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Three essays on networks, innovation, and sustainability

par
Yang Gao

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Présentée par :

Yang Gao

a été évaluée par un jury composé des personnes suivantes :

Thierry Warin
HEC Montréal
Président rapporteur

Ekaterina Turkina
HEC Montréal
Codirectrice de recherche

Ari Van Assche
HEC Montréal
Codirecteur de recherche

Paola Perez-Aleman
McGill University
Membre du jury

Yanze Liang
University of Groningen
Examinateur externe

Patrick Cohendet
HEC Montréal
Représentant du directeur de HEC Montréal

Résumé

Cette thèse porte sur les liens entre les réseaux de connaissances, l'innovation et le développement durable dans le contexte des industries à forte intensité de connaissances des marchés émergents. Il construit d'abord un cadre global qui explique les relations entre les réseaux multiniveaux et l'innovation dans les organisations. En explorant les implications hétérogènes de deux caractéristiques structurelles importantes du réseau, le courtage et la densité du réseau, à trois niveaux d'un réseau à plusieurs niveaux, le premier chapitre de la thèse pose les bases théoriques des chapitres suivants. Étendant ce cadre théorique à un cadre plus large de durabilité culturelle, le deuxième chapitre soutient ensuite que les réseaux dans les industries culturelles et créatives contribuent au développement durable à travers trois mécanismes : en favorisant directement l'innovation et la créativité, en offrant indirectement des opportunités de développement aux groupes marginalisés, et en façonnant systématiquement les systèmes de valeur dans les sociétés. Le troisième chapitre examine le rôle des réseaux d'entreprises culturelles et créatives et l'adoption des technologies numériques dans la survie à la crise sanitaire mondiale en cours à partir de 2020 et donne un aperçu du fait que les ressources du réseau aident les entreprises à faire face à la crise. Le cadre de recherche de la thèse comprend deux industries à forte intensité de connaissances en Chine, l'industrie ferroviaire et les industries culturelles et créatives. Le premier chapitre teste les arguments théoriques sur les réseaux composés de 617 organisations collaborant sur des projets innovants dans l'industrie ferroviaire entre 2002 et 2012. Il trouve des preuves que le courtage en réseau de brevets, d'individus et d'organisations bénéficie systématiquement à la performance de l'innovation et que la densité du réseau de brevets et les individus a des résultats différenciés. Le deuxième chapitre évalue les progrès des objectifs de développement durable de 294 villes en Chine et conclut que les réseaux denses de propriété du patrimoine culturel dans les villes, l'échelle des industries culturelles et le transfert de connaissances translocal sont positivement associés aux progrès du développement durable. Le troisième chapitre analyse les capacités de 26 643 entreprises culturelles à survivre à la pandémie et constate que les activités culturelles numérisées et les entreprises avec plus de partenaires de réseau sont plus susceptibles de survivre à la pandémie plus

longtemps. En incorporant des théories et des arguments développés dans l'analyse de réseau, la géographie économique, les études culturelles et la littérature sur la durabilité, cette étude permet de mieux comprendre le rôle de l'innovation à la fois dans la performance au niveau de l'entreprise mais aussi dans le développement au niveau du système. Dans chacun des trois chapitres, une méthodologie d'analyse de réseau a été adoptée et différents types de régressions qui intègrent à la fois les caractéristiques de l'entreprise et les caractéristiques structurelles du réseau ont été utilisées pour tester les hypothèses proposées concernant les relations entre les réseaux, l'innovation et la durabilité. Ainsi, il met en lumière des politiques et des stratégies plus pratiques qui visent non seulement à améliorer les résultats centrés sur les acteurs, mais qui tiennent également compte des changements sociétaux.

Mots clés : réseau à plusieurs niveaux, innovation, durabilité, objectifs de développement durable, industrie ferroviaire, industries culturelles et créatives, patrimoine culturel, pandémie

Méthodes de recherche : analyse de réseau, analyse de réseau d'ego, analyse de réseau entier, régression linéaire multiple, modélisation multiniveaux

Abstract

This thesis addresses the links between knowledge networks, innovation, and sustainable development in the context of emerging market knowledge intensive industries. It first builds a comprehensive framework that explains the relationships between multilevel networks and innovation in organizations. By exploring the heterogeneous implications of two important network structural features, network brokerage and density, at three levels of a multilevel network, the first chapter of the thesis lays the theoretical foundation of the subsequent chapters. Extending this theoretical framework to a broader setting of cultural sustainability, the second chapter then argues that networks in cultural and creative industries contribute to sustainable development through three mechanisms: directly fostering innovation and creativity, indirectly offering development opportunities for marginalized groups, and systematically shaping value systems in societies. The third chapter examines the role of networks of cultural and creative firms and adoption of digital technologies in surviving the ongoing global health crisis starting in 2020 and provides insights that network resources help firms to cope with the crisis. The research setting of the thesis includes two knowledge intensive industries in China, the railway industry and the cultural and creative industries. The first chapter tests the theoretical arguments on networks composed of 617 organizations collaborating on innovative projects in the railway industry between 2002 and 2012. It finds evidence that network brokerage of patents, individuals, and organizations consistently benefit the innovation performance and that network density of patents and individuals has differentiated outcomes. The second chapter evaluates the Sustainable Development Goal progress of 294 cities in China and concludes that dense cultural heritage ownership networks in cities, the scale of cultural industries, and trans-local knowledge transfer are positively associated with sustainable development progress. The third chapter analyzes the capabilities of 26,643 cultural firms in surviving the pandemic and finds that digitalized cultural activities and firms with more network partners are more likely to survive the pandemic longer. By incorporating theories and arguments developed in network analysis, economic geography, cultural studies, and sustainability literature, this study provides a better understanding of the role of innovation in both firm level performance but also

system level development. In each of the three chapters, network analysis methodology was adopted and different types of regressions that incorporate both firm features and network structural features were used to test hypotheses proposed regarding the relationships between networks, innovation, and sustainability. Thus it sheds light on more practical policies and strategies that not only aim to improve actor centric outcomes but also consider the societal changes.

Keywords: multilevel network, innovation, sustainability, Sustainable Development Goals, railway industry, cultural and creative industries, cultural heritage, pandemic

Research methods: network analysis, ego network analysis, whole network analysis, multiple linear regression, multilevel modelling

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List of abbreviations

CASS	Chinese Academy of Social Sciences
CCI	cultural and creative industry
CNIPA	China National Intellectual Property Administration
CNKI	China National Knowledge Infrastructure
CRS	China Railway Society
CRSSTA	China Railway Society Science and Technology Award
CSTAD	China Science and Technology Achievement Database
GDP	Gross Domestic Product
ICC	intraclass correlation
IPC	International Patent Classification
MNE	multinational enterprise
MOR	Ministry of Railways
MYSTA	Mao Yi-sheng Science and Technology Award
NBS	National Bureau of Statistics of China
NCHA	National Administration of Cultural Heritage
NECIPS	National Enterprise Credit Information Publicity System
NO	nitric oxide
NO_2	nitrogen dioxide
O3_8h	8-hour ozone concentration
OECD	Organisation for Economic Co-operation and Development
PM10	particulate matters with diameters of 10 micrometers and smaller
PM2.5	particulate matters with diameters of 2.5 micrometers and smaller
R&D	research & development
SAMR	State Administration for Market Regulation
SAR	Special Administrative Region
SDGs	Sustainable Development Goals
SO_2	sulfur dioxide
TUSDG	The Institute for Sustainable Development Goals of Tsinghua University
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNESCO-UIS	UNESCO Institute for Statistics
VIF	variance inflation factor
WCED	World Commission on Environment and Development
WHC	World Heritage Centre
WHO	World Health Organization
WWF	World Wide Fund for Nature
ZTRSTA	Zhan Tianyou Railway Science and Technology Award

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Preface

There is a growing consensus that our social systems are functioning in networks. From creative collaborations between entrepreneurs to strategic alliances formed by multinational enterprises and from local community social lives to migration flow between nations, networks are everywhere. But the implications of these networks are not always clear and effectively strategies of utilizing resources embedded in networks are even more complex to formulate and implement.

I am always fascinated by the complexity of the social systems and interested in how network features contribute to development of individuals, organizations, cities, and regions in distinct aspects and under various contexts. More specifically, my research explores two critical and interrelated topics, namely innovation and sustainability, in the current turbulent time which has several grand challenges for the human beings.

Various network characteristics, such as structure, composition, multilevel feature, and multiplexity, foster creativity of individuals and innovation performance of organizations, industrial clusters, and ecosystems. To build on this steam of research, this dissertation I incorporated creativity and innovation into the discussion of sustainable development under the framework developed by the United Nations and examine the role of innovation networks of the cultural and creative industries in achieving the Sustainable Development Goals.

In the three chapters of this dissertation, I explore several important research questions and topics.

1. What implications of the multilevel features of the innovation networks that are composed of patents, individuals, and organizations have on innovation performance.
2. How network structure and composition of the cultural and creative industries contribute to local sustainable development.
3. What network features help cultural and creative industry firms survive the pandemic of the COVID-19.

The primary method utilized in this dissertation is the social network analysis, which is particularly useful and convenient in handling large-scale quantitative relational data in empirical studies. The main frameworks of this dissertation were built upon the theories and frameworks in network studies, including various network identification techniques, large scale automated data collection, and network construction and visualization. I combined network analysis with multilevel regression models to deal with complex multilevel networks in different settings. With the aid of open-source packages such as R and Python, I carried out rigorous complex network analysis.

By empirically examining networks in two industries in China, this dissertation provides insights on how various networks aid in knowledge creation, induce innovation, and contribute to grand challenges faced by societies in social systems.

Introduction

As economic activities become more and more complex and interdependent in the current era of knowledge economy, networks are observed everywhere in our social systems (Kadushin, 2012). Creative individuals rely on social networks and knowledge communities to generate ideas, to exchange perspectives, and to translate ideas into tangible innovation outcomes (Cohendet et al., 2017; Perry-Smith & Mannucci, 2017). Firms form and maintain various relationships with their partners to reduce transaction risks, to access complementary resources, and to enable interorganizational learning (Gilsing et al., 2008; Gulati et al., 2000; Phelps, 2010). Clusters, cities, and regions also participate in global production and innovation networks by integrating in global value chains, formulating trans-local knowledge pipes, and combining local and distant knowledge resources (Bathelt & Li, 2014; Bathelt et al., 2004; Turkina & Van Assche, 2018).

Scholars of innovation and creativity research have acknowledged the importance of networks and explored the relationships between various network features and knowledge outcomes and innovation performance (Phelps et al., 2012). Many aspects of knowledge networks, such as their structure, composition, and change have been explored (Brass, 2022). Specific network features, such as density, centrality, structural holes, and tie strengths, have been argued to contribute to or hinder innovation (Burt, 2004; Levin & Cross, 2004; Uzzi & Spiro, 2005; Wang et al., 2014).

