "innovation sweet spot" (Carlile & Lakhani, 2011) by placing an emphasis on the capacity of *guanxi* to create a 'buffer zone' for Chinese digital entrepreneurs in their innovation networks. More specifically, we highlight the importance of this buffer zone in promoting cognitive and relational proximity at an optimal level, to support the reconciliation of interpersonal tensions and the coordination of heterogeneous knowledge.

Second, our focus on the willingness of Chinese digital entrepreneurs to fill structural holes and take care of those otherwise isolated members has a theoretical implication for the definition of roles in relation to 'opportunistic brokers' (Burt, 2000), 'technology brokers' (Hargadon & Sutton, 1997), 'knowledge brokers' (Hargadon & Sutton, 2000), and 'innovation brokers' (Klerkx & Gildemacher, 2012) in the literature on innovation networks. Specifically, among these four kinds of broker, opportunistic brokers are those typical brokers who take advantage of their central position to magnify internal network competition and maximize their own personal benefit. A technology broker was first proposed by Hargadon and Sutton (1997) as a middleman who utilizes their vantage point between diverse, disconnected industries to recognize the potential of existing technologies to generate unexpected innovations in new markets. Hargadon and Sutton (1997) went on to identify knowledge brokers as people who effectively act as intermediaries between previously non-connected pools of ideas, establishing a relationship between creators and users of knowledge to leverage old ideas into new combinations for new approaches in new places. Deriving from the notion of 'honest brokers' (Obstfeld, 2005), innovation brokers are defined as people occupying an impartial third-party position who purposefully facilitate communication and interaction among network actors to catalyse the innovation process. Although all of these types of broker tend to perform as trusted, credible third parties in facilitating network development, they do profit from their prestigious and advantageous positions. Distinct from these brokers, we highlight the way in which Chinese 'integrators' 'open the gate' to otherwise disconnected outsiders, bringing them together for purely altruistic purposes, and making the integrators especially indispensable for those networks with a cohesive culture. We emphasize their willingness to initiate the process of filling structural holes and bridging existing boundaries through their desire to benefit the innovation network as a whole. In

addition, our focus on the role of 'knowledge orchestrators' in identifying relevant knowledge, engaging those network actors who have an adequate base of common knowledge yet sufficient diversity in their intelligence resources, has a set of theoretical implications for knowledge scanning, knowledge mobility and knowledge leverage for innovation (Dhanaraj & Parkhe, 2006; Möller & Rajala, 2006).

Finally, in terms of theoretical implications, the fact that we have not taken into account the issue of reverse causality produces an implication for future research in moving toward the testing of the reverse hypotheses. The behaviour drives the outcome, but what about vice versa? We have corroborated that business *guanxi* creates more structural hole fillers, leading to enhanced knowledge coordination, but does this outcome of improved knowledge coordination promote stronger business *guanxi* and the creation of even more structural hole fillers? In addition, we have corroborated that a large number of structural holes impede the mobilization and coordination of knowledge, but does this outcome of attenuated knowledge mobilization and knowledge coordination lead to the creation of a greater number of structural holes? Thus, we believe that a promising direction for future researchers is to examine the reverse hypotheses in order to deepen understanding of the interaction between social network structures and knowledge orchestration, as well as to enhance the development of theory in relation to digital innovation networks.

Aside from theoretical implications, our research underlines some key business and policy implications. First of all, our focus on the Chinese integrators gives rise to the practical suggestion that established digital entrepreneurs should strategically leverage their business *guanxi* to encourage the behaviour of structural hole filling. Specifically, our results help Chinese digital entrepreneurs recognize the significance of cultivating *guanxi* with the hub actors who could occupy multiple yet-to-be-filled structural holes, in order to encourage them to commit to the innovation network and simultaneously motivate them to pull in more fresh talent with sufficient diversity in their intelligence resources where and when it is most needed. Being embedded within a Confucian culture, it makes sense for these mature entrepreneurs to skillfully utilize *mianzi* and *renqing* to attract such network actors, who reside at the boundaries of otherwise separated contacts, to fill their structural holes. For example, we suggest these Chinese entrepreneurs publicly reward those 'integrators' who have

actively pulled together distributed actors for collective interest. In this way, those structural hole owners who have a high concern for *mianzi* are very likely to act as structural hole fillers and bring in more actors, increasing the potential to create unexpected innovations. Besides *mianzi* saving on one's own account, saving someone else's face (or giving someone face) is also a significant motivator for Chinese entrepreneurs to become key contributors in their digital innovation networks. More specifically, the Chinese value their *mianzi*, especially those who have a higher status within their social networks. In this way, giving them *mianzi* by acknowledging their social status, promoting their innovation networks and introducing them to a broader range of talented and new contacts could help these '*mianzi* givers' accumulate more *renqing,* which is essential for their future development. In addition, we suggest that network leaders organize greater numbers of meaningful social events to facilitate the exchange of favours among heterogeneous network members, encouraging everyone to feel attached and committed to the innovation network. By continuously exchanging social resources with each other, networks of entrepreneurs create a coherent culture with a high level of relational proximity, increasing their willingness to bring in more dispersed and diverse actors together to contribute to the innovation network.

The second business implication derives from our focus on knowledge orchestration and provides several suggestions for Chinese entrepreneurs, especially those who have large innovation networks, when it comes to acting as competent orchestrators in order to effectively manage the transfer, acquisition and integration of knowledge in their innovation networks. Specifically, given the cognitive heterogeneity of innovation networks, it is important for those hub orchestrators who occupy multiple structural holes to create common ground, or act as a transferrable medium, for interaction and communication, thereby promoting the mobilization and codification of tacit knowledge among the network actors. Furthermore, it is crucial for these orchestrators to utilize *guanxi* to create a cohesive culture and facilitate the relational proximity among the network members, in order to increase the latter's willingness to contribute their knowledge for innovation. As a result, we effectively provide these Chinese entrepreneurs with a practical way of strategically leveraging their business *guanxi* and structural holes to orchestrate and add value to their innovation networks.

Finally, uncovering the comparative advantages of family-or-friend *guanxi* and business *guanxi* in entrepreneurial start-up and growth stages provides a business implication for Chinese digital ventures in the control of relationships. According to Yoo et al. (2010), with a layered modular architecture, a digitized product can be a product (component) and a platform at the same time, but not all digital ventures have the capacity to simultaneously pursue both of these. Specifically, we suggest that those established ventures that are able to build a digital product platform leverage their business *guanxi* to facilitate favour exchange, *renqing* accumulation, and *mianzi* preservation in order to develop sufficient incentives to attract heterogeneous actors to create novel innovations, while the ventures themselves continue to control the core components. However, those smaller start-ups, who cannot afford a digital product platform, have to focus on creating novel components for an existing one until they achieve and accumulate a sufficiently stable user base. Under such conditions, we suggest those start-ups utilize their family-or-friend *guanxi* to share and acquire useful knowledge resources in order to make themselves less vulnerable. Through the provision of emotional support and access to resource, relatives and close friends can help nascent entrepreneurs decrease the cost of mobilizing external knowledge across structural holes and lower the entry barrier for their start-ups in digital innovation (Chen et al., 2013; Hite & Hesterly, 2001; Nambisan, 2013).

CHAPTER 6 Conclusion

Drawing on the three studies, this chapter summarizes the contributions and discusses the implications of the findings and suggestions for future research.

6.1 Summary of Contributions

This research has focused on exploring how the material and symbolic artefacts as well as the social network structures orchestrate knowledge in order to coordinate the fragmented and heterogeneous knowledge in doubly distributed innovation networks in the Chinese context. In terms of research methodology, I adopted a mixed-methods research approach to conduct all the three studies.

In my first study, I explored how epistemic objects serve to orchestrate knowledge among collaborative organizations in their IT innovation alliance networks. After building three hypotheses drawing on the existing literature, I conducted a case study to explain the relationships and used 107 questionnaires to test the hypotheses. To summarize I found that by acting as a trust trigger and a knowledge elicitor, epistemic objects positively influence knowledge acquisition, knowledge integration and knowledge sharing among collaborative organizations, which in turn coordinate the discontinuity and heterogeneity in knowledge that is mobilized within their IT innovation alliance.

In the second study, I explored how activity objects orchestrate knowledge for crowdsourced digital innovation. After reviewing the literature, I deductively develop three hypotheses to investigate the role of activity objects in knowledge sharing, knowledge acquisition and knowledge integration for crowdsourced digital innovation. By adopting a mixed-methods research approach, my quantitative results of 355 web-based questionnaires corroborate all the three hypotheses, and my qualitative evidence collected from interview data enriches and adds depth to my explanations. As a result, I found that by acting as a trigger for expansive learning, and a director and motivator of crowdsourcing communities, activity objects serve to facilitate the sharing, acquisition, and integration of knowledge, coordinating the knowledge fragmentation and heterogeneity for crowdsourced digital innovation.

In the third study, I explored how Chinese digital entrepreneurs interact and leverage "*guanxi*"- a system of influential relationships and social network dynamics in Chinese culture- to orchestrate knowledge and add value to their innovation networks. After building a research model based on the existing literature, I develop ten hypotheses to investigate the role of family or friend *guanxi*, business *guanxi* and structural holes in knowledge mobilization and knowledge coordination at entrepreneurial start-up stages and growth stages respectively. By adopting a mixed-methods research approach, my quantitative results of 325 web-based questionnaires corroborate five hypotheses, and my qualitative evidence collected from 48 interviews enriches and makes sense of my quantitative results. I found that in the Chinese context, structural holes impede the mobilization and coordination of knowledge, while *guanxi* moderates the detrimental impacts of structural holes by providing a buffer zone for Chinese digital entrepreneurs, around which an abundance of cognitive and social resources flow in the form of favour exchange, *renqing* accumulation, and *mianzi* preservation, thereby coordinating the knowledge fragmentation and heterogeneity in their innovation networks.

In this way, I have developed my contributions of the research, a part of which is grounded on the literature and the rest is from empirical investigation, demonstrating the interaction between material & symbolic artefacts and knowledge orchestration as well as the interaction between social network structures and knowledge orchestration in order to handle the knowledge fragmentation and heterogeneity in digital innovation networks. Specifically, the contribution target of this research has been on the exploration of how material & symbolic artefacts used in and social network structures of innovation networks serve to coordinate the fragmented and heterogeneous knowledge for digital innovation. This research makes seven contributions in total, which can be presented using two perspectives: a perspective of material artifacts and a social perspective.

From the perspective of material artefacts, my emphasis on the independent role of epistemic objects and activity objects as enablers in knowledge orchestration provides a novel understanding of the role of material & symbolic artefacts as well as humans in the practices of digital innovation, which are primarily obtained from my first and second studies. In contexts where digital technology has democratized the

communication tools, where product and industry boundaries have become blurred and fluid, and where decentralized, crowdsourcing communities emerge to leverage mutual intelligence for innovation, the danger lies in knowledge being too fragmented and heterogeneous (von Hippel, 2005). Most previous research has highlighted that as technical objects or managerial instruments, material artefacts are generally utilized to sustain and support the daily work in the hands of managers who speak on their behalf (Orlikowski, 2007). The literature has also emphasized the active role of managers as the agents of control through supervision or normative means (Vázquez, 2006). Building on the literature, I highlighted the active role of the material and symbolic artefacts in enabling networks of actors to share, acquire and integrate knowledge freely and in mediating dialogue between differing perspectives, to maximize the collective wisdom for digital innovation. In this way, my research provides a new insight into how material & symbolic artefacts can coexist with other types of formal managerial control in a beneficial manner geared towards coordinating the fragmented and heterogeneous knowledge that is mobilized within digital innovation networks. To be more specific, I gave prominence to the role of an epistemic object, an object of knowledge (Knorr-Cetina, 1997), as a trust trigger and a knowledge elicitor, to create a knowledge community, invite a knowing process, establish various strands of knowledge relationships with participating actors, elicit heterogeneous knowledge and empower the knowledge on the behalf of that epistemic object (Rennstam, 2012; Surowiecki, 2004), contributing an alternative view of human control with instrumental objects on knowledge orchestration in digital innovation networks. In addition to epistemic objects, I also placed an emphasis on activity objects which have been applied to collaborative development within virtual communities of practice (Hemetsberger & Reinhardt, 2009), building on the perspective of seeing crowdsourced digital innovation as "an object-oriented, collective, and culturally mediated human activity" (Engestrom, 1999, p. 9). By recognizing the role of an object of a crowdsourced digital innovation activity, as a trigger for expansive learning, and a motivator and director of crowdsourcing communities, to leverage the orchestration of knowledge, this research makes a contribution to presenting a novel private-collective model for crowdsourced digital innovation, with an integration of personal investment and collective action (Trompette et al., 2008). There are therefore three contributions of this part of the research, demonstrated as follows.