However, we know less about how multiple networks that nest into each other collectively contribute to both the outcomes of individuals/firms and the development of innovation at the system level (Brass, 2022). Individuals' capability of accessing knowledge not only depend on their network position but also on the network features of the knowledge communities in which they are embedded (Bizzi, 2013). It is also possible that firms possessing obsolete knowledge and technologies are trapped in in the periphery of knowledge networks and thus lower potential for innovation (Maoret et al., 2020).

Since our societies are essentially composed of multilevel networks with distinct features, answering this question would help us to more effectively utilize networks to foster truly transformative innovation (Bathelt & Cohendet, 2014; Paruchuri et al., 2019). Without the consideration of the nested structure of networks, our understanding of how innovation is socially constructed is limited (Bizzi, 2013). Strategies and policies aiming to foster innovation are likely to be biased if we fail to acknowledge the heterogeneous roles played by different layers of networks (Paruchuri et al., 2019; X. Wang et al., 2020).

Understanding the role of network structure for the transmission of knowledge and innovation performance has become especially important as governments and firms have started focusing on grand societal challenges and acknowledging the importance of culture in building inclusive and sustainable cities. The grand challenges such as climate and resources, social resilience, digital transformation, and inequality are well-documented in the Sustainable Development Goal (SDG) framework (George et al., 2016). Given that innovation and creativity are critical in solving numerous grand challenges faced by humankind and in realizing transformations needed to achieve the Sustainable Development Goals (SDGs), a clearer understanding of this question can help build a sustainable future that survives the volatile, uncertain, complex, and ambiguous times (Brass, 2022; Sachs et al., 2019). Knowledge networks not only directly contribute to the focal actor's performance but also indirectly help build important knowledge externalities and concentration of creative talents that are beneficial for local development (Asheim et al., 2011). By connecting different entities and fostering collaboration among economic actors, networks provide valuable opportunities for building creative and cohesive communities, offering employment, and empowering marginalized groups, which are critical for cultural, social, and economic aspects of sustainable development (Lee, 2015; Martin & Moodysson, 2011).

This thesis contributes to this discussion by clarifying the different implications of several nested networks and by examining the role of knowledge networks in sustainable development and survival in crisis. More specifically, I develop three interrelated studies to elaborate the relationships between networks, innovation, and sustainability: (1) the multilevel network structure and innovation performance in organizations; (2) the role of

CCI networks in achieving SDGs in cities; and (3) the relationship between networks, digitalization, and CCI firm survival in the pandemic.

The overarching theoretical framework of all the three chapters is that knowledge is created and transferred in networks and that different network structures provide heterogeneous opportunities for knowledge activities and innovation. Since these networks are largely localized, creative activities in turn contribute to local development both directly by fostering innovation, indirectly providing more employment opportunities and improving community cohesion, and comprehensively shaping value systems of societies.

Chapter 1 elaborates how network structures at different levels of a multilevel network contributes to innovation performance. This study builds on theories and arguments established by prior research that patent networks, interpersonal networks, and inter-organizational networks are all relevant to innovation performance. It then integrates the arguments developed at different levels into one multilevel framework. This study addresses one important research question: how network structural features of these three networks collectively contribute to innovation outcomes in organizations.

By adopting a multilevel perspective, this study helps to provide more reliable arguments of the theoretical isomorphism, which is extremely popular in network studies, and sheds lights on the implication of the interdependence between different layers of networks on knowledge generation in our social systems (Moliterno & Mahony, 2011). Since the locus of innovation is in knowledge networks (Powell et al., 1996), this study provides a more accurate picture of networked innovation process and helps explain the complex and intricate social construction of knowledge, which encompasses collaborations between different levels of the social systems (Cohendet et al., 2017). The empirical study of this chapter examines the multilevel networks composed of 617 organizations that collaborate on innovative projects in the railway industry between 2002 and 2012. Only by acknowledging the complexity and multilevel features of innovation, more general discussion of how innovation contributes to societal challenges, such as mechanisms of knowledge sharing across organizational boundaries, building creative communities and

cities, and CCIs as economic development engine, can become feasible (Bathelt & Cohendet, 2014; Perry-Smith & Mannucci, 2017).

Chapter 2 analyzes how the whole network structures in the cultural and creative industries (CCIs) within cities contribute to local sustainable development. The CCIs are sectors that provide products or services with cultural, artistic, or heritage value and are highly knowledge intensive in nature (UNESCO & World Bank, 2021). This study identifies three possible channels through which CCI networks contribute to local sustainable development: direct effects of knowledge creation and innovation, indirect effects of employment provision and social equity, and the overall sustainable and responsible lifestyle shaping role. The CCIs related to cultural heritage across 294 cities in China are the research setting for the second study. By analyzing the nexus between the CCIs and the Sustainable Development Goals (SDGs), this study provides a comprehensive framework that incorporates different mechanisms through which networks in the CCIs contribute to various SDGs at subnational level (Soini & Birkeland, 2014; Xu et al., 2020).

As one of the first studies to link business behaviors, relationships, and networks in the CCIs with cities' progress in achieving the SDGs, this study contributes to clarifying the role of culture in sustainability, identifying the regional development opportunities brought by the CCIs, and localizing the SDG frameworks (Salvia et al., 2019; Xu et al., 2020). Based on the knowledge network perspective, this study extends the arguments and theories developed in the first chapter and elaborates the possibilities of contribution of networks to system level change and development beyond actor centric performance.

Chapter 3 explores what factors contribute to CCI firms' survival in the crisis of the COVID-19 pandemic. The global health crisis poses tremendous threats on the cultural and creative activities that depend on social interaction and in-person presence. By adopting a multilevel lens, this study proposes that firm level features, ego network structure, and sectorial differences matter for CCI firms' resilience in the pandemic (Khlystova et al., 2022; Sharma et al., 2020). The pandemic represents one of the most damaging external forces that threaten the development and the growth of the CCIs and

the achievement of the SDGs (OECD, 2020; UNESCO, 2021a). It is thus imperative to analyze what features of firms might help them survive the crisis and develop resilient strategies for possible future crises. I chose 26,643 CCI firms as the research setting and compared their capability of surviving in the pandemic. This study highlights that network ties help mobilize resources, provide support, and exchange knowledge during the crisis and that digitalization of cultural activities provides an advantage for CCI firms to transform their business online in the pandemic.

The incorporation of the multilevel features of the factors related to the survival of CCI firms contributes to the dialogue of the resilience in the pandemic and sheds lights on the importance of knowledge networks and digital technologies transfer (Khlystova et al., 2022; S. L. Wang et al., 2020). As the concluding part of the three studies, this chapter empirically tests the potential of the CCIs, which is often cited as the "industry of tomorrow", in sustainable development during extremely difficult times (UNESCO, 2021b). It also provides insights on what conditions and factors related to firms, economic activities, and cities collectively constitute drivers of growth, knowledge creation engine, and sustainable cultural production and consumption (Raimo et al., 2021; Sedita & Ozeki, 2021).

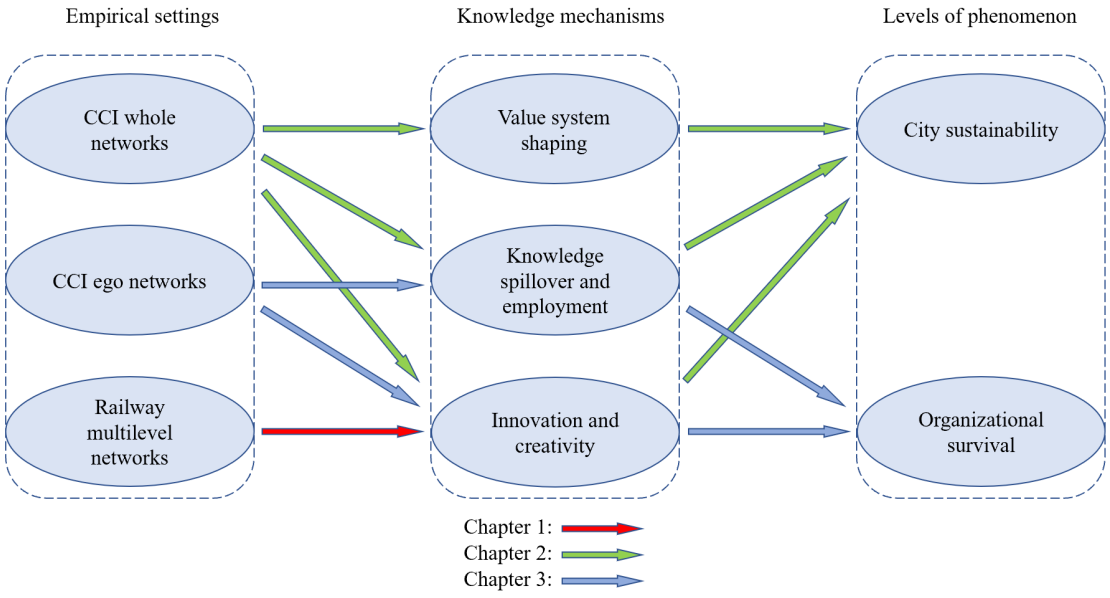


Figure 0.1 Conceptual frameworks of the three chapters

As shown in Figure 0.1, the three chapters focus on different aspects of the complex relationships between networks, innovation, organizational performance, and sustainability. The arrows in different colors represent the main arguments and propositions in the three chapters.

By analyzing the roles of networks in different research settings in realizing system level outcomes and individual performance, the three chapters provide a comprehensive understanding of the nexus between networks, innovation, and outcomes at different levels of our social systems.

The first chapter lays the overall theoretical framework that networks matter for innovation and creativity at the micro level. By establishing a multilevel network that includes patent, individual, and inter-firm level networks, the chapter develops arguments and provides conclusions that both firm resources and external networks of economic entities matter for organizational performance.

The second chapter extend the arguments proposed in the first chapter that both features and networks contribute to regional performance by taking a macro lens. By exploring the three knowledge mechanisms of how the CCIs and the CCI networks of cities contribute to local sustainable development at the system level, this chapter applies knowledge network frameworks to regional level. The micro mechanism points out that networks matter for knowledge transfer and innovation of firms. The middle mechanism introduces the spillover arguments and shows networks also contribute to network partners' knowledge accumulation and development opportunities. And these regional networked knowledge interactions in turn foster local lifestyle shaping and value system building. These macro mechanisms in turn contribute to local sustainable development.

Following these arguments, the third chapter examines knowledge mechanisms in interorganizational networks in an ongoing crisis that significantly challenges the functioning and operation of the CCI firms. This chapter complements the first two chapters by introducing a new and dynamic context and testing whether the theories and arguments developed in the first two chapters can explain the organizational performance. By answering how the network resources of individual CCI firms foster the capabilities

of surviving the pandemic, this chapter concludes the thesis by examining the strengths and the reactions of networks to external crisis. Thus, it builds on theoretical frameworks developed in the first two chapters and opens future research directions on the dynamics between networks and external environment (Brass, 2022).

Taken together, these three chapters synthesize prior network theories at different levels and provide comprehensive theoretical frameworks, extends the knowledge network arguments to both multilevel systems and regional development, and finally examines the organizational persistence and resilience brought by networks in the pandemic crisis.

The empirical settings of the thesis are the railway industry and the CCIs in China. The selection of these two industries is on the basis of two criteria:

Rapid growth in both industries. China's railway industry developed significantly in the first decade of this century. The railway industry has transformed from a very inefficient one to an advanced system with the largest scale of high-speed railway tracks in the world and the average speed of the railway system also increase considerably (Lyu & Jiang, 2017). During the modernization of the railway system, product and service innovation has been observed in every domain of the industry. China is one of the countries with rich cultural heritage and utilize cultural resources for local development; thus the CCIs are the appropriate setting to analyze the relationship between creative activities and sustainability (WHC, 2021). The contribution of the CCIs in China's GDP also increases from 2.52 percent in 2008 to 4.54 percent in 2019, which represents a significant growth in these sectors (NBS, 2020).

High knowledge intensity and frequent collaboration in networks. Both industries are characterized as knowledge-intensive sectors and the key drivers for these sectors are innovation and creativity. Patent generation by actors in railway industries has witnessed an exponential growth between 2002 and 2012 thanks to comprehensive knowledge transfer initiatives between foreign and domestic firms promoted by the government (Gao, 2022; J. He et al., 2018). Using knowledge intensive industries as the research setting allows observing patterns of knowledge creation activities in these sectors. Both the railway industry and the CCIs rely on collaboration between different types of actors in

networks to generate innovation, which provides the necessary condition to observe the network mechanisms (Lyu & Jiang, 2017; Wittel, 2001).

For the network analysis, three sets of network data were hand-collected for the three studies. The empirical study in the first chapter requires a multilevel network composed of three networks at patent level, individual level, and interorganizational level. I constructed these networks by consulting patent profiles of the firms which participate in award-winning innovative projects (China Railway Society, 1999). The middle layer of the multilevel network was constructed by searching academic journal information of the inventors of these patents (Wang et al., 2014). For the second study, I collected network data on 2,114 organizations that operate and manage the 1,355 cultural heritage sites across 294 cities in China. These organizations and their ownership network partners collectively form local networks that focus on CCI activities closely related to cultural heritage. For the third chapter, I collected ego network data on 26,643 CCI firms by searching for their shareholders and firms they invest in. The main databases used to obtain network data include National Enterprise Credit Information Publicity System (NECIPS), China National Knowledge Infrastructure (CNKI), China National Intellectual Property Administration (CNIPA), various statistical yearbooks for Chinese cities, provinces, and both industries.

After constructing the networks, I carried out a series of regressions to explore the hypotheses on the relationship between networks, innovation, and sustainability. At the end of each chapter, I discussed the empirical results, provided the theoretical and practical implications of these results, and pointed out future research directions.

By building the core conceptual framework that knowledge creation and innovation are carried out in networks and examining the propositions that networks matter for both organizational performance, firm survival, and systematic level sustainable development in different empirical settings, this thesis provides a clearer picture of the knowledge creation in networks and how innovation and creativity bring about social change and development.

References

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies*, *45*(7), 893-904. https://doi.org/10.1080/00343404.2010.543126

Bathelt, H., & Cohendet, P. (2014). The creation of knowledge: local building, global accessing and economic development-toward an agenda. *Journal of Economic Geography*, *14*(5), 869-882. https://doi.org/10.1093/jeg/lbu027

Bathelt, H., & Li, P.-F. (2014). Global cluster networks—foreign direct investment flows from Canada to China. *Journal of Economic Geography*, *14*(1), 45-71. https://www.jstor.org/stable/26158716

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, *28*(1), 31-56. https://doi.org/10.1191/0309132504ph469oa

Bizzi, L. (2013). The Dark Side of Structural Holes: A Multilevel Investigation. *Journal of Management*, *39*(6), 1554-1578. https://doi.org/10.1177/0149206312471385

Brass, D. J. (2022). New Developments in Social Network Analysis. *Annual Review of Organizational Psychology and Organizational Behavior*, *9*(1), 225-246. https://doi.org/10.1146/annurev-orgpsych-012420-090628

Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, *110*(2), 349-399. https://doi.org/10.1086/421787

China Railway Society. (1999). Societies. In China Railway Society (Ed.), *China Railway Yeabook*. China Railway Publishing House.

Cohendet, P., Parmentier, G., & Simon, L. (2017). Managing knowledge, creativity and innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 197-214). https://doi.org/10.4337/9781782548522

Gao, Y. (2022). The Belt and Road Initiative and cascading innovation in China's domestic railway ecosystem [Article]. *Journal of International Business Policy*, *5*(2), 236-258. https://doi.org/10.1057/s42214-022-00132-1

George, G., Howard-Grenville, J., Joshi, A., & Tihanyi, L. (2016). Understanding and tackling societal grand challenges through management research. *Academy of Management Journal*, *59*(6), 1880-1895.

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy*, *37*(10), 1717-1731. https://doi.org/10.1016/j.respol.2008.08.010

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203-215. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<203::Aid-smj102>3.0.Co;2-k

He, J., Lyu, T., Huang, Y., & Jiang, H. (2018). Motivation structure and capacity building of technological catch-up: Experience and policy implication of China's High-Speed Rail. *Journal of Management World*, *34*(10), 191-207. https://doi.org/10.19744/j.cnki.11-1235/f.2018.10.016

Kadushin, C. (2012). *Understanding social networks : theories, concepts, and findings*. Oxford University Press.

Khlystova, O., Kalyuzhnova, Y., & Belitski, M. (2022). The impact of the COVID-19 pandemic on the creative industries: A literature review and future research agenda. *Journal of Business Research*, *139*, 1192-1210. https://doi.org/10.1016/j.jbusres.2021.09.062

Lee, M. (2015). Fostering connectivity: a social network analysis of entrepreneurs in creative industries. *International Journal of Cultural Policy*, *21*(2), 139-152. https://doi.org/10.1080/10286632.2014.891021

Levin, D. Z., & Cross, R. (2004). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science*, *50*(11), 1477-1490.

Lyu, T., & Jiang, H. (2017). From Reverse Engineering to Forward Engineering—The Implications of High-Speed Railway Equipment Industry on Technological

Catch-up and Independent Innovation in the Chinese Equipment Manufacturing Industry. *Business and Management Journal*, *39*(10). https://doi.org/10.19616/j.cnki.bmj.2017.10.001

Maoret, M., Tortoriello, M., & Iubatti, D. (2020). Big Fish, Big Pond? The Joint Effect of Formal and Informal Core/Periphery Positions on the Generation of Incremental

Innovations. *Organization Science*, *31*(6), 1538-1559. https://doi.org/10.1287/orsc.2020.1365

Martin, R., & Moodysson, J. (2011). Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies*, *19*(7), 1183-1203. https://doi.org/10.1080/09654313.2011.573131

Moliterno, T. P., & Mahony, D. M. (2011). Network Theory of Organization: A Multilevel Approach. *Journal of Management*, *37*(2), 443-467. https://doi.org/10.1177/0149206310371692

NBS. (2020). *China Statistical Yearbook on Culture and Related Industries*. China Statistics Press.

OECD. (2020). *Culture shock: COVID-19 and the cultural and creative sectors*. https://www.oecd.org/coronavirus/policy-responses/culture-shock-covid-19-and-the-cultural-and-creative-sectors-08da9e0e/

Paruchuri, S., Goossen, M. C., & Phelps, C. (2019). Conceptual foundations of multilevel social networks. In S. E. L. Humphrey, James M. (Ed.), *The handbook of multilevel theory, measurement, and analysis* (First Edition. ed.). American Psychological Association,.

Perry-Smith, J. E., & Mannucci, P. V. (2017). From Creativity to Innovation: The Social Network Drivers of the Four Phases of the Idea Journey. *Academy of Management Review*, *42*(1), 53-79. https://doi.org/10.5465/amr.2014.0462

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890-913. https://doi.org/10.5465/amj.2010.52814627

Powell, W. W., Koput, K. W., & SmithDoerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, *41*(1), 116-145. https://doi.org/10.2307/2393988

Raimo, N., De Turi, I., Ricciardelli, A., & Vitolla, F. (2021). Digitalization in the cultural industry: evidence from Italian museums. *International Journal of Entrepreneurial Behavior & Research*. https://doi.org/10.1108/ijebr-01-2021-0082

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockstrom, J. (2019). Six Transformations to achieve the Sustainable Development Goals. *Nature Sustainability*, *2*(9), 805-814. https://doi.org/10.1038/s41893-019-0352-9

Salvia, A. L., Leal, W., Brandli, L. L., & Griebeler, J. S. (2019). Assessing research trends related to Sustainable Development Goals: local and global issues. *Journal of Cleaner Production*, *208*, 841-849. https://doi.org/10.1016/j.jclepro.2018.09.242

Sedita, S. R., & Ozeki, T. (2021). Path renewal dynamics in the Kyoto kimono cluster: how to revitalize cultural heritage through digitalization. *European Planning Studies*, 1-19. https://doi.org/10.1080/09654313.2021.1972938

Sharma, P., Leung, T. Y., Kingshott, R. P. J., Davcik, N. S., & Cardinali, S. (2020). Managing uncertainty during a global pandemic: An international business perspective. *Journal of Business Research*, *116*, 188-192. https://doi.org/10.1016/j.jbusres.2020.05.026

Soini, K., & Birkeland, I. (2014). Exploring the scientific discourse on cultural sustainability. *Geoforum*, *51*, 213-223. https://doi.org/https://doi.org/10.1016/j.geoforum.2013.12.001

Turkina, E., & Van Assche, A. (2018). Global connectedness and local innovation in industrial clusters. *Journal of International Business Studies*, *49*(6), 706-728. https://doi.org/10.1057/s41267-018-0153-9

UNESCO. (2021a). *Cultural and creative industries in the face of COVID-19: an economic impact outlook*. https://unesdoc.unesco.org/ark:/48223/pf0000377863

UNESCO. (2021b). *UNESCO Roadmap for International Year of Creative Economy for Sustainable Development 2021*. https://en.unesco.org/sites/default/files/creative_economy2021-unesco-roadmapen-ok2.pdf

UNESCO, & World Bank. (2021). *Cities, Culture, Creativity: Leveraging Culture and Creativity for Sustainable Urban Development and Inclusive Growth* https://openknowledge.worldbank.org/handle/10986/35621

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*(2), 447-504. https://doi.org/10.1086/432782

Wang, C. L., Rodan, S., Fruin, M., & Xu, X. Y. (2014). Knowledge Networks, Collaboration Networks, and Exploratory Innovation. *Academy of Management Journal*, *57*(2), 484-514. https://doi.org/10.5465/amj.2011.0917

Wang, S. L., Gu, Q., Von Glinow, M. A., & Hirsch, P. (2020). Cultural industries in international business research: Progress and prospect. *Journal of International Business Studies*, *51*(4), 665-692. https://doi.org/10.1057/s41267-020-00306-0

WHC. (2021). *Special Issue - World Heritage in China*. UNESCO. https://whc.unesco.org/en/review/99

Wittel, A. (2001). Toward a network sociality. *Theory Culture & Society*, *18*(6), 51-+. https://doi.org/10.1177/026327601018006003

Xu, Z. C., Chau, S. N., Chen, X. Z., Zhang, J., Li, Y. J., Dietz, T., Wang, J. Y., Winkler, J. A., Fan, F., Huang, B. R., Li, S. X., Wu, S. H., Herzberger, A., Tang, Y., Hong, D. Q., Li, Y. K., & Liu, J. G. (2020). Assessing progress towards sustainable development over space and time. *Nature*, *577*(7788), 74-+. https://doi.org/10.1038/s41586-019-1846-3

Chapter 1
Network brokerage, network density, and innovation: A multilevel study

Abstract

Despite a growing recognition that networks play critical roles in the innovation performance of organizations, their multilevel nature is underexplored. This is a lacuna since firms' innovation is generated in technological space, is created by inventors embedded in an interpersonal collaboration network, and is produced while operating in an inter-organizational network. This study conceptualizes how structural features of a nested multilevel network jointly contribute to the innovation performance of patents. We use data from China's railway industry between 2002 and 2012 to evaluate how network positions at different levels relate to patent innovation performance. We find that brokering position relates positively to innovation performance across the three networks. At the same time, network density reveals differentiated relationships with innovation performance across networks: it has a negative relation in the knowledge network; a positive relation in the interpersonal network.