The first contribution is the recognition of the material & symbolic artefacts as a motivator for active involvement to encourage networks of actors to contribute their knowledge for collective digital innovation. In terms of epistemic objects (investigated in my first study), which arouse 'interest in them' as well as keep them "alive as targets of research" (Rheinberger, 2005, p. 406), most previous literature has highlighted that this motivation comes from the compulsion to know (Covington, 1992). Drawing on this work, I further place an emphasis on a high degree of both affective-based and cognitive-based trust triggered by the emotional investment toward, and the intimate attachment to, the same epistemic object (Knorr-Cetina, 1997) among a temporary knowledge community. Specifically, a community of practice can be created around an epistemic object when the actors jointly engage in a knowing work and what holds them together is a shared interest, a common goal and a need to know what they each know (Mandl et al., 1996). In this sense, affective-based trust may be developed among the community members, with a strong confidence that their "interests will be fully protected", resulting in the creation of a collective that is better than the sum of its individual parts (Lewicki & Bunker, 1996, p. 122). This knowledge community is also a temporary group, recognized as "a set of diversely skilled people working together on a complex task over a limited period of time" (Goodman & Goodman, 1976, p. 494). Thus, swift trust, or cognitive-based trust, may emerge in such a group, dependent on the occurrence of everything in a proper order and the attitude of respect for the competence of the other partners to carry out their share of the tasks at hand (Holste & Fields, 2005). In this way, I extended the motive from the intrinsic desire, triggered by the unfulfilled epistemic objects, to a high level of affective-based and cognitive-based trust. I have hence contributed a new insight into how epistemic objects develop a knowledge community around themselves and how epistemic objects produce a novel source of motivation among the members which increases not only their willingness but also their confidence in each other's competence to contribute to collective knowledge orchestration activities for digital innovation, going beyond the work of studies that have focused on formal incentives such as monetary rewards and/or normative control (Robertson & Swan, 2003).

As for activity objects (explored in my second study), I identified their capacity to provide their community members with activity-related incentives for active in-

volvement in crowdsourced digital innovation. Specifically, I highlighted the ability of an activity object to motivate its community members with a desire for social recognition and a struggle for personal identity (Hegel, 1977; 1983), by attaching "esteem achieved in community life" (Miettinen, 2005, p. 62) to it and objectifying its members' participation in the products of their actions, with their achievements constituting the objectified demonstration of their capability to contribute to their communities and the target activity (Knorr-Cetina, 1997; Miettinen, 2005). As a result, an activity object is capable of recognizing, acknowledging and rewarding the unique contributions that its members make, essential for giving identity to themselves, which in turn continuously fuel their participation in and contribution to the activity and their communities (Miettinen, 2005). It is especially true in highly distributed, virtual crowdsourced activities, where division of labor is a source of individuality (Lerner & Tirole, 2001; Miettinen, 2005). Apart from social recognition and approval, I also emphasized the capacity of an activity object to trigger emotional attachment and unspecified intrinsic obligations, such as social affiliation, feelings of belonging, trust and self-actualization, that are not restricted to individuals but performed as an engine of solidarity, a collective obligation and an emotional affiliation, constituting a morally binding force among its community members (Nicolini et al., 2012). In this way, this activity object provides a "family of invisible friends" with a "home", where a sense of loyalty can be engendered in committing to the crowdsourced digital innovation goal (Abrams et al., 2003).

My second contribution is the recognition of the capacity of material & symbolic artefacts as a knowledge elicitor to handle the knowledge heterogeneity, which contributes a novel understanding of knowledge identification in collaborative practices of digital innovation. Specifically, I found in my first study that by engaging in a knowing process and establishing various relationships with an epistemic object, the members can achieve a sense of identity associated with their own domains of expertise in their community so that they are more willing and able to utilize their specialization to solve problems. Brown & Lewis (2011) similarly highlighted that an adequate knowledge identification on the expertise of the community members themselves could make them pay more attention to their own specialized knowledge while problem-solving. Building on their work, I have further focused on the capacity of epistemic objects to allow the members to have a complete picture of each oth-

er's domains of knowledge and help them quickly and accurately detect the required knowledge for innovation. Via the mechanism of knowledge elicitation, the participants have the opportunity to identify the knowledge in their community so that they have a full understanding of what they have already completed, what they still need, who knows what, and how they can acquire the needed knowledge from the right person, leading them to an intelligent recombination of heterogeneous pieces of knowledge for digital innovation. In this way, I linked the theory of transactive memory to epistemic objects, contributing a better understanding of how material & symbolic artefacts trigger the development of transactive memory among the community, and how this knowledge of who knows what enhances their collective sensemaking so as to facilitate a transformation from dispersed information input to high-quality knowledge output, thereby coordinating the knowledge heterogeneity for digital innovation (Lewis, 2003; Wegner, 1986).

Third, my focus of the second study on the role of activity objects in directing the qualifying process (Paul et al., 2012), through the representation of *Zhihu* – a Q&A website, contributes a novel insight into the attainment of high-quality knowledge and even the shift from highly credible ideas to potential innovation opportunities (Trompette et al., 2008). Specifically, this co-evaluation process combines quantitative and qualitative means. For the quantitative measures, I found that the crowd can evaluate an answer's usefulness via voting, with more authoritative answers getting up-voted, and less popular ones getting down-voted and filtered out (Patil & Lee, 2016). By attributing a "like" to an answer to indicate how many users favour the answer, *Zhihu* directs the process of separating high-quality content from alternatives, which saves significant time and allows crowdsourcing communities to make more accurate decisions (Mladenow et al., 2014). For the qualitative means, I found that the crowd may offer their various opinions on certain questions, comment on answers given or convert novel ideas into feasible plans (Trompette et al., 2008). For example, *Zhihu*'s 'invite' mechanism enables the crowd to tag users in certain questions to obtain more useful answers. Therefore, through the representation of *Zhihu*, I highlighted that activity objects have the capacity to shape the collective activity and "find the signal in the noise" for crowdsourced digital innovation (Paul et al., 2012).

From a social perspective, my focus on the interaction between social network structures and knowledge orchestration in Chinese digital innovation networks has produced four contributions, which are achieved from my third study. First, my primary contribution is the recognition of *guanxi* as a "shock absorber" to lessen the detrimental impacts of structural holes, by providing a "buffer zone" for Chinese digital entrepreneurs in their innovation networks, around which an abundance of cognitive and social resources flow in the form of favour exchange, *renqing* accumulation, and *mianzi* preservation. Specifically, my results suggest that structural holes induce adverse impacts among a network of entrepreneurs including poor communication and coordination, restricted information mobilization, a mismatch of strategies, amplified incompatibility of their personal values and behaviours, as well as intensified dissimilarity in their capacities and expertise, thereby hindering the mobilization and coordination of knowledge. Meanwhile, the negative image of the brokers actually becomes a liability of Chinese digital entrepreneurs to resource mobilization, which exacerbates the knowledge fragmentation and heterogeneity. Within the collectivist society that is built on interwoven networks of social relations (Xiao & Tsui, 2007), *guanxi* pulls previously non-connected entrepreneurs together and constructs a buffer zone within a highly competitive and turbulent business environment, moderating the adverse effects generated by manipulating structural holes.

More specifically, in a buffer zone, those entrepreneurs who frequently leverage their business *guanxi* respect for and comply with a tacit, subtle and everybody-does-it rule of reciprocal favour exchange to oil the wheels of resource mobilization and get things done. Refusing to return a previously received favour will severely damage personal creditability, resulting in a humiliating loss of *mianzi* and an exclusion from further *guanxi* maintenance (Nguyen & Cremer, 2016). As these entrepreneurs take turns to give and receive favours between each other, their *renqing* is developed and gradually accumulated, that is seen as a form of relational capital providing leverage in social exchange to facilitate the social bonding and obtain access to otherwise unavailable resources (Yang, 1994). With favour mobilization and *renqing* development within the network, entrepreneurs create a harmonious atmosphere where they share a high level of emotional understanding with each other to reduce their personal disagreement and even conflict, so that their *mianzi* is fully protected and preserved. When the entrepreneurs respect for each other's commitment to reciprocate,

they have opportunities to achieve the 'insider' information, circumvent the institutional barriers, and decode the government official policy intents for spurring more innovations (Nguyen & Cremer, 2016). In this way, I present how business *guanxi* and structural holes coexist in a beneficial manner geared towards coordinating knowledge heterogeneity and countering its fragmentation for digital innovation, adding to the work of Xiao and Tsui (2007) and Batjargal (2005, 2010) who highlighted the constraining impact of the collectivistic values of China on structural holes. I thus contribute a novel network configuration for Chinese digital entrepreneurs, which meshes *guanxi* and structural holes in a complementary way to promote the mobilization and coordination of knowledge, orchestrating their innovation networks.

Even though my results demonstrate that structural holes are detrimental to the mobilization and coordination of knowledge, I do not deny the significance of those hub actors who occupy a prestigious and advantageous position in their innovation networks. My second contribution is to complement the extant literature by systematically presenting how those structural-hole holders promote the mobility and leverage of knowledge for maximizing the value of the whole network. Specifically, I tease out the unique value that "structural hole fillers" add to their innovation networks, by highlighting their pivotal role in influencing the other actors' relationships. As I have discussed, *guanxi* affords the creation of a buffer zone, that is initiated by a collection of integrators who are sitting at the center of diverse structural holes and willing to fill these holes. Unlike those typical brokers as "gatekeepers", who control the information inflow and outflow, the Chinese integrators tend to serve as the "honest" brokers (Obstfeld, 2005) and the "pathfinders" (Xiao & Tsui, 2007). By opening the gate to bring outsiders into a buffer zone, the otherwise isolated entrepreneurs around structural holes are pulled together, and those widely dispersed, heterogeneous social and cognitive resources are connected to benefit the innovation network as a whole (Grandori & Kogut, 2002). In this way, I contradict the view of many western scholars that perceived a middleman as an opportunistic broker who takes advantage of their position to reap personal benefit (Burt, 1992, 1997, 1999, 2002).

My focus on how these structural-hole holders purposefully and deliberately orchestrate knowledge for maximizing the output of digital innovation and coordinating

knowledge fragmentation & heterogeneity additionally makes my third contribution to identifying the under-explored value that the "knowledge orchestrators" add to their innovation networks. Based on Dhanaraj and Parkhe (2006)'s network orchestration model, I endorse the approach of a hub in networks (Heikkinen & Tähtinen, 2006), and extend it from single-hub innovation networks to multi-hub innovation networks (Gnyawali & Madhavan, 2001). Specifically, I recognize those hub actors who hold centrality in their networks as the orchestrators, who are not only willing to act as the glue holding the network together, but also are able to effectively mediate and manage the network members' knowledge, thereby facilitating the mobilization and coordination of knowledge. In this way, I highlight the leading role that knowledge orchestrators play in transferring, acquiring and integrating knowledge resource through their individual action, as Burt (1992) believed, a hub position can only produce value, when and if the position holder takes a real action.

Finally, as I uncover evidence of when and what type of *guanxi* is used the most among Chinese digital entrepreneurs, I add to the current literature on network theory (Ebers & Grandori, 1999; Kenis & Knoke, 2002). By making a distinction between family or friend *guanxi* and business *guanxi*, and identifying the role each *guanxi* plays in entrepreneurial start-up and growth stages, I capture the dynamics of *guanxi*, recognize the reality of change in entrepreneurial network relationships and highlight the relationship control among different Chinese digital entrepreneurs (Kenis & Knoke, 2002; Madhavan et al., 1998). Specifically, with a layered modular architecture (Yoo et al., 2010), the distinctiveness of those entrepreneurs with established digital ventures depend on their capacity to build a digital product platform, encompassing loosely coupled layers of device, network, service, and contents, which attract heterogeneous start-up entrepreneurs to remix digital components for digital innovation (Yoo, 2013). It is therefore vital for these mature entrepreneurs to utilize their business *guanxi* strategically to develop appropriate incentives for attracting nascent entrepreneurs to join the innovation network, while controlling the core components (Henfridsson & Yoo, 2014). Nevertheless, for those start-up entrepreneurs who cannot afford a digital product platform and seek to create novel components across multiple layers outside of the digital platform, I found that they have no choice but to rely on their family or friend *guanxi*. This finding thus makes a significant contribution to *guanxi* identification on knowledge orchestration for digital

innovation, by suggesting that Chinese digital entrepreneurs should recognize the relative advantages of family or friend *guanxi* and business *guanxi* with a view to applying the right *guanxi* at the right time in the right context.