1.1 Introduction

Networks are fundamental for a company's innovation performance (Phelps et al., 2012) . They are a means by which companies can access knowledge and use it to increase their innovation capacity (Gulati et al., 2000). Firms rely on networks to supplement their own resources with knowledge that is currently unavailable (Lavie, 2007), to tap into knowledge pockets that are locally absent (Bathelt et al., 2004), and to speed up the process of getting products to market (Almeida & Kogut, 1999).

It is thus not surprising that researchers have heavily relied on social network analysis to examine the drivers of a company's ability to innovate (Ahuja et al., 2008). Several features of social networks have been associated with learning and innovation outcomes, including what benefits network embeddedness brings to innovation (Ahuja, 2000; Huggins & Thompson, 2016; Zaheer & Bell, 2005), how brokerage opportunities can

boost creativity in organizations (Burt, 2004), and why networks matter differently depending on the type of innovation that firms conduct (Hemphala & Magnusson, 2012; Sammarra & Biggiero, 2008).

Despite these insights, a limitation of this research stream is that most contributions have focused squarely on structural properties of a single type of network – mostly the inter-organizational network – on innovation performance and have considered less the role of other types of networks that firms are concomitantly embedded in. Researchers have shown that a firm's position in the knowledge network, for one, determines the structure of its knowledge relatedness with other firms (Wang et al., 2014; Yayavaram & Ahuja, 2008), which is critical for its ability to acquire new knowledge from other firms (Gilsing et al., 2008). Other scholars have revealed that the position of a firm's researchers in the interpersonal network influences knowledge development since their innovation capabilities are harnessed by their social ties (Perry-Smith & Mannucci, 2017; X. Wang et al., 2020).

Since these three types of networks are nested into each other (Brennecke & Rank, 2017), it is important to consider their effects jointly when studying the relation between networks and innovation performance (Wang et al., 2014; Zappa & Lomi, 2015). Extant studies acknowledge that knowledge properties, individual factors, and organizational features are all relevant to innovation, yet explicit comparison between network structures that are composed of knowledge, organizational members, and organizations remains rare (Paruchuri et al., 2019; Phelps et al., 2012; Rothaermel & Hess, 2007). It remains unclear how the multilevel nature of networks contributes to innovation performance in organizations, a limitation noted by Brass (2022, p. 232) as 'an old future direction that has yet to be fully realized'. In this paper, our purpose is to explore the link between network structure and innovation performance from a multi-level perspective by integrating three distinct networks – knowledge, interpersonal and inter-organizational – into a nested multilevel framework.

We use China's railway industry as the empirical setting for our analysis. In the past two decades, China's railway industry has been characterized by explosive innovation which

was the result of frequent inter-organizational collaboration (Lyu & Jiang, 2017). Firms, government agencies, and research institutions established a large number of inter-organizational ties as they collaborated in innovative projects which were critical for the modernization of China's railway industry. Relying on hand-collected data on the collaboration and patenting behaviours of organizations from 1998 to 2012, we construct a three-level network composed of 617 organizations, 39,191 individuals, and 119,742 patents. Using a three-level multilevel regression method (Roback & Legler, 2021; Snijders & Bosker, 2012), we study how structural properties of these three networks jointly contribute to the innovation performance of patents.

The study is organized as follows. Section 2 reviews the literature on the relationship between network structure of multilevel networks and innovation performance. The section proposes two sets of hypotheses on the role of network structural features in innovation. Section 3 introduces the methodology adopted by in this study. Section 4 presents and discusses the empirical results. The final section provides reflections on the theoretical and practical implications of the research and concludes the study.

1.2 Theory and Hypotheses

We adopt the view that innovation is induced by the integration and recombination of knowledge (Kogut & Zander, 1992; Phelps, 2010). The extant literature has examined the role of structural features of different types of networks on innovation (Bergenholtz & Waldstrøm, 2011). Numerous empirical studies provide evidence that structures of networks, such as network position, density, and structural holes, at different levels matter for knowledge creation (Phelps et al., 2012).

Brokering position, one of the most important and most studied structural features of a network, contributes to knowledge creation since it means access to richer and diverse information, opportunities to recombine knowledge, and thus potential to innovate and better innovation performance (Halevy et al., 2019; Kwon et al., 2020).

Empirical evidence of the brokerage argument has been found at several levels of analysis. In knowledge networks, where knowledge elements are connected by technological

relationships, a knowledge element's brokering position reflects its combinational potential with other knowledge pieces (Wang et al., 2014). A knowledge element bridges other elements is thus expected to have more technological connections with other elements, to be easily understood by community members, and to have more potential in developing innovation (Guan & Liu, 2016; Wang et al., 2014). At the individual level, innovators possessing the brokering position in interpersonal networks not only reveal higher-level of creativity but also facilitate knowledge creation of their colleagues (Burt, 2004; Gonzalez-Brambila et al., 2013; Grigoriou & Rothaermel, 2014; Tortoriello et al., 2015). At the inter-organizational level, firms with a brokering position often achieve a higher innovation performance (Balachandran & Hernandez, 2018; Gilsing et al., 2008; Zang, 2018).

Similarly, network density, an important local structural feature that reflects the connectedness of a network, has been found to be relevant for innovation performance in different types of networks. A dense knowledge network means that there are multiple linkages among a small set of knowledge elements, which on the one hand facilitates future knowledge combination and on the other hand suggests some redundancy of knowledge and thus limited opportunity for new knowledge generation (Brennecke & Rank, 2017; Wang et al., 2014). At the individual level, denser interpersonal networks have been found to promote trust and social support (Coleman, 1988) and to facilitate knowledge transfer (Carnabuci & Operti, 2013; Obstfeld, 2005). At the inter-organizational level, dense networks are found to be helpful in collaborative learning and in knowledge sharing (Ahuja, 2000; Gilsing et al., 2008; Schilling & Phelps, 2007).

It is intuitive that organizations are multilevel social systems. Individuals are nested in work groups, groups are nested in departments, and departments are nested in firms (Zappa & Lomi, 2015). From the network perspective, organizations can thus be described as multilevel networks in which lower-level actors (e.g., individuals) are nested in higher-level collectives (such as departments and groups). Formally, a multilevel network refers to a collection of nodes with the features that exist at multiple levels and that lower-level nodes are at least partially nested in higher-level nodes and a collection of different ties connecting nodes at each level (Paruchuri et al., 2019).

Without analysing joint effects of different layers of networks simultaneously, our understanding of the complex process of knowledge creation and innovation may thus have been hampered for several reasons (Perry-Smith & Mannucci, 2017). Theoretically, it has prevented more refined theory building as scholars assume that evidence on one level also applies to other levels. Empirically, it has prevented scholars from appropriately validating performance implications since extant studies have overlooked collective effects of different network levels. We consider these theoretical and empirical shortcomings in turn.

In many studies, the existence of isomorphism across levels is assumed rather than tested. The arguments from previous research that networks influence knowledge creation at different levels should be treated with caution since these studies often apply theories and conclusions from one level of network to another without justification (Moliterno & Mahony, 2011; Paruchuri et al., 2019). For instance, following Coleman (1988) who argues that dense interpersonal network tends to promote trust, researchers studying inter-organizational networks implicitly assume that the causal inference of trust and social support brought by interpersonal network cohesion also apply to the interaction between organizations (Ahuja, 2000). Similarly, when analysing the relationship between unit centrality in an intraorganizational network and its innovation, Tsai (2001) refers to the empirical evidence of prior individual-level research that centrality is a significant predictor of innovation (Ibarra, 1993). The lack of explanation of why theoretical relationships hold for different network levels leads to potentially unreliable conclusions, for instance, one might challenge the comparability between interpersonal trust and inter-organizational trust or question to what extent individuals' behaviours resemble organizations' strategic moves.

Second, recent studies suggest that effects of networks at different levels are not independent from each other. Bizzi (2013) identifies a 'dark side of structural holes' effect that the positive effect of boundary-spanning individuals in accessing knowledge is contingent on the level of structural holes at the group level. It is also possible that organizations located in the periphery of a knowledge network within an industry have fewer opportunities to combine their knowledge with other organizations thus lower

potential for innovation (Grigoriou & Rothaermel, 2014; Maoret et al., 2020). Wang et al. (2014, p. 508) show that for the nested knowledge network and individual collaborative network, 'positions in one do not necessarily mirror those in the other'. Turkina and Van Assche (2019) empirically show that inter-organizational network structure is highly related, but not a perfect match, with knowledge network structure.

Without multilevel analysis, it is thus difficult to distinguish which levels of network structure matter more for innovation performance. Therefore, in this study, we introduce a three-level network model with knowledge network as the bottom level, interpersonal network as the medium level, and inter-organizational network as the top level (see Figure 1.1).