6.2 Implications for Theory and Practice

6.2.1 Implications for Theory

My research, with a contribution target presenting how material & symbolic artefacts used in and social network structures of digital innovation networks leverage the orchestration of knowledge in order to coordinate the fragmented and heterogeneous knowledge, produces a set of theoretical implications, which are demonstrated from three perspectives. First, within a doubly distributed innovation network, shaped by a layered modular architecture, digital ventures generally seek to design and create a digital product platform in order to cater for multisided markets in a highly chaotic, dynamic and competitive landscape (Eisenman et al., 2006). It is therefore strategically significant for established firms to develop sufficient incentives for attracting diverse, distributed start-ups to join their vibrant digital ecosystem and to produce novel components on various layers outside of their digital product platform. Overall, my focus on the capacity of the material objects to motivate those dispersed actors to join the innovation networks and devote themselves to collective activities of knowledge orchestration and innovation, has a theoretical implication for the coordination of the knowledge discontinuity in digital innovation networks. Specifically, by demonstrating how epistemic objects trigger the creation of both affective-based and cognitive-based trust among the community members as a novel source of motivation for knowledge diffusion, and how activity objects serve to provide both extrinsic and intrinsic activity-related incentives for crowdsourcing communities to contribute their knowledge to crowdsourced digital innovation, the research produces a theoretical implication for alleviating the fragmented knowledge pieces within doubly distributed innovation networks. To be more specific, I highlight the ability of epistemic objects to trigger affective-based trust among the community members who have a strong confidence that their "interests will be fully protected", resulting in the creation of a collective that is better than the sum of its individual parts (Lewicki & Bunker, 1996, p. 122). Additionally, I identify the capacity of epistemic

objects to develop cognitive-based trust in a temporary knowledge community, which is dependent on the occurrence of everything in a proper order and the attitude of respect for the competence of the other partners to carry out their share of the tasks at hand (Holste & Fields, 2005). Apart from epistemic objects, I also highlight the ability of activity objects to create both extrinsic and intrinsic incentives for crowdsourced digital innovation activities. Specifically, drawing on the attention economy which pointed out that information consumes its recipients' attention, the newly involved actors, who are attracted to join the innovation network and to contribute their knowledge to creating novel innovations, expect to seek attention as their extrinsic reward. In this way, I present how an activity object, through the representation of *zhihu*, serves to promote such a doubly distributed innovation network as a marketplace, which connects newcomers' needs for attention-obtainment, by recognizing, detailing and rewarding newcomers' differing contributions (Choudhury et al., 2014; Wasko & Faraj, 2005). As extrinsic benefits provide the main motivations for new actors to initiate the behaviour of designing novel components on multiple layers for digital innovation, intrinsic rewards which are involved in social exchanges that emphasize unspecified obligations, such as social affiliation, feelings of belonging, trust and self-actualization, carry more weight in their motivation for continuous engagement in the process of innovation (Sigala & Chalkiti, 2015). In this way, I demonstrate how an activity object provides a 'home' for a 'family of invisible friends' (Abrams et al., 2003), intrinsically motivating them to identify themselves with the communal goal while putting their self-interests aside, thereby fueling the impetus for them to return to the totality. As a result, I highlight the ability of epistemic objects and activity objects to create affective-based & cognitive-based trust and extrinsic & intrinsic activity-related incentives, which serve to foster the information transmission that helps mobilize and aggregate disconnected pieces of knowledge for digital innovation in doubly distributed innovation networks. In this way, my research provides a theoretical implication for the coordination of the knowledge discontinuity, complementing the work of Granovetter (1973) who believed the strength of weak ties in accelerating information diffusion within the network.

Second, as increasing start-ups are attracted to join the doubly distributed innovation networks, wherein dominant firms build their digital product platforms to control the

core components with a layered modular architecture, reconciling the coexistence of competition and cooperation among heterogeneous actors and managing the trade-off between centralization and distribution of power in the control of collaborative processes of knowledge orchestration and innovation is of strategic theoretical importance (Baldwin & von Hippel, 2011; Ghazawneh & Henfridsson, 2010; Henfridsson & Yoo, 2014). In other words, it is theoretically significant for established digital ventures in the Chinese business context to manage the tensions and conflicts between diverse voices in a negotiation, sense-making and sense-giving processes in order to leverage differentiated cognitive resources into something that give novel meanings (Boland & Tenkasi, 1995). Overall, my focus on the capacity of the material objects used in and the social network structures of innovation networks to leverage the orchestration of heterogeneous knowledge, actors, technologies and activities to achieve unexpected innovations, has a range of theoretical implications. From the perspective of material artefacts, by demonstrating how epistemic objects trigger the development of transactive memory among the participating actors, and how this knowledge of "who knows what" enhances the collective sense-making, my focus on knowledge elicitation produces several theoretical implications for knowledge identification, task decomposition, heterogeneous knowledge distribution and the coordination of the knowledge heterogeneity for innovation, complementing the work of Brown and Lewis (2011) and Wegner (1986). Specifically, as digital innovations' core tasks are becoming layered modularized with a layered modular architecture (Yoo et al., 2010), the knowledge needed for implementing an innovation is increasingly heterogeneous, so the research on traditional modes of organizing for innovation may be not enough (Boudreau & Lakhani, 2009; Fjeldstad et al., 2012). In this way, I highlight the independent role of an epistemic object as an enabler in establishing different knowledge relationships with the participants, eliciting heterogeneous knowledge and empowering the knowledge on its behalf. By inviting a knowing process, through which knowledge of what to do and how to do it is elicited, epistemic objects allow the members to not only identify their own domains of expertise in their community to make them more concentrate on their specialization, but also have a complete picture of each other's expertise so that they could have a full understanding of what they have already completed, what they still need, who knows what and how they can acquire the needed knowledge from the right person, leading to an efficient integration of different pieces of knowledge for innovation. As a re-

sult, my finding generates a theoretical implication for the coordination of the knowledge heterogeneity. In addition, my focus on the capacity of epistemic objects to recognize relevant knowledge, as well as to engage the network actors who have an adequate common knowledge base, and yet sufficient heterogeneity in their intelligent resources, produces an additional theoretical implication for the formation of a generative dance of knowledge scanning, knowledge identification, knowledge creation, knowledge mobilization and knowledge integration for digital innovation (Kale et al., 2000; Möller & Rajala, 2006).

From the perspective of social network structures, my focus on the role of *guanxi* as a shock absorber presents how those dominant firms leverage their business *guanxi*, with an implicit rule of favour exchange among the participating actors who are in asymmetric social status (Peng, 2003), to facilitate the network resource mobilization (Yoo, 2013), and reconcile the conflicts between differing voices. In this way, the research produces several theoretical implications for the management of tensions among diverse actors in a negotiation, sense-making and sense-giving process in the Chinese business context (Boland & Tenkasi, 1995), and the coordination of the heterogeneous knowledge resources within doubly distributed innovation networks (Lyytinen et al., 2015). Specifically, digital innovation involves social translations, occurring at the boundaries of different communities, in a 'digitally enabled trading zone' (Yoo et al., 2010), where actors cross pragmatic boundaries (Carlile, 2002) to mutually negotiate and adjust to each other's perspectives, and in 'an innovation sweet spot', where there is a delicate balance between known and novel knowledge among heterogeneous actors (Carlile & Lakhani, 2011). Drawing on their work, I further extend the concepts of 'trading zone' (Boland et al., 2007; Galison, 1997) and 'innovation sweet spot' (Carlile & Lakhani, 2011) by placing an emphasis on the role of *guanxi* in creating 'a buffer zone' for Chinese digital entrepreneurs, around which an abundance of cognitive and social resources flow in the form of favour mobilization, *renqing* accumulation and *mianzi* preservation. In this way, both cognitive and relational proximity is promoted at an optimal level, to leverage a certain amount of knowledge orchestration for lessening the knowledge heterogeneity, which is exacerbated by the convergent digital technology and excessive structural holes in loosely coupled innovation systems.

In addition, my focus on the willingness of the Chinese 'integrators' to act as a glue, holding the network together by filling structural holes and taking care of otherwise isolated actors, has a theoretical implication for the role identification among "opportunistic brokers" (Burt, 2000), "technology brokers" (Hargadon & Sutton, 1997), "knowledge brokers" (Hargadon & Sutton, 2000), and "innovation brokers" (Klerkx & Gildemacher, 2012) in the literature on innovation networks. Specifically, among these four kinds of brokers, opportunistic brokers are those typical brokers who take advantage of their central position to magnify the internal competition and maximize their personal benefits. A technology broker is first proposed by Hargadon and Sutton (1997) as a middleman who utilizes their in-between vantage point between diverse, disconnected industries to recognize existing technologies to invent unexpected innovations in new markets. Hargadon and Sutton (1997) further identified knowledge brokers as intermediary persons between previously non-connected pools of ideas, who develop a relationship between creators and users of knowledge for leveraging old ideas into new combinations, for new ways, in new places. Last, deriving from the notion of "honest brokers" (Obstfeld, 2005), innovation brokers are defined as people standing at an impartial third-party position, who purposefully facilitate the communication and interaction among the network actors to catalyze the innovation progress. Apart from opportunistic brokers, even though the other three types of brokers tend to perform as trusted, credible third parties to facilitate the network development, they do profit from their prestigious and advantageous position. Different from these brokers, I highlight that the Chinese integrators open the gate to bring in together otherwise disconnected outsiders for a purely altruistic purpose, who are especially indispensable for those networks with a cohesive culture. I emphasize their willingness to initiate the process of filling structural holes and bridging existing boundaries, with a wish to benefit the innovation network as a whole.

Third, according to Yoo et al. (2010), with a layered modular architecture, a digitized product can be a product (component) and a platform at the same time, but not all digital ventures have the capacity to simultaneously pursue both of them. In other words, those small, new start-ups that cannot afford a digital product platform have to focus on creating novel components across multiple design hierarchies until they achieve and accumulate a sufficiently stable user base (Yoo et al., 2010). Under such

conditions, it is critically significant for digital start-ups to acquire useful, complementary external resources in order to move away from a vulnerable position and reduce their liability of newness (Freeman et al., 1983; Stinchcombe, 1965). Overall, by suggesting that both material artefacts used in and social network structures of innovation networks can help those start-ups obtain valuable, external resources for creating unexpected innovations, the research produces a set of theoretical implications demonstrated as follows. Specifically, my focus on the role of activity objects as a trigger for expansive learning, and a director and motivator of crowdsourcing communities, presents a novel collective-private model for crowdsourced digital innovation, with an integration of collective action of separating high-quality content from alternatives and personal investment of dispersed diverse cognitive resources, which helps those dispersed, small start-ups effectively access required resources from external networks (Trompette et al. 2008; Jin et al. 2015). In this way, the research underlines some key theoretical implications for the development of new collaboration rules and theories among distributed, heterogeneous participating innovators, for managing tensions to trigger expansive learning, for identifying extrinsic and intrinsic incentives to enhance individual involvement and for establishing the "collective brain" (Trompette et al. 2008) to direct the innovation activity.

In addition, by identifying the important role of family or friend *guanxi* in helping digital start-ups obtain access to external knowledge resources for innovation, my research uncovers evidence on when and what type of *guanxi* is used the most for Chinese digital entrepreneurs, producing a theoretical implication for the dynamics of the Chinese entrepreneurial relationship on knowledge orchestration. Specifically, by making a distinction between family or friend *guanxi* and business *guanxi*, and identifying the role each *guanxi* plays in knowledge mobilization and knowledge coordination at entrepreneurial start-up and growth stages, I highlight that developing *guanxi* between Chinese digital entrepreneurs is a more dynamic process where favor exchange, *renqing* accumulation, and *mianzi* preservation occur to trigger a transition from being treated as an outsider to insider. This finding is different from the traditional *guanxi* valuing long-term cooperation (Ambler et al. 1999), or swift relationship highlighting one-time transaction in online marketplaces (Ou et al. 2014), providing a theoretical implication for the reality of change in entrepreneurship network relationships in Chinese culture.

6.2.2 Implications for Practice

Apart from theoretical implications, this research additionally produces a range of practical implications, which are also presented from three perspectives. In terms of the perspective of incentive creation, my focus on the interaction between the social network structures and knowledge orchestration produces several important suggestions for those established entrepreneurs to strategically leverage business *guanxi* to generate sufficient motivations. Specifically, my research helps Chinese digital entrepreneurs recognize the significance of cultivating *guanxi* with nascent network actors who occupy yet-to-be-filled structural holes and who have sufficient diversity in their intelligent resources, in order to make them commit to the innovation network and simultaneously motivate them to pull in more newcomers where and when it is most needed. Embedded within the Confucian culture, it is smart for the leading innovators to skillfully utilize *mianzi* and *renqing* to attract those actors, who remain at the boundaries of separated contacts, to join in the innovation networks, and fill in their structural holes. For example, these leading innovators could encourage and reward those 'integrators', who have actively brought newcomers in the innovation networks to design and produce novel components for digital innovation. In this way, more heterogeneous structural-hole owners who have a high concern for gaining *mianzi* as well as a great potential for creating unexpected innovations are very likely to be attracted to bring more actors and contribute to the innovation network. Besides saving *mianzi*, saving someone's face is also a significant motivator for those nascent network actors to become key contributors in their innovation networks. To be more specific, the Chinese value their *mianzi*, especially those who have more power and a higher status within their innovation networks. Giving them *mianzi* by acknowledging their digital product innovation, creating attractive components based on their platforms and promoting the use of their digital platforms to wider dispersed, talented and new communities, could help these contributors accumulate more *renqing* which is essential for the personal future development. In addition, the network leaders are also advised to organize more social events to facilitate the exchange of favours among heterogeneous newcomers in order to make everyone feel attached and committed to the innovation network. By continuously exchanging social resources among the network actors, a coherent culture is created, a shared

identity is built, a relational embeddedness is promoted. In this way, these newcomers are more willing to devote themselves to the innovation activities and pull more distributed newcomers into the network.

With regard to the perspective of network asset leverage, a set of practical implications are given rise to suggesting how mature digital entrepreneurs should strategically utilize material artifacts and symbolic representations to coordinate the heterogeneous pieces of knowledge for effective network resource leverage. Specifically, digital innovations involve cognitive translations, through the process of which, dominant participants map the heterogeneous knowledge into relevant symbolic representations in order to elicit knowledge and make it known to the other network actors (Boland & Tenkasi, 1995). In this way, by highlighting the role of epistemic objects as a knowledge elicitor in demonstrating how the innovation task is decomposed, eliciting who knows what, and presenting how this knowledge of who should perform a subtask enhances the collective sense-making in order to achieve an overall goal (Lewis, 2003), my research suggests how those established digital entrepreneurs should interact with epistemic objects to trigger the development of transactive memory (Wegner, 1986) among the network actors, in order to promote the transfer and integration of tacit, embedded and heterogeneous knowledge for innovation (Brown & Lewis, 2011). To be more specific, as implicit knowledge is hard to be transferred via structured processes and can be easily lost (Pfeffer & Sutton, 1999), a complete transactive memory system, triggered by the epistemic representations, allows the network participants to get acquainted with each other. Hence, when initiating the work of knowledge orchestration, it is critical for the network leaders to take advantage of their epistemic objects to identify the knowledge in their community in order to foster the diffusion and coordination of each other's implicit expertise.

As for the perspective of external resource acquisition, this research underlines several practical suggestions for those start-ups to obtain valuable, external resources for creating unexpected innovations, which are divided into two parts. First, I pay an attention to the influence of material and symbolic artefacts on external knowledge access. By identifying activity objects as a trigger for expansive learning, I suggest that those nascent entrepreneurs, which are unable to afford a digital product platform, should strategically utilize their activity objects in order to promote the crea-

tion of expansive learning during the process of innovation so as to foster the acquisition of high-quality knowledge resources within doubly distributed innovation networks (Paul et al., 2012; Trompette et al., 2008). Specifically, activity objects are able to create a community, which is inherently composed of members rooted in different boundaries, whose trajectory is shaped by heterogeneous knowledge relationships, and where contradictions abound to trigger expansive learning (Nicolini et al., 2012; Patil & Lee, 2016; Rennstam, 2012). In this way, activity objects serve to engage the network actors in a reflective dialogue, in which those start-up entrepreneurs are empowered to compare and contrast their perspectives with each other, as well as to evaluate conflicting interpretations and assumptions regarding optimal solutions (Scarbrough et al., 2004). It can therefore be seen that activity objects have the capacity to facilitate the creation and assimilation of 'knowledge-in-context' in terms of the various requirement of the network members (Paul et al., 2012), and increase their opportunities to recognize and acquire high-quality cognitive resources for innovation.

Second, by shedding light on the effect of social network structures on the achievement of external resources, for those entrepreneurs of start-ups who cannot afford a digital product platform, I suggest that they have no choice but to rely on their family or friend *guanxi* to design and produce novel components for innovation within a layered modular architecture. To explain this in more detail, it is not surprising that family or friend *guanxi* is able to provide these entrepreneurs with a commitment advantage due to its high level of relational proximity (Anderson, 2008). Through the provision of emotional support and resource access, families or close friends may buffer those nascent entrepreneurs' depressed affection and give them a shelter from opportunism (Chen et al., 2013; Hite & Hesterly, 2001; Pollack et al., 2012). In this way, such a high relational proximity serves to facilitate the flow of cognitive and social resources throughout the doubly distributed innovation networks, thereby decreasing the cost of mobilizing knowledge across multiple layers and lowering start-ups' entry barrier to digital product innovation (Benkler, 2006; Nambisan, 2013; Yoo, 2013).

6.2.3 Reflections on the Mixed-methods Research Methodology

In this thesis, I used a mixed-methods (Venkatesh et al., 2016; Zachariadis et al., 2013) research approach to conduct all the three studies. Below, I reflect on the three aspects of my application of this methodology in my research: usefulness of mixed-methods research, epistemological perspective, and paradigmatic assumptions.

First, based on our research questions, the primary purpose of such a mixed-methods research approach is to establish a more comprehensive picture and systematic account of phenomenon (Leech, 2012; Zachariadis et al., 2013). Specifically, quantitative methods are usually seen as better at identifying non-obvious regularities in larger, often numerical, samples where qualitative methods would not have been effective. On the other hand, qualitative methods are seen as able not only to explain propositions but can also identify the mechanisms through which complex phenomena interact and the various contingencies that affect them. In our research, we used quantitative surveys to test the hypotheses and estimate their impacts, which were then discussed in conjunction with our qualitative results and existing theory. In parallel, our qualitative analysis of the case study and interviews allowed us not only to explain these relationships but also to make better sense of the quantitative results by revisiting our interview data.

Second, in terms of epistemological perspectives, I conducted my mixed-methods research using multiple paradigms, which claim that alternative, compatible paradigms are adopted in one research (Teddlie & Tashakkori, 2003; Venkatesh et al., 2016). Denzin (2012) recognized such combination of diverse paradigms and methodological practices as a strategy adding "rigor, breadth complexity, richness and depth to a research inquiry" (Venkatesh et al., 2016, p. 442). In this thesis, the quantitative and qualitative components of the study adopted different paradigmatic assumptions: positivism in quantitative data collection & analysis as well as interpretivism in qualitative data collection & analysis.

Third, with regard to paradigmatic assumptions, I endorse the complementary strengths stance and conducted my mixed-methods research by embracing and

combing two paradigmatic approaches from various worldviews (Creswell et al., 2003; Venkatesh et al., 2016). Specifically, on the one hand, I used the positivism assumption in my quantitative research based on a belief that "a priori fixed hypotheses or relationships" exist "among constructs that one typically investigates with structured instrumentation" and "the researcher and the object of inquiry are independent of each other (Venkatesh et al., 2016, p. 443; Lee, 1991). On the other hand, in my qualitative part of the research, I embraced the interpretivism paradigm and believed that people build their personal understanding and subjective knowledge while interacting with the world around them; therefore, researchers seek to access the meanings that participants assign to them in order to understand phenomena (Orlikowski & Baroudi, 1991; Tashakkori & Teddlie, 2003). Based on these three properties, I made my design decisions to adopt a mixed-methods research approach to conduct the three studies that make up this thesis.

6.2.4 Limitations and Future Research

There are some limitations inherent to my research. First, the fact that each of my three studies is respectively based on a single case could raise an issue regarding the generalizability of my findings. Specifically, my first study was conducted in a relatively stable environment with the inter-firm members who were pulled together with an attempt to develop an innovative emergency command system for the Zhoushan Ministry of Transport. It could be argued that the different functions afforded by the material objects may have been exaggerated by the specific context of this study. As a result, one needs to take these conditions into account before generalizing my findings. However, I would argue that in this research I used both qualitative and quantitative methods to explain the propositions and test the hypotheses in a complementary way. Both methods generated convergent results, the integration of which could provide a stronger argument for the inference quality, indicating a high degree of reliability.

My second limitation concerns the challenges involved in the collection and validation of data regarding *guanxi*. In China, any topic related to *guanxi* is very sensitive. As Lin (2001) indicated, favour exchange is a prerequisite to *guanxi* development, and thus immediately ethical issues and implications become apparent. China is a low-trust society, as Liu (2009, p. 63) found, compared with Western societies, "so-

cial research in Asian societies proves to be much more difficult in terms of collecting empirical data, particularly from face-to-face interviews". Apart from interviews, Hubbard et al. (2008) also indicated that Chinese businesses generally distrust non-governmental research surveys because they often do not see the benefit in participating in research surveys and have a higher level of trust in government sponsored research. As a result, Chinese businesses particularly small businesses are very unwilling to disclose any information concerning their *guanxi*, personal connections and social resources in such a highly competitive and uncertain environment. Furthermore, due to the tacit and subtle nature of *guanxi,* it is also difficult for me to explicate and interpret it exactly in an accurate way. Additionally, *guanxi*, as a system of influential relationships and social network dynamics in Chinese culture, changes with the passage of time. Therefore, readers should pay attention to the validity of the results that have emerged during the process of data analysis.

My third limitation concerns the potential bias in my qualitative data, due to the fact that by the nature of the interpretive research, inter-subjectivity cannot be avoided. According to Gaskin et al. (2014), an interview-based or observation-based approach like any intensive qualitative inquiry, places a heavy burden on data analysis. It is because that people build their personal understanding and subjective knowledge while interacting with the world around them, and researchers seek to access the meanings that participants assign to them in order to understand phenomena (Orlikowski & Baroudi, 1991; Tashakkori & Teddlie, 2003). My first study involves the analysis of a particular case and several semi-structured interviews, where I inevitably made most of the interpretations based on my own personal opinion. In addition, due to my involvement as a project manager assistant in the project, it is possible that the role of the object of investigation was more pronounced than it would have been otherwise. However, such bias in qualitative data is common in all qualitative inquiry.

Fourth, the fact that there is no control over extraneous variables in my quantitative research design may lead to several negative issues including decreased internal validity, the creation of confounding variables, wasted time and resources, as well as the difficulty for other researchers in replicating the study in the same way (Shuttleworth, 2008).

The final limitation of my research is that this study has not considered into account the issue of reverse causality, leading to the creation of a collection of possible implication for future research in moving toward the testing of the reverse hypotheses. According to Xiao and Tsui (2007), Brass and Burkhardt (1993), and Brass (1995), network development and performance are ongoing processes, which may lead to a structuration effect: networks influence performance, and performance influences networks. Moving on to my third study, the issue of reverse causality raises a question: the behaviour drives the outcome, but what about vice versa? I have corroborated that business *guanxi* creates more structural hole fillers, leading to enhanced knowledge coordination, but does this outcome of improved knowledge coordination promote stronger business *guanxi* and the creation of even more structural hole fillers? In addition, I have corroborated that a large number of structural holes impede the mobilization and coordination of knowledge, but does this outcome of attenuated knowledge mobilization and knowledge coordination lead to the creation of a greater number of structural holes? Thus, I believe that a promising direction for future researchers is to examine the reverse hypotheses in order to deepen understanding of the interaction between material objects and knowledge orchestration as well as the interaction between social network structures and knowledge orchestration, thereby enhancing the development of theory in relation to digital innovation networks.

REFERENCES

Abrams, L.C., Cross, R., Lesser, E. and Levin, D. (2003), "Nurturing Interpersonal Trust in Knowledge- Sharing Networks," *The Academy of Management Executive,* 17(4): 64-77.

Accenture, (2016), *Digital China 2020: An action plan for Chinese enterprises.*

Ahuja, G. (2000), 'Collaboration networks, structural holes, and innovation: A longitudinal study', *Administrative Science Quarterly*, 45 (3), 425–455.

Ambler, T., Styles, C., and Wang, X. C. (1999), 'The Effect of Channel Relationships and Guanxi on the Performance of Inter-Province Export Ventures in the People's Republic of China,' *International Journal of Research in Marketing*, 16 (1), 75-87.

Ambrosini, V. and Bowman, C. (2008), "Surfacing Tacit Sources of Success," *International Small Business Journal,* 26 (4), 403-431.

Anderson, M. H. (2008), 'Social networks and the cognitive motivation to realize network opportunities: A study of managers' information gathering behaviors', *Journal of Organizational Behavior*, 29 (1), 51–78.

Anderson, J. C. and Gerbing, D. W. (1988), "Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach," *Psychological Bulletin,* 103 (3), 441-423.

Argyris, C. and Schon, D. A. (1996), *Organizational Learning II: Theory, Method, and Practice*, United State of America: Addison-Wesley Company, Inc.

Arora, A., Andrea, F. and Alfonso, G. (2002), *Markets for technology. The economics of innovation and corporate strategy*, Cambridge, MA: MIT Press.

Arthur, W. (2009), *The Nature of Technology: What It Is and How It Evolves*, New York, NY, USA: Free Press.

Bacheldor, B. (2003), 'Keep pace on the innovation speedway—Vehicle manufacturers use IT to stay in tune with changing tastes', *InformationWeek* 500 (September 22).

Baker, W.E. (1984), 'The social structure of a national securities market', *American Journal of Sociology*, 89, 775-811.

Baldwin, C. Y. and Clark, K. B. (1997), "Managing in the age of modularity," *Harvard Business Review,* 75 (5), 84-93.

Baldwin, C. and von Hippel, E. (2011), 'Modeling a paradigm shift: from producer innovation to user and open collaborative innovation', *Organization Science*, 22 (6), 1399–1417.

Barrett, M., Oborn, E., Orlikowski, W. J. and Yates, J. (2012), 'Reconfiguring boundary relations: Robotic innovations in pharmacy work', *Organization Science*, 23 (5), 1448–1466.

Batjargal, B. (2004), 'Comparative Social Capital: Networks of Entrepreneurs and Venture Capitalists in China and Russia', *Davis Center, Harvard University, working paper*.

Batjargal, B. (2005), 'Comparative Social Capital: Networks of Entrepreneurs and Investors in China & Russia', *William Davidson Institute Working Paper*, Number 783, July.