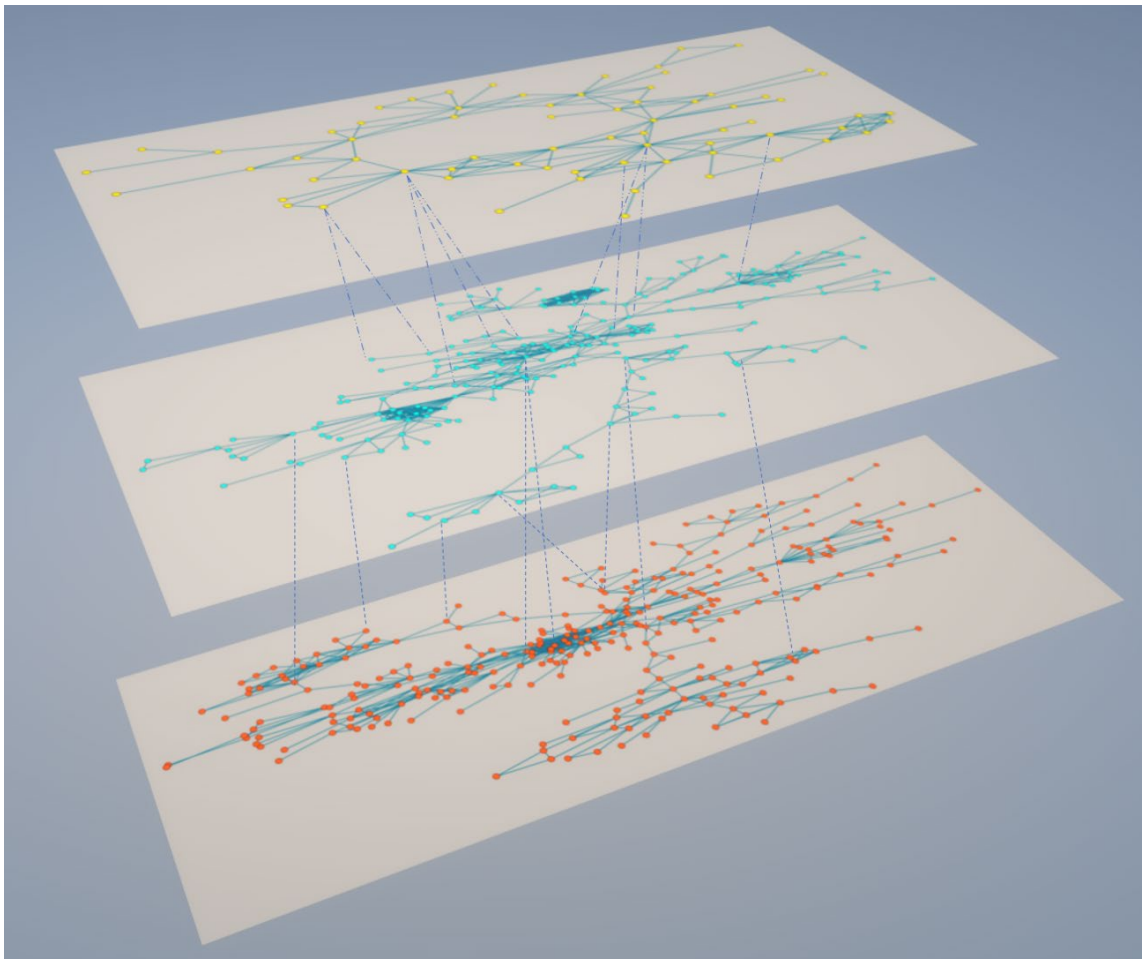


Figure 1.1 Illustration of a three-level network. Red nodes represent patents, ties between two patents represent that they belong to the same technological category; blue nodes represent individuals, ties between organizations represent co-authorship; yellow nodes represent organizations, ties between organizations represent collaboration in projects. Dotted lines represent affiliation ties between knowledge elements and individuals and between individuals and organizations (for the purpose of a clearer illustration, not all affiliation ties are drawn in the figure).

In the knowledge network, a set of knowledge elements (the red nodes) are considered nodes and relationships among knowledge elements ties. Knowledge elements could be identified through many ways, such as patents, features of products, or functions of software (Gilsing et al., 2008; Phelps, 2010; Wang et al., 2014). Ties between knowledge elements are often revealed by technological relationships such as the underlying logical connection, technical similarity, compatibility on the same development platform. In this study, we construct the knowledge network by conceptualizing patents as nodes and two patents belonging to the same technological category as ties, since patent classification reflects 'an underlying connection in the subject matters of two knowledge elements' (Wang et al., 2014, p. 487).

Knowledge is possessed by individuals who are listed as inventors on the patent applications. These individuals (the blue nodes) form interpersonal networks by social interaction. Two individuals are considered connected if they have social relationship such as friendship, advice seeking, co-authorship, and product co-developing (X. Wang et al., 2020). In this study, we construct the interpersonal network by treating inventors as nodes and identifying co-authorship relationships in publishing academic papers as collaboration ties between individuals.

Organizations (the yellow nodes) form inter-organizational networks by developing relationships such as strategic alliances, buyer-supplier linkages, and joint research and development projects. Two organizations are perceived as connected if they participate in formal or informal relationships with each other (Gulati et al., 2000; Nohria & Garcia-Pont, 1991). In this study, we identify nodes in the inter-organizational networks as organizations that formally collaborate in innovation projects and ties as co-participation in these projects.

1.2.1 Joint effects of brokering position at different levels

In this section, we develop several hypotheses relating brokering position at different network levels with innovation performance. We first discuss the role of brokering position at the macro inter-firm network before zooming in on the meso interpersonal and the micro knowledge network.

As economic activities become more complex, innovation is rarely confined within organizational boundaries. Rather, organizations increasingly utilize inter-organizational networks to source, access, or create knowledge that is critical to innovation (Gulati et al., 2000; Powell et al., 1996). Indeed, several studies reveal that an organization's centrality in the inter-organizational network is positively related to its innovative outcomes (Ahuja, 2000; Kogut, 2000). These arguments suggest that occupying a critical position in an inter-organizational network is relevant to organizational knowledge development and innovation performance.

Organizations possessing brokering position are perceived by other organizations in the network as high-status actors who are highly capable and possess useful knowledge since they have more opportunities to exchange knowledge with external sources (Gilsing et al., 2008). Access to diverse external knowledge through the brokering position leads to more dynamic knowledge combination of an organization's knowledge resources. First, a central organization that is located on the paths of knowledge sharing between different organizations means that it is exposed to more organizations. Exposure to diverse knowledge of different organizations, either intentionally or unintentionally, leads to challenges of existing experience, established routines, and knowledge heuristics (Quintana-Garcia & Benavides-Velasco, 2008). Second, inter-organizational learning through networks not only brings new knowledge, but also provides opportunities to identify new combination possibilities and to modify the established approach of utilizing internal knowledge (Grigoriou & Rothaermel, 2017). In both cases, a brokering organization's knowledge has higher chance of being combined for innovation. This leads to the following hypothesis:

Hypothesis 1a: *In a multilevel network, an organization's brokering position in the inter-organizational network positively influences the performance of its patents.*

The position of the inventors in the interpersonal network is also relevant for innovation performance and should act as an additional force beyond centrality in the inter-organizational network. First, extant literature highlights that status, prestige, and power derived from an individual's centrality increases the chance of exchanging knowledge

with others (Ibarra, 1993; Sasidharan et al., 2012). Possessing a brokering position in the interpersonal network thus removes some of the obstacles of interpersonal knowledge sharing. Indeed, several studies show that this type of centrality is positively related to an inventor's knowledge outcomes, such as managerial innovativeness, research citations, and new idea generation (Gonzalez-Brambila et al., 2013; Wong & Boh, 2014).

We extend this reasoning and argue that innovation performance of patents developed by inventors who broke the interpersonal network also benefit from these social interactions. Since an inventor's knowledge, perspectives, and opinions are more likely to be accepted and shared by network partners, his or her patents, as bundles of knowledge, are more likely to generate new knowledge as well (Perry-Smith, 2006). Second, individuals possessing a brokering position are more likely to bridge different knowledge communities that possess non-redundant information and knowledge. Since knowledge brokers lie on many paths of knowledge exchange, they can turn this advantageous position as a resource for knowledge creation of their own (Beaudry & Allaoui, 2012; Venkataramani et al., 2014). Therefore, we argue that an individual's brokering position in the interpersonal network also facilitates a patent's innovation performance.

Hypothesis 1b: *In a multilevel network, an inventor's brokering position in the interpersonal network positively influences the innovation performance of his or her patents.*

A knowledge element's brokering position in the knowledge network acts as a third force that influences innovation performance, reflecting the knowledge element's potential to be combined with other knowledge for innovation (Brennecke & Rank, 2017). In line with the concept of technological space, a central position in the knowledge network means that an element is commonly combined with other well-connected knowledge elements to create innovation (Guan & Liu, 2016; Wang et al., 2014). One refined conceptualization of central position is to look at the brokerage of a focal node, i.e., in terms of connecting otherwise disconnected actors (Kwon et al., 2020).

As far as innovation is about combining different knowledge, a knowledge element's brokering position in the knowledge network facilitates innovation by increasing the

potential for knowledge combination (Kwon et al., 2020). Furthermore, the brokering position of a knowledge element means that other nodes depend on the connection with it to reach each other and that the chance of knowledge flow through the focal node is higher (Borgatti, 2005).

This dependency gives the focal node the advantageous position of combining with other knowledge shared through network ties since 'brokering positions between others provide the opportunity to intercept or influence their communication' (Brandes et al., 2016). Therefore, in knowledge networks, a patent that lies on many potential combinational paths between different patents is more likely to be exposed to and combined with other knowledge elements to generate new knowledge.

A patent with a high brokering position is therefore a key knowledge element that connects different knowledge pools and is more likely to generate new knowledge. This leads to our next hypothesis.

Hypothesis 1c: *In a multilevel network, a patent's brokering position in the knowledge network positively influences its innovation performance.*

1.2.2 Joint effects of network density at different levels

Traditionally, network density, the degree to which nodes are connected in a network, is viewed as the opposite end of structural holes in the continuum of describing network closure and openness (Phelps et al., 2012). On the one hand, in dense networks, it is easier to communicate among network members, to generate trust and social support, and to collaborate efficiently (Coleman, 1988). On the other hand, dense networks imply closed triads of nodes (i.e., a focal node's immediate neighbours are also connected), redundant knowledge circulating through ties, and lack of timely access to external and distant knowledge (Burt, 1992).

Single-level studies often reveal conflicting relations between network density and innovation performance (Ahuja, 2000; Fleming et al., 2007; Gonzalez-Brambila et al., 2013; Schilling & Phelps, 2007). We argue that the relation between network density and innovation performance varies across levels for different reasons in multilevel networks.

A dense inter-organizational network provides firms the opportunity of reducing risks and costs associated with collaborative innovation. By definition, innovation implies risks as it is a process of combining different knowledge, and risk generally increases with the degree of novelty of innovation (Lavie & Rosenkopf, 2006; March, 1991). Also, innovation requires a large amount of resources and investment, and firms have to choose carefully whom to collaborate with and where to locate their valuable knowledge resources (Beckman et al., 2004). A dense network helps to overcome these risks because firms are more familiar with and visible to others in densely connected networks (Gulati et al., 2000). While in sparse inter-organizational networks, information asymmetry is higher and thus the costs of searching valuable knowledge and reliable partners increase (Phelps, 2010).

Furthermore, a dense network brings the possibility of enhancing the focal organization's absorptive capacity. First, when an organization's network partners are connected, the focal organization can leverage the weakness of its own absorptive capacity by relying on complementary knowledge capabilities of its other network partners. Second, since alters are also connected, the focal organization can learn from multiple network partners in densely connected networks with lower learning cost and higher efficiency. In both cases, a dense network brings the benefit of improving absorptive capacity, which facilitates the processing and absorbing knowledge, and in turn brings higher chance of knowledge combination (Gilsing et al., 2008). Innovation performance therefore benefits from dense inter-organizational networks that have lower risks in knowledge sharing, complementary knowledge sources, and lower costs of learning.