Batjargal, B. (2007), 'Internet entrepreneurship: social capital, human capital, and performance of Internet ventures in China', *Research Policy*, 36 (5), 605-618.

Batjargal, B. (2010), 'The Effects of Network's Structural Holes: Polycentric Institutions, Product Portfolio, and New Venture Growth in China and Russia', *Strategic Entrepreneurship Journal*, 4 (2), 146-163.

Baum, J. A. C., Calabrese, T. and Silverman, B. S. (2000), "Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology," *Strategic Management Journal*, 21, 267–294.

Baum, J. A. C., Shipilov, A. V. and Rowley, T. J. (2003), 'Where do small worlds come from?', *Industrial and Corporate Change*, 12 (4), 697-725.

Bayus, B. L. (2013), "Crowdsourcing new product ideas over time: An analysis of the Dell IdeaStorm community," *Management Science,* 59 (1), 226–244.

Bell, D. (2000), 'Guanxi: a nesting of groups', *Current Anthropology*, 41 (1), 132-138.

Benkler, Y. (2006), *The Wealth of Networks: How Social Production Transforms Markets and Freedom*, New Haven, CT: Yale University Press.

Berente, N., Srinivasan, N., Yoo, Y., Boland, R. J. and Lyytinen, K. (2007), 'Binate diversity and the rolling edge of design networks,' Paper presented at *the 28th International Conference on Information Systems*, December 9–12, Association for Information Systems, Atlanta.

Bizzi, L. (2013), 'The Dark Side of Structural Holes: A Multilevel Investigation', *Journal of Management*, 39 (6), 1554-1578.

Boland, R.J., Lyytinen, K. and Yoo, Y. (2007), 'Wakes of Innovation in Project Networks', *Organization Science*, 18 (4), 631–647.

Boland, R. J. and Tenkasi, R. V. (1995), 'Perspective making and perspective taking in communities of knowing', *Organization Science*, 6, 350–372.

Boschma, R. (2005), 'Proximity and innovation: a critical assessment', *Regional Studies*, 39, 61–74.

Boudreau, K. J. and Lakhani, K. R. (2009), 'How to manage outside innovation', *MIT Sloan Management Review*, 50 (4), 69–76.

Brass, D. J. (1995), "A social network perspective on human resources management." In G. R. Ferris (ed.), *Research in Personnel and Human Resources Management*, 13: 39–79. Greenwich, CT: JAI Press.

Brass, D. J. and Burkhardt, M. E. (1993), "Potential power and power use: An investigation of structure and behavior," *Academy of Management Journal,* 36, 441–470.

Brass, D. J., Butterfield, K. D. and Skaggs, B. C. (1998), 'Relationships and unethical behavior: A social network perspective', *Academy of Management Review*, 23, 14–31.

Brockman, B. K. and Morgan, R. M. (2003), "The role of existing knowledge in new product innovativeness and performance", *Decision Sciences*, 34 (2), 385-419.

Brown, J. S. and Duguid, P. (2000), *The Social Life of Information*, Boston, MA: Harvard Business School Press.

Brown, A. D. and Lewis, M. A. (2011), "Identities, discipline, and routines," *Organization Studies,* (37), 871–895.

Burt, R. S. (1980), 'Autonomy in a social topology', *American Journal of Sociology*, 85, 892-925.

Burt, R. S. (1992), *Structural Holes*, Cambridge, MA: Harvard University Press.

Burt, R. S. (1997), 'The contingency of social capital', *Administrative Science Quarterly*, 42, 339-365.

Burt, R. S. (1999), 'The social capital of opinion leaders', *Annals*, 566, 37-54.

Burt, R. S. (2000), 'The network structure of social capital', *Research in Organizational Behavior*, 22, 345-423.

Burt, R. S. (2002), 'Bridge decay', *Social Networks*, 24 (4), 333-363.

Burt, R. S. (2005), *Brokerage and Closure: an Introduction to Social Capital*, Oxford University Press, New York.

Burt, R. S., Hogarth, R. M. and Michaud, C. (2000), 'The social capital of French and American managers', *Organization Science*, 11, 123–147.

Buttner, E. H. (1992), 'Entrepreneurial stress: Is it hazardous to your health?' *Journal of Managerial Issues*, 4 (2), 223–240.

Cantner, U., Meder, A. and Ter Wal, A. L. J. (2010), 'Innovator networks and regional

knowledge base,' *Technovation*, 30, 496-507.

Carlile, P. R. (2002), 'A pragmatic view of knowledge and boundaries: Boundary objects in new product development', *Organization Science*, 13 (4), 442–455.

Carlile, P. R. (2004), "Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries," *Organization Science,* 15 (5), 555–568.

Carlile, P. R. and Lakhani, K. R. (2011), 'Innovation and the challenge of novelty: the novelty-confirmation-transformation cycle in software and science', *Working paper*, Cambridge, Mass: Harvard Business School.

Cecez-Kecmanovic, D., Galliers, R. D., Henfridsson, O., Newell, S. and Vidgen, R. (2014), "THE SOCIOMATERIALITY OF INFORMATION SYSTEMS: CURRENT STATUS, FUTURE DIRECTIONS," *MIS Quarterly, Special Issue: Sociomateriality of IS & Organizing*, 38 (3), 809-830.

Chan, R. Y. K., Cheng, L. T. W. and Szeto, R. W. F. (2002), 'The dynamics of guanxi and ethics for Chinese executives', *Journal of Business Ethics*, 41 (4), 327-336.

Chen, X. P. and Chen, C. C. (2004), 'On the Intricacies of the Chinese Guanxi: A Process Model of Guanxi Development', *Asia Pacific Journal of Management*, 21 (3), 305–324.

Chen, C. C., Chen, X. P. and Huang, S. (2013), 'Chinese guanxi: An integrative review and future research directions', *Management and Organization Review*, 9, 167–207.

Chen, C. C., Chen, Y. R. and Xin, K. (2004), 'Guanxi practices and trust in management: A procedural justice perspective', *Organization Science*, 15 (2), 200−209.

Chen, C. C., Peng, M. and Saparito, P. A. (2002), 'Individualism, collectivism, and opportunism: A cultural perspective on transaction cost economics', *Journal of Management*, 28, 567–583.

Cheon, Y., Choi, S. K., Kim, J. and Kwak, K. T. (2015), 'Antecedents of relational inertia and information sharing in SNS usage: The moderating role of structural autonomy', *Technological Forecasting & Social Change*, 95, 32–47.

Chesbrough, H., Vanhaverbeke, W. And West, J. (2006), *Open Innovation: Researching a New Paradigm*, Oxford University Press: New York.

Choi, B. and Lee, H. (2003), "An empirical investigation of KM styles and their effect on corporate performance," *Information & Management,* (40), 403–417.

Choi, S. Y., Lee, H. and Yoo, Y. (2010), "The Impact of Information Technology and Transactive Memeory Systems on Knowledge Sharing, Application, and Team performance: A Field Study," *MIS Quarterly,* 34 (4), 855-870.

Choudhury, S., Alani, H. and KMI, U. (2014), "Exploring user behavior and needs in Q&A communities," in *Proceedings of the European Conference on Social*

Clark, K.B. (1985), 'The interaction of design hierarchies and market concepts in technological evolution', *Research Policy*, 14, 235–251.

Cohen, W. and Levinthal, D. (1990), "Absorptive capacity:a new perspective on learning and innovation," *Administrative Science Quarterly,* (35), 128-152.

Cole, M. and Derry, J. (2005), "We have met technology and it is us," In *Intelligence and technology. The impact of tools on the nature and development of human abilities*, R.J. Sternberg & D. Preiss (Eds.), pp. 209–227, Hillsdale, N.J.: Lawrence Erlbaum Associates.

Collins, K. M., Onwuegbuzie, A. J. and Jiao, Q. G. (2007), "A mixed methods investigation of mixed methods sampling designs in social and health science research," *Journal of Mixed Methods Research*, 1 (3), 267-294.

Colombo, M. G., Grilli, L. and Piva, E. (2006), 'In search of complementary assets: The determinants of alliance formation of high-tech start-ups', *Research Policy*, 35 (8), 1166–1199.

Cooper, R. B. and Zmud, R. W. (1990), "Information technology implementation research: a technological diffusion approach," *Management Science*, 36, 123–139.

Costa, A. C. and Bijisma-Frankema, K. (2007), 'Trust and control interrelations: New perspectives on the trust-control nexus', *Group & Organization Management*, 32, 392-406.

Covington, M. V. (1992), *Making the grade: A self-worth perspective on motivation and school reform*, New York: Cambridge Univ. Press.

Creswell, J. W. (2003), *Research design: Qualitative, quantitative, and mixed methods approaches*, (2nd Edition), Sage Publications, Thousand Oaks: London, New Delhi.

Creswell, J. W. (2009). *Research designs: Qualitative, quantitative, and mixed methods approaches (3rd ed.)*. Thousand Oaks, CA: Sage.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L. and Hanson, W. E. (2003), "Advanced mixed methods research designs," *In* A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (1st ed.) (pp. 209-240). Thousand Oaks, CA: Sage.

Crossan, M. M. and Inkpen, A. C. (1995), 'The subtle art of learning through alliances,' *Business Quarterly*, 60 (2), 68-78.

Crossan, M. M., Lane, H. W. and White, R. E. (1999), "An organizational learning framework From intuition to institution," *Academy of Management Review,* 24 (3), 522-537.

Davenport, T. H. and Perusak, L. (1998), *Working knowledge*, Boston, MA: Harvard Business School.

Davies, A. and Brady, T. (2000), 'Organizational capacities and learning in complex product systems: towards repeatable solutions', *Research Policy*, 29, 93l-953.

Davison, R. M. and Ou, X. (2008), 'Guanxi, knowledge and online intermediaries in China', *Chinese Management Studies*, 2 (4), 281-302.

Davidson, E. and Vaast, E. (2010), "Digital Entrepreneurship and Its Sociomaterial Enactment", *43rd Hawaii International Conference on System Sciences (HICSS)*, p. 1530-1605.

Day, G. S. (1994), "The Capabilities of Market-Driven Organizations," *Journal of Marketing*, 58 (4), 37.

De Leo, F. D. (1994), "The Competitive Value of Tacit Knowledge Transfer: An Assessment Methodology," (Doctoral dissertation), University of Georgia, Athens, Athens.

Denzin, N. K. (2012), "Triangulation 2.0," *Journal of Mixed Methods Research*, 6 (2), 80-88.

Dhanaraj, C. and Parkhe, A. (2006), 'Orchestrating innovation networks', *Academy of Management Review*, 31 (3), 659-669.

Dodgson, M. (1993), "Learning, trust and technological collaboration", *Human Relations*, 46 (1), 77–95.

Dougherty, D. and Dunne, D. D. (2011), 'Organizing ecologies of complex innovation', *Organization Science*, 22 (5), 1214–1223.

Doz, Y. (1996), 'The evolution of cooperation in strategic alliances: Initial conditions or learning processes?', *Strategic Management Journal, Special Issue (*17), 55-83.

Doz, Y. L., Olk, P. M. and Ring, P. S. (2000), "Formation processes of R&D consortia: Which path to take? Where does it lead?" *Strategic Management Journal,* 21, 239–266.

Dyer, J. H. and Noveoka, K. (2000), "Creating and managing a high-performing knowledge-sharing network", *Strategic Management Journal*, 21, 345—367.

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

Ebers, M. and Grandori, A. (1999), "The forms, costs, and devel- opment dynamics of inter-organizational networking", In: *The formation of inter-organizational networks,* M. Ebers (Ed.), 265–286. London: Oxford University Press.

Eisenman, T., Parker, G. and Van Aystyne, M.W. (2006), "Strategies for two-sided markets," *Harvard Business Review*, 84 (10), 92–101.

Engeström, Y. (1987), *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research*, Orienta Konsultit, Helsinki, Finland.

Engestrom, Y. (1991), "Nonscolae sed vitae discimus: Toward overcoming the encapsulation of school learning", *Learning and Instruction*, 1, 243-259.

Engeström, Y. (1999), "Activity theory and individual social transformation," in *Perspectives on activity theory*, Y.

Engeström, Y. and Blackler, F. (2005), "Special issue: On the life of the object," *Organization,* 12 (3).

Erzberger, C. and Kelle, U. (2003), "Making inferences in mixed methods: The rules of integration," *In* A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (1st ed.) (pp. 457-490). Thousand Oaks, CA: Sage.

Ewenstein, B. and Whyte, J. (2009), "Knowledge practices in design: The role of visual representations as 'epistemic objects," *Organization Studies,* 30 (1), 7-30.

Fan, Y. (2002), 'Questioning Guanxi: definition, classification and implications', *International Business Review*, 11, 549-564.

Faraj, S., Jarvenpaa, S. L. and Majchrzak, A. (2011), "Knowledge collaboration in online communities," *Organization Science*, 22 (5), 1224–1239.

Faraj, S. and Johnson, S.L. (2011), 'Network exchange patterns in online communities', *Organization Science*, 22 (6), 1464–1480.

Fichman, R. G., Dos Santos, B. L. and Zheng, Z. (2014), "Digital Innovation as a Fundamental and Powerful Concept in the Information Systems Curriculum", *MIS Quarterly*, 38 (2), 329-353.

Fichter, K. (2009), 'Innovation communities: the role of networks of promotors in Open Innovation,' *R&D Management*, 39, 357–371.

Fjeldstad, Ø. D., Snow, C. C., Miles, R. E. and Letti, C. (2012), 'The architecture of collaboration', *Strategic Management Journal*, 33 (6), 734–750.

Freeman, L. C. (1977), 'A set of measures of centrality based on betweenness', *Sociometry*, 40, 35-40.

Freeman, J., Carroll, G. R. And Hannan, M. T. (1983), "The Liability of Newness: Age Dependence in Organizational Death Rates", *American Sociological Review*, 48 (5), 692-710.

Frye, T. (2000), *Brokers and Bureaucrats: Building Market Institutions in Russia*, University of Michigan Press: Ann Arbor, Michigan.

Fu, P. P., Tsui, A. S. and Dess, G. G. (2006), 'The Dynamics of Guanxi in Chinese Hightech Firms: Implications for Knowledge Management and Decision Making', *Management International Review*, 46 (3), 1-29.

Galagan, P. A. (1993), "The search for the poetry of work," *Training and Development* 47 (10), 33-37.

Galison, P. (1997), *Image and Logic: A Material Culture of Microphysics*, The University of Chicago Press: Chicago.

Gann, D. and Salter, A. (2000), "Innovation in project-based, service-enhanced firms: the construction of complex products and systems," *Research Policy,* (29), 955-972.

Gargiulo, M. and Benassi, M. (2000), 'Trapped in your own net? network cohesion, structural holes, and the adaptation of social capital', *Organization Science*, 11 (2), 183-196.

Garrety, K. and Badham, R. (2000), "The politics of socio-technical intervention: An interactionist view", *Technology Analysis and Strategic Management*, 12, 103-118.

Gaskin, J., Berente, N., Lyytinen, K. and Yoo, Y. (2014), "TOWARD GENERALIZABLE SOCIOMATERIAL INQUIRY: A COMPUTATIONAL APPROACH FOR ZOOMING IN AND OUT OF SOCIOMATERIAL ROUTINES", *MIS Quarterly*, Special Issue: Sociomateriality of IS & Organizing, 38 (3), 849-871.

Gawer, A. and Cusumano, M. (2008), 'How companies become platform leaders,' *MIT Sloan Management Review*, 49 (2), 28.

Geyer, A. and Davies, A. (2000), "Managing project-system interfaces：case studies of railway projects in restructured UK and German markets", *Research Policy*, 29, 991-1013.

Ghazawneh, A. and Henfridsson, O. (2010), "Governing third-party development through platform boundary resources," *Proc. Internat. Conf. Inform. Systems (ICIS),* St. Louis, MO.

Gnyawali, D. and Madhavan, R. (2001), "Cooperative networks and competitive dynamics: A structural embeddedness perspective," *Academy of Management Review,* 26, 431– 445.

Gold, A. H., Malhotra, A. and Segars, A. H. (2001), "Knowledge Management: An Organizational Capabilities Perspective," *Journal of Management Information Systems*, 18 (1), 185-214.

Gomes-Casseres, B. (1994), "Group versus group: How alliance networks compete," *Harvard Business Review,* 72 (4), 62–74.

Goodman, R. A. and Goodman, L. P. (1976), "Some management issues in temporary systems: A study of professional development and manpower-The theatre case," *Administrative Science Quarterly,* (21), 494-501.

Grandori, A. and Kogut, B. (2002), "Dialogue on organization and knowledge," *Organization Science,* 13, 224–231.

Granovetter, M. S. (1973), "The Strength of Weak Ties," *American Journal Of Sociology,* (78), 1360-1380.

Grant, R. (1996), 'Towards a knowledge-based view of the firm', *Strategic Management Journal*, 17, 109-122.

Gu, F. F., Hung, K. and Tse, T. K. (2008), 'When does Guanxi matter? Issues of capitalization and its dark side', *Journal of Marketing*, 72, 12−28.

Gubrium, J. F. and Holstein, J. A. (2007), The construction mosaic. In: *Handbook of Constructionist Research*, J.A. Holstein, J. F. Gubrium, eds, Guilford Press: New York, p. 3–12.

Gulati, R. (1999), 'Network location and learning: The influence of network resources and firm capabilities on alliance formation', *Strategic Management Journal*, 20, 397-420.

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

Gupta, A. K., Tesluk, P. E. and Taylor, M. S. (2007), 'Innovation at and across multiple levels of analysis', *Organization Science*, 18 (6), 885-897.

Guthrie, D. (1998), "The Declining Significance of Guanxi in China's Economic Transition", *The China Quarterly,* 154, 254-282.

Hagedoorn, J. (1995), "A note on international market leaders and networks of strategic technology partnering", *Strategic Management Journal,* 16, 241–250.

Hair, J., Anderson, R., Tatharn, R. and Black, W. (1998), *Multivariate Data Analysis with Readings*, Prentice Hall International, Upper Saddle River, NJ.

Hansen, M.T. (2002), 'Knowledge networks： explaining effective knowledge sharing in multiunit companies, *Organization Science*, 13 (3), 232-248.

Hargadon, A. B. and Sutton, R. I. (1997), "Technology brokering and innovation in a product development firm," *Administrative Science Quarterly*, 42, 716–749.

Hargadon, A. and Sutton, R. (2000), 'Building an innovation factory'. *Harvard Business Review*, May–June, 157–166.

Harper, F. M., Raban, D., Rafaeli, S. and Konstan, J. A. (2008), "Predictors of answer quality in online Q&A sites," in *Proc. of CHI*.

Haveman, H. A., Jia, N., Shi, J. and Wang, Y. (2016), 'The Dynamics of Political Embeddedness in China', *Administrative Science Quarterly*, 1–38.

Hegel, J, W. F. (1977), *Phenomenology of spirit* (A.V. Miller, Trans.). Oxford, UK: Oxford University Press.

Hegel, J, W. F. (1983), *Jena Lectures on the Philosophy of Spirit. In Hegel and the Human Spirit: A Translation of the Jena Lectures of the Philosophy of Spirit (1805-6)* (L. Rauch, Ed. & Trans.). Detroit, MI: Wayne University Press.

Heikkinen, M. and Tähtinen, J. (2006), "Managed formation process of R&D networks", *International Journal of Innovation Management,* 10 (3), 271-298.

Hemetsberger, A. and Reinhardt, C. (2009), "Collective Development in Open-Source Communities: An Activity Theoretical Perspective on Online Collaboration," *Organization Studies,* 30 (9), 987-1008.

Henderson, K. (1995), "The Political Career of a Prototype: Visual Representation in Design Engineering," *Social Problems*, 42, 274-299.

Henfridsson, O. and Bygstad, B. (2013), 'The Generative Mechanisms of Digital Infrastructure Evolution,' *MIS Quarterly*, 37 (3), 907-931.

Henfridsson, O., Mathiassen, L. and Svahn, F. (2014), 'Managing Technological Change in the Digital Age: The Role of Architectural Frames', *Journal of Information Technology*, 29 (1), 27-43.

Henfridsson, O. and Yoo, Y. (2014), 'The Liminality of Trajectory Shifts in Institutional Entrepreneurship,' *Organization Science*, 25 (3), 932-950.

von Hippel, E. (1988), *The Sources of Innovation*, New York: Oxford University Press.

von Hippel, E. (1994), "'Sticky information' and the locus of problem solving: Implications for innovation", *Management Science*, 40, 429-439.

von Hippel, E. (2005), 'Open source software projects as user innovation networks - no manufacturer required,' In: *Perspectives on Free and Open Source Software*, J. Feller, B. Fitzegeral, S. Hissam, and K. Lakhani, Eds. Cambridge: MIT Press.

Hislop, D., Newell, S., Scarborough, H. and Swan, J. (2000), 'Networks, knowledge and power: Decision making, politics and the process of innovation', *Technology Analysis & Strategic Management*, 12 (3), 399-411.

Hite, J. M. and Hesterly, W. S. (2001), 'The evolution of firm networks: from emergence to early growth of the firm', *Strategic Management Journal*, 22 (3), 275-286.

Hobday, M. and Rush, H. (1999), "Technology Management in Complex Product Systems (CoPS): Ten Questions Answered", *International Journal of Technology Management*, 17, 618-638.

Holste, J. S. and Fields, D. (2005), "The relationship of affect and cognition based trust with sharing and use of tacit knowledge," in *Academy of Management Best Conference Paper*, MED: B1.

Howe, J. (2006), "The rise of crowdsourcing," *Wired,* 14 (6), 176–183.

Hsu, I. C. (2008), "Knowledge sharing practices as a facilitating factor for improving organizational performance through human capital: A preliminary test," *Expert Systems with Applications,* (35), 1316–1326.

Huang, J., Henfridsson, O., Liu, M. J. and Newell, S. (2017), "Growing on Steroids: Rapidly Scaling the User Base of Digital Ventures Through Digital Innovation," *MIS Quarterly,* 41 (X).

Hubbard, K.A.B., Adams, J.H. and Whitten, D.D. (2008), "Issues In Conducting Empirical Research In The People's Republic Of China: A Case Study Of Primary Research On Purchasing Practices In Chinese Small Businesses", International Business & Economics Research Journal, 7 (7), 41-46.

Hutchins, E. (1995), *Cognition in the wild*, Cambridge, MA: MIT Press.

Hwang, K. K. (1987), 'Face and Favor: The Chinese Power Game', *American Journal of Sociology*, 92 (4), 944–974.

Iansiti, (1996), *Living on internet Time: Product Development at Netscape, Yahoo!, Netdynamics, and Microsoft*, Harvard Business School.

Inkpen, A. C. and Currall, S. C. (1998), "The nature, antecedents, and consequences of joint venture trust," *Journal of International Management,* 4 (1), 1-20.

Jin, J., Li, Y., Zhong, X. and Zhai, L. (2015), "Why users contribute knowledge to online communities: An empirical study of an online Q&A community," *Information & Management,* (52), 840–849.

Joshi, K. D., Chi, L., Datta, A. and Han, S. (2010), 'Changing the Competitive Landscape: Continuous Innovation Through IT-Enabled Knowledge Capabilities', *Information Systems Research*, 21 (3), 472-495.

Joshi, M. and Yermish, I. (2000), "The digital economy: A golden opportunity for entrepreneurs?", *New England Journal of Entrepreneurship*, (3: 1), p. 15-21.

Kale, P., Singh, H. and Perlmutter, H. (2000), 'Learning and protection of proprietary assets in strategic alliances: building relational capital', *Strategic Management Journal*, March Special Issue (21), 217–237.

Kallinikos, J., Aaltonen, A. and Marton, A. (2013), 'The Ambivalent Ontology of Digital Artifacts,' *MIS Quarterly*, 37 (2), 357-370.

Kaptelinin, V. and Nardi, B. A. (2006), *Acting with Technology: Activity Theory and Interaction Design*, Cambridge, MA: MIT Press.

Kellogg, K. C., Orlikowski, W. J. and Yates, J. (2006), 'Life in the trading zone: Structuring coordination across boundaries in post-bureaucratic organizations', *Organization Science*, 17 (1), 22–44.

Kenis, P. and Knoke, D. (2002), "How organizational field net- works shape interorganizational tie-formation rates", *Academy of Management Review,* 27, 275–293.

King, A.Y. (1991), 'Kuan-hsi and Network Building: A Sociological Interpretation', *Daldalus*, 120, 63–84.

Klerkx, L. And Gildemacher, P. (2012), "The Role of Innovation Brokers in Agricultural Innovation Systems," in: *AGRICULTURAL INNOVATION SYSTEMS:AN INVESTMENT SOURCEBOOK*, 221-230, World Bank: Netherlands.

Knorr-Cetina, K. (1997), "Sociality with objects: social relations in post-social knowledge societies," *Theory, Culture and Society,* 14 (4), 1-30.

Knorr-Cetina, K. (1999), *Epistemic Cultures: How the Sciences Make Knowledge, Handbook*, Cambridge, MA: Harvard University Press.

Knorr-Cetina, K. (2001), "Objectual practice," in *The Practice Turn in Contemporary Theory*, T. Schatzki, K. Knorr-Cetina and E. Von Savigny (eds.), London: Routledge, pp. 175–188.

Kogut, B. and Zander, U. (1996), 'What firms do? Coordination, identity, and learning,' *Organization Science*, 7 (5), 502-518.

Kojève, A. (1969). *Introduction to the reading of Hegel. Lectures on the phenomenology of spirit*. London: Cornell University Press.

Koufteros, X. A. (1999), "Testing a model of pull production: A paradigm for manufacturing re-search using structural equation modeling," *Journal of Operation Management,* (17), 467-488.

Lanham, R. A. (2006), *The Economics of Attention: Style and Substance in the Age of Information*, University of Chicago Press.

Latour, B. (1987), *Science in Action: How to Follow Scientists and Engineers through Society*, Harvard University Press: Cambridge, MA.

Latour, B. (2005), *Reassembling the Social: An Introduction to Actor-Network-Theory*, Oxford, UK: Oxford University Press.