Hypothesis 2a: *In a multilevel network, an organization's network density in the inter-organizational network positively influences the performance of its patents.*

In a dense interpersonal network, individuals are more familiar with each other and thus able to provide their network partners social support, trust, and communication efficiency that are critical in innovation (Coleman, 1988; McFadyen et al., 2009). During the journey from creativity to innovation, after creative sparks are ignited, it is essential to transform ideas to innovation propositions. Dense and cohesive networks contribute to this

transformation by facilitating an inventor's sensemaking, promoting, and championing the ideas to knowledge communities to gain legitimacy, support, and approval for further development and implementation (Cohendet et al., 2017; Perry-Smith & Mannucci, 2017). During this social process, patents possessed by individuals embedded in dense interpersonal network are more likely to be visible to many individuals and thus have higher chance to be combined than those possessed by individuals embedded in sparse interpersonal network.

Hypothesis 2b: *In a multilevel network, an inventor's network density in the interpersonal network positively influences the innovation performance of his or her patents.*

It should be noted that several prior studies have suggested that dense interpersonal network hinders knowledge creation based on the assumption that knowledge possessed by familiar individuals who frequently collaborate is more likely to be similar and redundant, and thus less valuable in terms of knowledge combination (Fleming et al., 2007; Gonzalez-Brambila et al., 2013). But this assumption is often not tested (Phelps et al., 2012). In this study, we distinguish between the density of the knowledge network and the density of the interpersonal network by using a multilevel approach. We argue that in multilevel networks, interpersonal networks provide benefits rather than constraints once we account for the knowledge network explicitly.

A patent embedded in a dense knowledge network means that it is located in the network neighbourhood of similar patents that are thematically related or belonging to the same technological domain. Since patents are technologically similar, knowledge bundled in these patents is more likely to be redundant and overlapping, and opportunities to recombine these knowledge elements to generate new knowledge are lower (Brennecke & Rank, 2017). Furthermore, the view that network density promotes social trust and communication efficiency does not apply to the knowledge network because in this case, patents do not interact, socialize, and collaborate with each other (Coleman, 1988). These considerations lead to our next hypothesis.

Hypothesis 2c: *In a multilevel network, a patent's network density in the knowledge network negatively influences its innovation performance.*

To summarize, we propose two sets of hypotheses to explore the relationships between network structures in different levels of the multilevel network and a patent's innovation performance. The first set of hypotheses specifies the role of brokering position in the knowledge, interpersonal, and inter-organizational network. The second set of hypotheses highlights the role of ego network density in these same multilevel networks.

1.3 Methodology

The goal of the empirical analysis is to investigate the relationships between features of multilevel networks and patent performance. To serve this objective and test the hypotheses in prior sessions, we selected the China's railway industry as the research setting for empirical analysis. China's railway industry is the appropriate setting for the current research for two reasons.

First, the railway industry in China experienced a dramatic development in the last two decades. As of 2018, the total length of rail tracks of China was 132,000 km (including 30,000 km of high-speed tracks), which was estimated to be more than twice the scale of the length in 1998, less than 60,000 km (China Railway Society, 1999). Meanwhile, the technological advance in the industry was also prevalent as reflected by the fact that maximum operation speed of trains in the system was 350 km/h in 2017, compared to 200 km/h in 1998. Technological, product, and service innovation were observed in many subsectors of the industry (Lyu & Jiang, 2017).

Second, the innovation mechanisms of China's railway industry make possible the construction and identification of the multilevel network that is essential to our empirical analysis. In the early 2000s, facing the discrepancy of the increasing demand for modernized transportation system and the lack of technology and knowledge, the Ministry of Railways (MOR) negotiated with several MNEs, e.g., Siemens, Alstom, Bombardier, and Kawasaki, to transfer technology to domestic firms (Lyu & Jiang, 2017). During the two decades of the development of the industry, basic research and applied research were often conducted by various players in the industry simultaneously since domestic firms needed to absorb the technologies and products acquired from MNEs, alter the structure of the imported products, and experiment various compatibility issues (J. He et al., 2018).

These dynamics lead to a phenomenon that academic publications (normally belong to basic research domain), inventions (in applied research domain), and innovative products (commercialized innovation) were often developed at the same time. This feature provides a necessary condition for us to construct the multilevel network revealed by patenting, publishing, and commercializing activities concurrently, which are less commonly seen in the traditional linear model of innovation (Cohendet & Simon, 2017).

1.3.1 Identification of the multilevel network

To develop the multilevel network, we took as a starting point the list of award-winning innovation projects that were conducted by various organizations in China's railway industry. China Railway Society (CRS) is a public organization that specializes in the collection and communication of public science education, scientific consultation, evaluation, other technical services, and rewarding innovation in the railway industry (China Railway Society, 1999). Since 2002, CRS publishes the China Railway Society Science and Technology Award (CRSSTA) annually to reward organizations and individuals that contribute to innovation in the industry.

The awards provide information of the projects being rewarded and the organizations carrying out these projects. The CRSSTA represents one of the most important awards in the industry and is often cited by firms, universities, research institutions, and individuals as recognition of their contribution to innovation in the industry (China Railway Society, 1999). The CRSSTA incorporates technological development, major construction innovation, and social science projects that are relevant to the advance of railway industry and targets at projects that have been commercialized for at least two years and have contributed to development of the industry.

To create a coherent research design, this study has adopted the list of award-winning projects between 2002, the year CRS started to publish awards, and 2012, one year before the major reform of the MOR, the key government agency in the industry, and subsequent significant network structural changes. Considering the average project length in the industry and the conventional five-year window that management studies use to determine active inter-organizational relationships (China Railway Society, 1999; Lavie, 2007;

Stuart, 2000), this study assumes that any inter-organizational ties reflected in a rewarded innovation project existed in the previous five years. This selection generated a list of a total of 1104 projects (excluding 10 projects that were awarded but belonged to spin-offs of railway organizations such as railway hospitals' innovation) and 966 organizations.

We started by searching patents applied by these organizations in the China National Intellectual Property Administration (CNIPA) who adopted the International Patent Classification (IPC) as the classification scheme. Following prior studies on innovation in China's railway industry, we only included patents in the invention category (Genin et al., 2021).

A patent document includes specific information of its technological specificities, inventors (individuals), and applicants (individuals or organizations), and we relied on this information to construct the bottom-level and medium-level networks.

After searching patents by organizations listed in the CRSSTA, we excluded organizations with no patent application during the five-year observation period, and thus we counted 617 organizations.

According to Paruchuri et al. (2019), a multilevel network is defined by two criteria: first, it consists of nodes that exist at minimum two levels and that lower-level nodes are nested within higher-level nodes; second, nodes at each level should be connected by different types of ties. We constructed the three-level network in this study through three types of ties: technical relationships between patents, co-authorship relationships between individuals who invented these patents, and inter-organizational cooperation between organizations to which those individuals are affiliated.

The affiliation relationships between patents, individuals, and organizations in this study were limited to the principal affiliations listed on the patent document only. That is, if a patent is co-invented by two or more individuals, we assigned the patent to the principal inventor; and if a patent is co-applied by two or more organizations, the principal applicant was viewed as the owner of the patent. In other words, we constructed a fully nested cross-unit multilevel network, where a lower-level node can affiliate only with one higher-level

node (i.e., a patent belongs to one individual and an individual belongs to one organization), but a lower-level node can be connected with other nodes at the same level outside its affiliating higher node (i.e., a patent can relate to patents invented by other individuals and an individual can collaborate with individuals from other organizations) (Paruchuri et al., 2019). In this study we did not distinguish the number of times two nodes are connected (value of ties), i.e., two nodes were only viewed either connected or disconnected.

Inter-organizational Network (Top-level). All actors participating in awarded projects were included in inter-organizational level innovation networks, including firms, universities, research institutions, and government agencies. Collaborations in the same project were conceptualized as ties between these organizations.

Knowledge Network (Bottom-level). We relied on the technology codes provided in the patents to develop the low-level network: the knowledge network. We conceptualized patents as nodes in the knowledge network and the fact that two patents belong to the same IPC group. Following prior literature, we argued that a patent presents a piece of knowledge, or a bundle of specific knowledge elements possessed by organizations (Gilsing et al., 2008). Again, we adopted the five-year window as the duration of organizations' knowledge network. For instance, if a firm A was awarded for a project in 2002, the knowledge network of firm A was identified by searching all patents applied by firm A from 1998 to 2002.

Interpersonal Network (Medium-level). The middle-level network in this study, interpersonal network, was identified by searching academic journal papers published by inventors in the core selection of China National Knowledge Infrastructure (CNKI) database (Acedo et al., 2006; Beaudry & Allaoui, 2012; Gonzalez-Brambila et al., 2013). Two inventors, nodes in the interpersonal network, were argued to have a collaborative tie if they co-author in at least one paper.

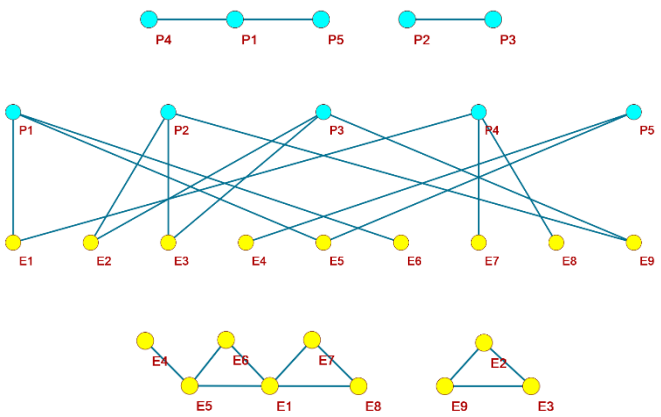
1.3.2 Dependent variable

The dependent variable of the study is a patent's innovation performance. As this study adopted a multilevel approach, we measured the dependent variable at the patent level (Paruchuri et al., 2019). This study operationalizes innovation performance of a patent as the number of times a patent is cited by subsequent patents. Patent forward citations have been widely used as a proxy of innovation performance and importance and potential of an invention in terms of technological and economic value (Katila & Ahuja, 2002; Phelps, 2010; Singh, 2005).

1.3.3 Explanatory variables

In this study, we use betweenness centrality to measure brokering position in the multilevel network because, compared to other brokerage measures such as structural holes and network constraints, which only take into account the direct ties surrounding a focal node, betweenness centrality measures the extent to which a focal node connects all other nodes in the network and thus a global indicator of brokerage (Brennecke & Stoemmer, 2018; Perry-Smith & Mannucci, 2015). Mathematically, betweenness is calculated as the average proportion of the number of shortest paths that pass through a focal node between any pair of nodes in the network relative to the total number of shortest paths between this pair of nodes (Jackson, 2008). By definition, a node with high betweenness centrality means that it is brokering many different parts of the entire network.

To measure betweenness centrality of a patent in the knowledge network, we constructed a two-mode affiliation knowledge network in which patents were associated with IPC codes (at group level) and then projected the two-mode networks onto single-mode knowledge network (Kadushin, 2012). Figure 1.2 illustrates the projection of a two-mode knowledge network onto a single-mode patent network and a single-mode patent code network. In the middle of the graph is the affiliation of patent codes with patents, for instance, Patent 1 (P1) was assigned two patent codes (E1 and E5) in patent filing system; Patent 4 (P4) was assigned three codes (E1, E7, and E8). These affiliation relationships could be projected into two types of single-mode networks: patent network and knowledge element (patent code in this case) network. In this study, P1 is considered as connected with P4 because they share the common patent code E1.



Single-mode patent network

Affiliation network

Single-mode patent code network

Figure 1.2 Illustration of two-mode knowledge network. Yellow nodes represent patent codes and blue nodes represent patents.

To get the measure of the betweenness centrality of a patent, we first calculated the ratio of the number of shortest paths between a pair of patents that pass the ego relative to the total number of shortest paths between the pair. Betweenness centrality of the focal patent was then calculated by averaging the ratio of all possible pairs in the network (excluding the ego) (Jackson, 2008).

We used the raw two-mode data of co-authorship relationships between individuals to construct the two-mode network and projected it onto a single-mode co-authorship network, in which nodes were individuals and ties were co-authorship.

We obtained the betweenness centrality of an individual by calculating the average ratio of the number of times an individual locating on the shortest paths between two other individuals to the number of all shortest paths between the two individuals.

Similarly, we constructed two-mode affiliation inter-organizational network in which organizations were associated with awarded projects and then projected the two-mode network onto a single-mode inter-organizational network. The betweenness centrality of an organization is the proportion of shortest paths of between two other organizations that pass through the focal organization.

Our second network structure of interest is network density. Mathematically, network density is the proportion of actual ties among nodes relative to all possible ties in a network (Jackson, 2008). Typically, network density measures the level of connectedness of the entire network, but it could also be applied to the ego network, where it only takes into account the ties present in a focal node's immediate neighbourhood (Phelps, 2010). In the latter case, the calculation of density is changed to the proportion of ties among a focal node's alters (immediate network neighbours) relative to all possible ties among the alters (Scott, 1991). In this study, to ensure a coherent research design, we focus on ego network density because similarly to betweenness centrality, it is a measure of network structure of a focal node rather than the entire network.

We operationalized a patent's ego network density by calculating the percentage of existing ties among the patent's immediate neighbours in all possible ties among the alters

in the single-mode patent network identified in the previous step. Similarly, an individual's ego network density was calculated in the same manner as in the single-mode co-authorship network, and an organization's ego network density was obtained by the same approach by measuring the proportion of realized ties relative to all possible ties in the single-mode inter-organizational network.

1.3.4 Control variables

We included several control variables at each of the three levels of the network to account for potential confounding effects. At the patent level, we included number of backward citations of the patent and number of inventors as control variables. Number of backward citations represented the knowledge connection between a patent and patents filed before it and to some extent reflected the knowledge flow between different patents and within the industry (Katila & Ahuja, 2002). Number of inventors (individuals who invent the patent) indicated the level of collective knowledge creation effort by different parties and thus could reveal the uniqueness of the knowledge embedded in a patent, i.e., whether knowledge bundled in a patent was accessible to many higher-level entities (Brennecke & Rank, 2017).

At the individual level, we included number of patents and star status of an individual to account for differences in creative capacity and productivity across the population (Azoulay et al., 2010; Grigoriou & Rothaermel, 2014; Khanna, 2021). We collected number of patents by counting patents with a given individual as inventor. To get information regarding whether an individual could be categorized as a star, we consulted two awards in the railway industry, Mao Yi-sheng Science and Technology Award (MYSTA) and Zhan Tianyou Railway Science and Technology Award (ZTRSTA), named after two pioneer scientists in railway industry and operated by two development foundations in the railway field respectively. Awardees of these two awards were identified as stars in the railway expert communities since these awards represents recognition of an individual's contribution to the railway sector in basic research, applied research, commercialization of technologies, and service innovation. Stars were then coded as 1 and non-star individuals were coded as 0.

We included several organizational level variables to account for the differences in financial resources, knowledge inventory, and experience in the industry (Sorensen & Stuart, 2000). We included the registered capital, which was obtained by consulting State Administration for Market Regulation (SAMR) database and the CRSSTA list. Lastly, since the initial development of China's railway industry relied on knowledge transfer between multinational enterprises (MNEs) in the international railway market and indigenous firms, we included a variable to represent international experience (Rosenkopf & Almeida, 2003). We consulted the China Science and Technology Achievement Database (CSTAD) and selected projects belonging to 'international technology transfer and absorption' category in the 'Subject C – Railway Transportation' field and identified organizations that conducted these projects. Thus, we generated a list of international projects that included information of the domestic organizations involved in the projects. Then, we counted number of international projects by an organization as a general indicator of international alliance experience. Lastly, since our sample includes both firms and other non-firm organizations such as universities and research institutions, we included a dummy variable to represent whether an organization belongs to the firm category (coded as 0) or not (coded as 1).

1.3.5 Model specification

We used the open-source platform R, particularly the lmer() function, to build the three-level multilevel models and to test our research hypotheses (West et al., 2015). Since our hypotheses which did not involve cross-level interactions, we followed prior studies and built models with no random slopes assigned to variables (Heisig & Schaeffer, 2019; West et al., 2015). Multilevel models require several assumptions to be satisfied regarding residuals, e.g., normality, homoscedasticity, and autocorrelation, to satisfy these assumptions, we log transformed the dependent variable and all control variables except the two dummy variables (Bjork et al., 2011; Fleming et al., 2007).

1.4 Results

Tables 1.1 and Table 1.2 present descriptive statistics of the variables. No overly high correlations were observed between different variables in Table 1.1. Table 1.3 reports the results for the multilevel regression.

Table 1.1 Descriptive Statistics

	Min.	Max.	Mean	s.d.
Innovation performance	0	285	5.090	5.969
Number of citations	0	22	1.750	2.364
Number of inventors	1	34	4.630	2.523
Patent betweenness centrality	0	0.114	0.000	0.001
Patent ego network density	0	1	0.807	0.241
Number of patents	1	299	12.390	25.607
Star status	0	1	0.020	0.150
Individual betweenness centrality	0	0.024	0.000	0.001
Individual ego network density	0	1	0.038	0.173
Logged registered capital	3.912	18.974	12.125	1.373
International experience	0	21	3.070	4.333
Firm	0	1	0.820	0.387
Organization betweenness centrality	0	0.415	0.014	0.045
Organization ego network density	0	1	0.609	0.384

Table 1.2 Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Innovation performance													
2	Number of citations	-.070**												
3	Number of inventors	.052**	.055**											
4	Patent betweenness centrality	.009**	-.065**	-.018**										
5	Patent ego network density	-.021**	.086**	.041**	-.133**									
6	Number of patents	-.016**	.057**	-.059**	-.021**	0.004								
7	Star status	.025**	-.009**	.124**	-0.004	.016**	.008**							
8	Individual betweenness centrality	.009**	-.009**	.041**	-0.002	.017**	-.011**	.305**						
9	Individual ego network density	.020**	.012**	.047**	0	.010**	.008**	.162**	.056**					
10	Logged registered capital	-.046**	.066**	.111**	-.025**	-.007*	.076**	-.010**	-.023**	-.034**				
11	International experience	-.012**	-.079**	-.068**	.049**	-.047**	-.037**	.181**	.154**	.220**	-.128**			
12	Firm	.066**	-.128**	-.173**	.028**	-.011**	.036**	-.110**	0	-.028**	-.571**	.082**		
13	Organization betweenness centrality	.014**	-.064**	0.005	.034**	-.017**	-.024**	.178**	.127**	.192**	-.048**	.525**	.055**	

14	Organization ego network density	-.033**	.059**	-.035**	-.041**	.007*	.056**	-.082**	-.062**	-.086**	.187**	-.231**	-.215**	-.260**

Note: *p < .05. **p < .01

Table 1.3 Results of Multilevel Modelling Analysis

Level and variable	Model 1	Model 2	Model 3	Model 4
Intercept	1.423***	1.323***	1.31***	1.413***
	(0.013)	(0.018)	(0.019)	(0.090)
Level 1				
Number of citations		-0.096***	-0.096***	-0.096***
		(0.003)	(0.003)	(0.003)
Number of inventors		0.136***	0.133***	0.133***
		(0.007)	(0.007)	(0.007)
Patent betweenness		9.316***	9.381***	9.28***
centrality		(1.681)	(1.681)	(1.681)
Patent ego network density		-0.09***	-0.091***	-0.091***
		(0.010)	(0.010)	(0.010)
Level 2				
Number of patents			0.004 (0.005)	0.004 (0.005)
Star status			0.124***	0.122***
			(0.025)	(0.025)
Individual betweenness			11.195*	10.749*
centrality			(5.213)	(5.216)
Individual ego network			0.086***	0.083***
density			(0.020)	(0.020)
Level 3				
Logged registered capital				-0.012†
				(0.007)
International experience				0.021 (0.014)
Firm				0.008 (0.027)
Organization betweenness				0.449†
centrality				(0.259)
Organization ego network				0.017 (0.032)
density				
Variance components				
σ^2int: organization	0.048	0.038	0.038	0.038
σ^2int: individual	0.142	0.142	0.141	0.141
σ^2 (residual variance)	0.541	0.535	0.535	0.535
Model information criteria				
–2 RE/ML log-likelihood	285890.386	284596.666	284551.275	284567.022
AIC	285898.386	284612.666	284575.275	284601.022
BIC	285937.158	284690.211	284691.592	284765.804

Note: †p<0.1. *p < .05. **p < .01. ***p < .001.

Model 1 was used to determine whether it is necessary to adopt the multilevel approach to analyse knowledge creation in multilevel networks. The organizational level intraclass correlation (ICC) of 0.07 and the individual level ICC of 0.19 indicated that there is significant variation in outcomes between individuals and organizations and thus it is necessary to adopt the multilevel models (Roback & Legler, 2021; Snijders & Bosker, 2012). Model 2 introduced patent-level variables. Model 3 added individual level variables. Model 4 added organizational level variables.

Hypothesis 1a proposed that betweenness centrality of an organization to which a patent belongs has a positive effect on the patent's subsequent citations. The results supported this claim since the relationship was statistically significant in Model 4. Hypothesis 1b discussed the positive role of centrality in interpersonal network on patent performance, and coefficients in Model 3 and Model 4 provided support for this hypothesis. Hypothesis 1c proposed that a patent's performance is positively related to its betweenness centrality in the knowledge network. The positive and significant coefficients of this variable in Model 2 to Model 4 suggested that this is the case.

Hypothesis 2a was not supported, which might suggest a tendency of organizations relying on brokering position rather than dense local knowledge communities in China's railway industry. Prior studies have argued that China's domestic railway industry was characterized by highly collaborative relationships between different players and timely and constant knowledge sharing, in other words, it is possible that density benefits are similar to most actors in the network (i.e., little variation in terms of redundancy of knowledge among network partners) and the alternative channel through brokerage was more effective in knowledge generation (J. He et al., 2018). Hypothesis 2b was supported since the coefficients of individual ego network density were significant and positive. Aligned with hypothesis 2c, patent ego density revealed a negative relationship with patent citation.