Lave, J. (1992), "Situating learning in communities of practice", In *Perspectives on socially shared cognition*, L.B. Resnick, J.M. Levine, & S.D. Teasley (Eds.), Washington, DC: American Psychological Association, pp. 63-82.

Lave, J. and Wenger, E. (1991), *Situated learning: Legitimate peripheral participation*, Cambridge: Cambridge University Press.

Law, J. (2000), "On the subject of the object: Narrative, technology, and interpellation," *Configurations,* (8), 1–29.

Leavy, B. (2016), 'The next wave of global disruption and the role of China's entrepreneurs', *Strategy & Leadership*, 44 (3), 27-37.

Lee. A. S. (1991), "Integrating positivist and interpretive approaches to organizational research," *Organizational Science*, 2 (4), 342-365.

Lee, D. J., Pae, J. H. and Wong, Y. H. (2001), 'A model of close business relationship in China (Guanxi)', *European Journal of Marketing*, 35 (1/2), 51−69.

Leech, N. L. (2012), "Writing mixed research report," *American Behavioral Scientist*, 56 (6), 866-881.

Leonardi, P. M., Nardi, B. And Kallinikos, J. (2012), *Materiality and Organizing. Social interaction in a Technological World*, Oxford: Oxford University Press.

Leont'ev, A. N. 1978. *Activity, Consciousness, and Personality*, Englewood Cliffs, NJ: Prentice Hall.

Lerner, J. and Tirole, J. (2001), "Some simple economics of open source", *Journal of Industrial Economics* 50 (2), 197–234.

Lessard, D. R. and Zaheer, S. (1996), "Breaking the Silos: Distributed Knowledge and Strategic Responses to Volatile Exchange Rates," *Strategic Management Journal*, 17, 513-534.

Lessig, L. (2008), *Remix: Making art and commerce thrive in the hybrid economy*, The Penguine Press, New York.

Leung, K. and Bond, M. H. (1984), 'The impact of cultural collectivism on reward allocation', *Journal of Personality and Social Psychology*, 47, 793–804.

Levina, N. (2005), "Collaborating on Multiparty Information Systems Development Projects: A Collective Reflection-in-Action View," *Information Systems Research,* 16 (2), 109–130.

Lewicki, R. J. and Bunker, B. B. (1996), "Developing and maintaining trust in working relationships," in *Trust in Organizations: Frontiers of Theory and Research,* R.M. Kramer and T.R. Tyler (Eds.), Thousand Oaks, CA: Sage Publications, pp. 114– 139.

Lewis, K. (2003), "Measuring transactive memory systems in the field: Scale development and validation," *Journal of Applied Psychology,* 88 (4), 587-604.

Lin, N. (2001), 'Guanxi: A conceptual analysis', In: *The Chinese triangle of mainland China, Taiwan, and Hong Kong, Comparative institutional analysis*, A. So, N. Lin, and D. Poston (Eds), London: Greenwood Press, 153-166.

Luo, J. D. (2005), 'Particularistic trust and general trust: A network analysis in Chinese organizations', *Management and Organization Review*, 1, 437–458.

Luo, Y. (2007), *Guanxi and Business* (2nd Edition), World Scientific Publishing Co. Pte. Ltd, Singapore.

Lyles, M. A. and Salk, J. E. (1996), "Knowledge acquisition from foreign parents in international joint ventures: An empirical examination in the Hungarian context," *Journal of International Business Studies,* 29 (2), 154–174.

Lynn, G. S., Reilly, R. R. and Akgun, A. E. (2000), "Knowledge Management in New Product Teams: Practices and Outcomes," *IEEE Transactions on Engineering Management,* 47 (2), 221-231.

Lyytinen, K., Yoo, Y., Richard, J. and Boland, J. (2015), 'Digital product innovation within fourclasses of innovation networks', *Information Systems Journal*, 1-28.

Madhavan, R., Koka, B. R. and Prescott, J. E. (1998), “Networks in transition: How industry events (re)shape interfirm rivalry”, *Strategic Management Journal,* 19, 439–460.

Makhija, M. V. and Ganesh, U. (1997), “The relationship between control and partner learning in learning-related joint ventures,” *Organization Science,* 8, 508–527.

Mandl, H., Gruber, H. and Renkl, A. (1996), "Communities of practice toward expertise: Social foundation of university instruction", In *Interactive minds: Life-span perspectives on the social foundation of cognition*, P. B. Baltes, & U. M. Staudinger (Eds.), New York: Cambridge University Press, pp. 394-411.

March, J. (1991), ‘Exploration and exploitation in organizational learning’, *Organization Science*, 2, 71-87.

Markham, S. K., Ward, S. J., Aiman-Smith, L. and Kingon, A. I. (2010), ‘The valley of death as context for role theory in product innovation,’ *Journal of Product Innovation Management*, 27, 402–417.

Marks, M. A., Mathieu, J. E. and Zaccaro, S. J. (2001), ‘A temporally based framework and taxonomy of team processes’, *Academy of Management Review*, 26, 365-376.

Marshall, N. and Brady, T. (2001), "Knowledge management and the politics of knowledge: illustrations from complex products and systems", *European Journal of Information Systems*, 10, 99-112.

Maxwell, J.A. (1992), ‘Understanding and validity in qualitative research’, *Harvard Educational Review*, 62, 279-300.

McEvily, B. and Marcus, A. (2005), “Embedded ties and the acquisition of competitive capabilities,” *Strategic Management Journal,* 26 (11), 1033–1055.

McEvily, B. and Zaheer, A. (1999), “Bridging ties: a Source of firm heterogeneity in competitive capabilities,” *Strategic Management Journal,* 20 (12), 1133–1156.

McKinsey & Company (2014), *China’s digital transformation: The internet’s impact on productivity and growth*.

Merry, U. (1995), *Coping with Uncertainty: Insights from the New Sciences of Chaos, Self-Organization, and Complexity*, Westport, CT: Praeger Publishers.

Meyer, J. W. and Rowan, B. (1977), “Institutionalized organizations: Formal structure as myth and ceremony,” *American Journal of Sociology,* 83, 340–363.

Meyerson, D., Weick, K. E. and Kramer, R. M. (1996). "Swift Trust and Temporary Groups," in *Trust in organizations: Frontiers of theory and research*, R. M. Kramer and T. R. Tyler (eds.), California: Sage Publications, Inc, pp. 166-195.

Miettinen, R. (2005), "Object of activity and individual motivation," *Mind, Culture, Activity,* 12 (1), 53–69.

Miettinen, R. and Virkkunen, J. (2005), 'Epistemic objects, artefacts, and organizational change', *Organization*, 12 (3), 437–456.

Miles, M. and Huberman, A. M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*, Sage Publications: Thousand Oaks, CA.

Mladenow, A., Bauer, C. and Strauss, C. (2014), "Social Crowd Integration in New Product Development: Crowdsourcing Communities Nourish the Open Innovation Paradigm," *Global Journal of Flexible Systems Management,* 15 (1), 77–86.

Möller, K. and Rajala, A. (2006), 'Business Nets: Classification and Management Mechanisms', Helsinki School of Economics, *Working Papers,* W-407, Helsinki.

Molm, L., Peterson, G. and Takashaki, N. (1999), "Power in negotiated and reciprocal exchange," *American Sociological Review,* 64 (6), 876–890.

Moorman, C. (1995), "Organizational market information processes: Culture antecedents and new product outcome", *Journal of Marketing Research*, 32, 318-335.

Nahapiet, J. and Ghoshal, S. (1998), 'Social Capital, Intellectual Capital and the Organizational Advantage,' *Academy of Management Review*, 23 (2), 242-266.

Nambisan, S. (2013), 'Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research,' *Journal of the Association for Information Systems*, 14 (4), 215-226.

Nandhkumar, J. and Jones, M. (1997), 'Too close for comfort? Distance and engagement in interpretive information systems research', *Information Systems Journal*, 7, 109-131.

Nätti, S. and Halinen, A. and Hanttu, N. (2006), 'Customer Knowledge Transfer and Key Account Management in Professional Service Organisations,' *International Journal of Service Industry Management*, 17 (4), 304-319.

Nguyen, B. And De Cremer, D. (2016), "Why Guanxi Matters in Business Relationships with China", All China Review.

Nicolini, D., Mengis, J. and Swan, J. (2012), "Understanding the Role of Objects in Cross-Disciplinary Collaboration," *Organization Science,* 23 (3), 612–629.

Nonaka, I. (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, 5 (1), 14-37.

Nonaka, I. and Takeuchi, H. (1995), *The knowledge creating company: How Japanese companies create the dynamics of innovation,* New York: Oxford University Press.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V. and van den Oord, A. (2007), 'Optimal cognitive distance and absorptive capacity,' *Research Policy*, 36 (7), 1016–1034.

Obstfeld, D. (2005), 'Social networks, the tertius lungens orientation, and involvement in innovation', *Administrative Science Quarterly*, 50 (1), 100–130.

Oh, H., Chung, M. H. and Labianca, G. (2004), 'Group social capital and group effectiveness: The role of informal socializing ties', *Academy of Management Journal*, 47, 860–875.

Okhuysen, G. A. and Eisenhardt, K, M. (2002), "Integrating knowledge in groups: How formal interventions enable flexibility," *Organizational Science,* 13 (4), 370-386.

Onwuegbuzie, A. J. and Leech, N. L. (2006), "Linking research questions to mixed methods data analysis procedures," *The Qualitative Report*, 11 (3), 474-498.

Orlikowski, W. J. (2007), "Socio-material practices: Exploring technology at work," *Organization Studies,* 28 (9), 1435–1448.

Orlikowski, W. J. and Baroudi, J. J. (1991), "Studying information technology in organizations: Research approaches and assumptions," *Information Systems Research*, 2 (1), 1-28.

Orlikowski, W. J. and Scott, S. V. (2008), "Sociomateriality: Challenging the separation of technology, work and organization," *Academy of Management Annals*, (2), 433-474.

Orton, J. D. and Weick, K. E. (1990), "Loosely coupled systems: A reconceptualization," *Academy of Management Review,* 15, 203–223.

Ou, X., Pavlou, P. A. and Davison, R. M. (2014), 'Swift Guanxi in Online Marketplaces: The Role of Computer-Mediated Communication Technologies', *MIS Quarterly*, 38 (1), 209-230.

Parkhe, A. (1993), "Strategic alliances structuring: a game theoretic and transaction cost examination of inter-firm cooperation," *Academy of Management Journal,* 36 (4), 794-829.

Parolini, C. (1999), *The Value Net – A Tool for Competitive Advantage*, John Wiley & Sons, Chichester, England.

Patil, S. and Lee, K. (2016), "Detecting experts on Quora: by their activity, quality of answers, linguistic characteristics and temporal behaviors," *Social Network Analysis and Mining,* 6 (5), 1-11.

Paul, S. A., Hong, L. and Chi, E. H. (2012), "Who is authoritative? understanding reputation mechanisms in quora," in *Proc. of Collective Intelligence* (Cambridge, MA, April 2012).

Peng, M. W. (2003), 'Institutional transitions and strategic choices', *Academy of Management Review*, 28, 275–296.

Peschl, M. F. and Fundneider, T. (2014), "Designing and Enabling Spaces for collaborative knowledge creation and innovation: From managing to enabling innovation as socio-epistemological technology," *Computers in Human Behavior*, 37, 346–359.

Petch, N. (2017), "The Five Stages Of Your Business Lifecycle: Which Phase Are You In?", *Entrepreneur Media*, Inc.

Pettigrew A., Howard T. and Whittington R. (2002), *Handbook of Strategy and Management*, 1st Edition, SAGE Publications.

Pfeffer, J. and Sutton, R. 1999. "The smart-talk trap," *Harvard Business Review,* (77), 134-144.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004), 'Networking and innovation: a systematic review of the evidence,' *International Journal of Management Reviews*, 5 (6), 137–168.

Podolny, J. M. and Baron, J. N. (1997), 'Relationships and resources: Social networks and mobility in the workplace', *American Sociological Review*, 62, 673–693.

Podolny, J. and Page, K. (1998), 'Network Forms of Organization', *Annual review of Sociology*, 24, 57-76.

Pollack, J. M., Burnette, J. L. and Hoyt, C. L. (2012), 'Self-efficacy in the face of threats to entrepreneurial success: Mindsets matter', *Basic and Applied Social Psychology*.

Powell, W. W., Koput, K. W. and Smith-Doerr, L. (1996), "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology," *Administrative Science Quarterly,* 41, 116–145.

Rammert, W. (2004), "Two styles of knowing and knowledge regimes: between 'explicitation' and 'exploration' under conditions of 'functional specialization' or 'fragmental distribution*'"*. Berlin, *Working Papers*.

Ravasi, D. and Verona, G. (2001), 'Organising the Process of Knowledge Integration: The Benefits of Structural Ambiguity', *Scandinavian Journal of Management*, 17, 41–66.

Redding, G. (1990), *The spirit of Chinese capitalism*, Walter De Gruyter, Berlin & New York.

Regans, R. and McEvily, B. (2003), "Network structure and knowledge transfer: the effects of cohesion and range," *Administrative Science Quarterly,* 48 (2), 240–267.

Regans, R., Zuckerman, E. and McEvily, B. (2004), 'How to make the team: social networks vs. demography as criteria for designing effective teams', *Administrative Science Quarterly*, 49 (1), 101–133.

Rennstam, J. (2012), "Object-Control: A Study of Technologically Dense Knowledge Work," *Organization Studies,* 33 (8), 1071-1090.

Reve, T. and Lu, R. (2011), 'Guanxi, structural hole and closure', *Journal of Strategy and Management*, 4 (3), 275-288.

Rheinberger, H. (1997), *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*, Palo Alto, CA: Stanford University Press.

Rheinberger, H. (2005), "A reply to David Bloor: 'Toward a sociology of epistemic things'", *Perspective in Science,* 13 (3), 406–410.

Robert, L. P., Dennis, A. R. and Ahuja, M. K. (2008), 'Social Capital and Knowledge Integration in Digitally Enabled Teams', *Information Systems Research*, 19 (3), 314-334.

Robertson, M. and Swan, J. (2003), "'Control – What control?' Culture and ambiguity within a knowledge intensive firm," *Journal of Management Studies,* (40), 831–858.

Rosen, M. (1991), 'Coming to Terms with the Field: Understanding and Doing Organizational Ethnography,' *Journal of Management Studies*, 28 (1), 1-24.

Sammarra, A. and Biggiero, L. (2008), "Heterogeneity and Specificity of Inter-Firm Knowledge Flows in Innovation Networks," *Journal of Management Studies,* 45 (4), 800-829.

Sandström, A. (2004), 'Innovative Policy Networks-The Relation between Structure and Performance,' *PhD Thesis*, Lulea University of Technology, Sweden.

Santos, F. M. and Eisenhardt, K. (2005), 'Organizational boundaries and theories of organization,' *Organization Science,* 16 (5), 491-508.

Saxenian, A. and Quan, X. (2005), 'Guanxi and government: The Chinese software

industry in transition', In: *The Software Industry in Emerging Market*, Commander S (ed). Edward Elgar: Cheltenham, U.K., 73-132.

Scarbrough, H., Panourgias, N. S., and Nandhakumar, J. (2015), "Developing a Relational View of the Organizing Role of Objects: A study of the innovation process in computer games," Organization Studies, 36 (2), 197–220.

Scarbrough, H., Swan, J., Laurent, S., Bresnen, M., Edelman, L. and Newell, S. (2004), "Project-Based Learning and the Role of Learning Boundaries," *Organization Studies,* 25 (9), 1579–1600.

Shuttleworth, M. (2008), "Controlled Variables", retrieved from Explorable.com: https://explorable.com/controlled-variables

Schutz, D. M., Kim, Y., Yoo, Y. and Pavlou, P. A. (2009), 'An Empirical Investigation on the Role of IT Materiality in Multidisciplinary Innovation', *ICIS Proceedings*, 73.

Scott, J. C. (1998), *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press.

Shan, W., Walker, G. and Kogut, B. (1994), "Interfirm cooperation and startup innovation in the biotechnology industry," *Strategic Management Journal,* 15, 387–394.

Sigala, M. and Chalkiti, K. (2015), "Knowledge management, social media and employee creativity," *International Journal of Hospitality Management,* (45), 44–58.

Silverman, B. S. (2007), *A Very Short, Fairly Interesting and Reasonably Cheap Book About Qualitative Research*, Sage: London.

Singh, J. (2008), "Distributed R&D, Cross-regional Knowledge Integration and Quality of Innovative Output," *Research Policy*, 37 (1), 77-96.

Sinkula, J. M. (1994), "Market Information Processing and Organizational Learning," *Journal of Marketing*, 58 (1), 35.

Smith, W. K. and Lewis, M. W. (2011), "Toward a theory of paradox: a dynamic equilibrium model of organizing," *Academy of Management Review,* 36 (2), 381-403.

Sockalingam, S. (2000), *Discontinuity in Change: An Exploration of the Role of Conflict in Business Process Reengineering*, PhD thesis, Glasgow Caledonian University, UK.

Spender, J. C. (1992), 'Limits to learning from the west', *The International Executive*, 34 (September/October), 389–410.

Spender, J. C. (1996), 'Making Knowledge the Basis of a Dynamic Theory of the Firm', *Strategic Management Journal*, 17, 45–62.

Stamps, D. (1997), "Communities of practice: Learning is social. Training is irrelevant?", *Training*, 34 (2), 34-42.

Star, S. L. (1999), 'The ethnography of infrastructure', *American Behavioral Scientist*, 43 (3), 377–391.

Stinchcombe, A. L. (1965), "Social structure and organizations," In*: Handbook of Organizations*, J.G. March (ed.), p. 153-193, Chicago: Rand McNally.

Stockman, N. (2000), Understanding Chinese Society, Cambridge, UK: Polity Press.

Surowiecki, J. (2004), *The Wisdom of Crowds*, Doubleday.

Szulanski, G. (1995), 'Unpacking Stickiness: An Empirical Investigation of the Barriers to Transfer Best Practice Inside the Firm', *Academy of Management Journal*, Special Issue: Best Papers Proceedings, 437-446.

Tan, B., Lu, X., Pan, S. and Huang, L. (2015), 'The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com', *Journal of the Association for Information Systems*, 16 (4), 248-280.

Takeishi, A. (2002), "Knowledge Partitioning in the Interfirm division of Labor: The Case of Automotive Product Development," *Organization Science*, 17 (3), 321-338.

Tashakkori, A. and Teddlie, C. (1998), *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Tashakkori, A. and Teddlie, C. (2003), "The past and future of mixed methods research: From data triangulation to mixed model designs," *In* A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (1st ed.) (pp. 671-701). Thousand Oaks, CA: Sage.

Teddlie, C. and Tashakkori, A. (2009), *The foundations of mixed methods research: Integrating quantitative and qualitative techniques in the social and behavioral sciences*. Thousand Oaks, CA: Sage.

Tilson, D., Lyytinen, K. and Sorensen, C. (2010), 'Digital Infrastructures: The Missing IS Research Agenda', *Information Systems Research*, 21 (4), 748-759.

Tiwana, A. (2008), 'Do Bridging Ties Complement Strong Ties? An Empirical Examination of Alliance Ambidexterity', *Strategic Management Journal*, 29, 251-272.

Tiwana, A. and Mclean, E. R. (2005), "Expertise Integration and Creativity in Information Systems Development," *Journal of Management Information Systems*, 22 (1), 13-43.

Trompette, P., Chanal, V. and Pelissier, C. (2008), "Crowdsourcing as a way to access external knowledge for innovation: Control, incentive and coordination in hybrid forms of innovation," in *24th EGOS Colloquium*, Amsterdam, France.

Tsai, W. P. (2001), "Knowledge transfer in inter-organizational networks: Effects of network position and absorptive capacity on innovation," *Academy of Management Journal,* 44 (5), 996-1004.

Tsui, A. S. and Farh, J. L. (1997), 'Where Guanxi Matters', *Work and Occupations*, 24, 56–79.

Tsui, A., Farh, J. L. and Xin, K. (2000), 'Guanxi in the Chinese context', In: *Management and organization in the Chinese context*, J.T. Li, A. Tsui & E. Weldon, (Eds), London: Macmillan, 225-244.

Tuertscher, P., Garud, R. and Kumaraswamy, A. (2014), "Justification and interlaced knowledge at ATLAS, CERN," *Organization Science*, 25, 1579–1608.

Tuomi, I. (2002), *Networks of Innovation: Change and Meaning in the Age of the Internet*, New York: Oxford University Press.

Uzzi, B. (1997), 'Social structure and competition in interfirm networks,' *Administrative Science Quarterly,* 42, 35–67.

Van De Ven, A. H., Polley, D. E., Garud, R. and Venkatraman, S. (Eds) (1999), *The Innovation Journey*, Oxford University Press: New York.

Vázquez, X. H. (2006), "An eclectic explanation of shop floor control using efficiency and power theories," *Organization Studies,* (27), 1421–1446.

Vazquez, A. and Moreno, Y. (2003), "Disease spreading in structured scale-free networks," *Eur. Phys. J. B,* (31), 265-271.

Venkatesh, V., Brown, S. A. and Sullivan, Y. W. (2016), "Guidelines for Conducting Mixed-methods Research: An Extension and Illustration", *Journal of the Association for Information Systems*, 17 (7), 435-494.

Verona, G., Prandelli, E. and Sawhney, M. (2006), 'Innovation and Virtual Environments: Towards Virtual Knowledge Brokers', *Organization Studies*, 27 (6), 765–788.

Walsham, G. (1995), "Interpretive case studies in IS research: nature and method", European Journal of Information Systems, 4 (2), 74-81.

Wang, C. L. (2007), 'Guanxi vs. relationship marketing: Exploring underlying differences', *Industrial Marketing Management*, 36, 81−86.

Wareham, J., Fox, P. B. and Cano Giner, J. L. (2014), 'Technology Ecosystem Govern-

ance,' *Organization Science*, 25 (4), 1195-1215.

Wasko, M. M. and Faraj, S. (2005), "Why should I share? Examining social capital and knowledge contribution in electronic networks of practice," *MIS Quarterly,* 29 (1), 35–57.

Wasserman, S. and Galaskiewicz, J. (Eds.) (1994), *Advances in social network analysis,* London: Sage.

Weber, E. P. and Khademian, A. M. (2008), 'Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings', *Public Administration Review*, 68 (2), 334-349.

Wegner, D. M. (1986), "Transactive memory: A contemporary analysis of the group mind," in *Theories of group behavior*, B. Mullen and G.R. Goethals (eds.), New York: Springer-Verlag, pp. 185–208.

Werle, F. and Seidl, D. (2015), "The Layered Materiality of Strategizing: Epistemic Objects and the Interplay between Material Artefacts in the Exploration of Strategic Topics," *British Journal of Management,* (26), 67–89.

Wunderlich, P. J., Kranz, J. J. and Veit, D. J. (2013), 'Beyond Carrot-and-Stick: How Values and Endogenous Motivations Affect Residential Green IS Adoption', *34th International Conference on Information Systems*.

Xiao, Z. and Tsui, A. S. (2007), 'When Brokers May Not Work: The Cultural Contingency of Social Capital in Chinese High-tech Firms', *Administrative Science Quarterly*, 52 (1), 1–31.

Yan, Y. X. (1996), *The Flow of Gifts: Reciprocity and Social Networks in a Chinese Village*, Palo Alto, CA: Stanford University Press.

Yang, J. (2005), "Knowledge integration and innovation: Securing new product advantage in high technology industry," *Journal of High-Technology Management Research,* 16 (1), 121-135.

Yang, M. (1994), *Gifts, Favors, and Banquets*, Ithaca, NY: Cornell University Press.

Yang, M. (2016), *Gift, Favors, and Banquets: The Art of Social Relationships in China*, Cornell University Press: The Wilder House Series in Politics, History and Culture.

Yang, Z. and Wang, C. L. (2011), 'Guanxi as a governance mechanism in business markets: Its characteristics, relevant theories, and future research directions', *Industrial Marketing Management*, 40, 492–495.

Yanow, D. and Schwartz-Shea, P. (2006), *Interpretation and Method: Empirical Research Methods and the Interpretive Turn*, M.E. Sharpe, Armonk, NY.

Yau, O. H. M., Lee, J. S. Y., Chow, R. P. M., Sin, L. Y. M. and Tse, A. C. B. (2000), 'Relationship marketing the Chinese way', *Business Horizons*, 43 (1), 16-24.

Yen, D. A., Barnes, B. R., and Wang, C. L. (2011), 'The measurement of Guanxi: Introducing the GRX scale', *Industrial Marketing Management*, 40 (1), 97−108.

Yli-Renko, H., Autio, E. and Sapienza, H. J. (2001), 'Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms', *Strategic Management Journal*, June-July Special Issue (22), 587–613.

Yoo, Y. (2013), 'The Tables Have Turned: How Can the Information Systems Filed Contribute to Technology and Innovation Management Research,' *Journal of the Association for Information Systems, 14 (Special Issue)*, 227-236.

Yoo, Y., Boland, R. J., Lyytinen, K. and Majchrzak, A. (2012), 'Organizing for Innovation in the Digitized World', *Organization Science*, 23 (5), 1398-1408.

Yoo, Y., Henfridsson, O. and Lyytinen, K. (2010), 'Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research', *Information Systems Research,* 21 (4), 724-735.

Yoo, Y., Lyytinen, K. and Boland, R. J. (2008), 'Distributed Innovation in Classes of Networks', *Proceedings of the 41st Hawaii International Conference on System Sciences, IEEE.*

Zachariadis, M., Scott, S. and Barrett, M. (2013), 'Methodological Implications of Critical Realism for Mixed-Methods Research', *MIS Quarterly*, 37 (3), 855-879.

Zhang, Y. and Zhang, Z. G. (2006), 'Guanxi and organizational dynamics in China: a link between individual and organizational levels', *Journal of Business Ethics*, 67, 375–392.