Among the control variables, the number of citations of a patent is negatively related to subsequent citations, which might suggest the fact of diminishing value of exploitation of knowledge elements: a trend that value of knowledge combination was exhausted because

the patent has connected with many other patents technologically, reflected by its number of citations (Wang et al., 2014). Number of inventors and being a star are both significantly related to a patent's received citations, which indicates that individual level factors indeed matter for knowledge creation since innovation is a social construction process. Interestingly, firms' financial capability was negatively related to patent performance, possibly due to the over-reliance on exploitation of knowledge, a tendency that is particularly prominent in large firms with established knowledge profiles and routines (Raisch et al., 2009; Seo et al., 2022).

1.5 Discussion and conclusion

Although previous studies have provided empirical evidence on the theoretical relationships between networks at different levels and innovation performance, most of them were conducted at a single level. Since networks at different levels are nested into each other, we argue that a multilevel approach with focus on the nesting structural features helps us to get a whole picture of the intricate innovation process that starts with knowledge sparks in individuals' mind and finalizes with new products and new services of organizations (Cohendet & Simon, 2017; Perry-Smith & Mannucci, 2017).

We chose to explore three nested networks that are particularly important in knowledge generation: the knowledge, interpersonal, and inter-organizational network. Using China's railway between 2002 and 2012 as the research setting, we were able to illustrate that networks at different levels indeed have differentiated effects on patent performance. We found evidence that brokering position at the knowledge element level, inventor level and organization level each contribute to a patent's subsequent citations. We also revealed that network density in the knowledge and interpersonal network have the opposite implication in terms of patent performance.

This study has three contributions to innovation studies in networks. First, we address the limitation of prior research that focusing on performance implication of a certain type of network and ignoring others by simultaneously taking into consideration the nested structure of knowledge network, individual network, and inter-organizational network through a multilevel lens. Therefore, this study contributes to the discussion of theoretic

isomorphism of network arguments regarding network structures at different levels (Crossan & Apaydin, 2010; Moliterno & Mahony, 2011). We argue that brokerage indeed showed similar effects across the three levels, while network density at different levels do not always boost patent performance. These differentiated effects suggest that we should not arbitrarily apply network arguments hold at a certain level to other levels and that, at least in China's railway industry, not all networks at different levels are of equal significance in fostering high-performing innovation (Paruchuri et al., 2019).

Second, the multilevel approach allows us to build a more refined theory of how network structures are related to innovation performance by distinguishing implications of brokerage and density at different levels. Specifically, prior research often relies on one of the two competing theories: network brokerage story and network closure logic (Ahuja, 2000; Burt, 2004; Coleman, 1988). In this study, instead of assuming that dense interpersonal networks lead to redundant knowledge and depletion of knowledge combination opportunities, we directly took knowledge features into consideration by separating knowledge networks from interpersonal networks. This way, we help to resolve the conflicts between brokerage and density to a certain extent. Indeed, previous studies suggest that the conflicting results of the two prominent theories might be a result of their different roles in different stages of innovation (Perry-Smith & Mannucci, 2017). Our study supports this claim and reveals that innovation, as a process that entails both combination of diverse knowledge elements and socialization between individuals, relies on network structures that can induce these activities in knowledge network and interpersonal network respectively.

Third, this study responds to the recommendations that, as long as innovation is characterized by recombination of knowledge, innovation scholars need to explicitly take knowledge characteristics into consideration when exploring how network structures contribute to innovation (Phelps et al., 2012; Quintana-Garcia & Benavides-Velasco, 2008; Wen et al., 2021). There exist multiple approaches to add knowledge features into the equation, such as accounting for knowledge actors' technological profiles, evaluating internal and external knowledge diversity, and decoupling knowledge network and collaboration network (Phelps, 2010; Tang, 2016; Wang et al., 2014). This study provides

a more direct and comprehensive approach: constructing a multilevel network that starts with knowledge network composed of knowledge elements and evaluating knowledge generation from the bottom level. This approach sheds light on the micro-macro linkages of innovation phenomena and explains the role of various structural features of knowledge elements, in this case patents, jointly with other networks in knowledge generation.

In terms of practical implications, this study provides new insight for firms that aim to gain a competitive advantage through innovation in the knowledge economy. The current research highlights that not only inter-organizational networks but also knowledge profiles and knowledge communities, reflected by knowledge networks and interpersonal networks, can contribute to knowledge creation (Cuypers et al., 2020). For an organization competing for talent in the knowledge economy, the question of how knowledge network and interpersonal network structure matter for innovation based on combining existing organizational knowledge inventory is equally important. Organizations propose various organizational learning mechanisms not only to create knowledge through interaction, collaboration, and socialization of organizational members, but also to ensure the effective transfer of knowledge across members and to retain knowledge in the organization. Otherwise, valuable knowledge might be lost along with the departure of key individuals (Argote & Ingram, 2000; Argote & Miron-Spektor, 2011; Nonaka, 1994). For firms, network strategies should also explore their own knowledge inventory and internal knowledge networks to identify where innovation opportunities are located. Patents occupy different positions in knowledge networks and the effective utilization of knowledge bundled in patents also relies on patents' position and knowledge features.

However, contributions of this study should be viewed in light of its limitations. First, results of the empirical study should be viewed as tentative since we were not able to detect strict causal effects. Nevertheless, we put our effort to reduce the potential reverse causality problem by lagging dependent variable one year after the explanatory variables such as network features. Second, several other network features that are relevant in knowledge creation and innovation were not included in this discussion, such as structural holes, community structures, and other types of centralities (Burt, 2004; Phelps, 2010). We only included the same network structural feature across different levels in order to

get a preliminary comparison between knowledge network, individual network, and inter-organizational network. Future studies can conduct more refined research by incorporating more network structures to get a comprehensive view of how multilevel network structures influence innovation.

To conclude, the multilevel character of networks is an important yet underexplored topic in innovation studies. For organizations focusing on innovation, it is critical to distinguish effects of networks at different levels and leverage their strengths embedded in different types of networks for effective knowledge creation. By adopting a multilevel approach, this study contributes to this discussion by illustrating that brokering position consistently contributes to the performance of patents and that network density at different levels of networks reveals differentiated effects. Therefore, this study provides new insights regarding the role of different types of networks that nesting into each other in innovation.

References

Acedo, F. J., Barroso, C., Casanueva, C., & Galan, J. L. (2006). Co-authorship in management and organizational studies: An empirical and network analysis. *Journal of Management Studies*, *43*(5), 957-983. https://doi.org/10.1111/j.1467-6486.2006.00625.x

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, *45*(3), 425-455. https://doi.org/10.2307/2667105

Ahuja, G., Lampert, C. M., & Tandon, V. (2008). Moving Beyond Schumpeter: Management Research on the Determinants of Technological Innovation. *Academy of Management Annals*, *2*(1), 1-98. https://doi.org/10.5465/19416520802211446

Almeida, P., & Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, *45*(7), 905-917. https://doi.org/10.1287/mnsc.45.7.905

Argote, L., & Ingram, P. (2000). Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes*, *82*(1), 150-169. https://doi.org/10.1006/obhd.2000.2893

Argote, L., & Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science*, *22*(5), 1123-1137. https://doi.org/10.1287/orsc.1100.0621

Azoulay, P., Zivin, J. S. G., & Wang, J. L. (2010). Superstar Extinction. *Quarterly Journal of Economics*, *125*(2), 549-589. https://doi.org/10.1162/qjec.2010.125.2.549

Balachandran, S., & Hernandez, E. (2018). Networks and Innovation: Accounting for Structural and Institutional Sources of Recombination in Brokerage Triads. *Organization Science*, *29*(1), 80-99. https://doi.org/10.1287/orsc.2017.1165

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, *28*(1), 31-56. https://doi.org/10.1191/0309132504ph469oa

Beaudry, C., & Allaoui, S. (2012). Impact of public and private research funding on scientific production: The case of nanotechnology. *Research Policy*, *41*(9), 1589-1606. https://doi.org/10.1016/j.respol.2012.03.022

Beckman, C. M., Haunschild, P. R., & Phillips, D. J. (2004). Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. *Organization Science*, *15*(3), 259-275. https://doi.org/10.1287/orsc.1040.0065

Bergenholtz, C., & Waldstrøm, C. (2011). Inter-Organizational Network Studies—A Literature Review. *Industry and Innovation*, *18*(6), 539-562. https://doi.org/10.1080/13662716.2011.591966

Bizzi, L. (2013). The Dark Side of Structural Holes: A Multilevel Investigation. *Journal of Management*, *39*(6), 1554-1578. https://doi.org/10.1177/0149206312471385

Bjork, J., Di Vincenzo, F., Magnusson, M., & Mascia, D. (2011). The Impact of Social Capital on Ideation. *Industry and Innovation*, *18*(6), 631-647. https://doi.org/10.1080/13662716.2011.591976

Borgatti, S. P. (2005). Centrality and network flow. *Social Networks*, *27*(1), 55-71. https://doi.org/10.1016/j.socnet.2004.11.008

Brandes, U., Borgatti, S. P., & Freeman, L. C. (2016). Maintaining the duality of closeness and betweenness centrality. *Social Networks*, *44*, 153-159. https://doi.org/10.1016/j.socnet.2015.08.003

Brass, D. J. (2022). New Developments in Social Network Analysis. *Annual Review of Organizational Psychology and Organizational Behavior*, *9*(1), 225-246. https://doi.org/10.1146/annurev-orgpsych-012420-090628

Brennecke, J., & Rank, O. (2017). The firm's knowledge network and the transfer of advice among corporate inventors-A multilevel network study. *Research Policy*, *46*(4), 768-783. https://doi.org/10.1016/j.respol.2017.02.002

Brennecke, J., & Stoemmer, N. (2018). The Network-Performance Relationship in Knowledge-Intensive ContextsA Meta-Analysis and Cross-Level Comparison. *Human Resource Management*, *57*(1), 11-36. https://doi.org/10.1002/hrm.21823

Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*. Harvard University Press.

Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, *110*(2), 349-399. https://doi.org/10.1086/421787

Carnabuci, G., & Operti, E. (2013). Where Do Firms' Recombinant Capabilities Come From? Intraorganizational Networks, Knowledge, and Firms' Ability to Innovate

Through Technological Recombination. *Strategic Management Journal*, *34*(13), 1591-1613. https://doi.org/10.1002/smj.2084

China Railway Society. (1999). Societies. In China Railway Society (Ed.), *China Railway Yeabook*. China Railway Publishing House.

Cohendet, P., Parmentier, G., & Simon, L. (2017). Managing knowledge, creativity and innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 197-214). https://doi.org/10.4337/9781782548522

Cohendet, P., & Simon, L. (2017). Concepts and models of innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 33-55). https://doi.org/10.4337/9781782548522

Coleman, J. S. (1988). Social Capital in the Creation of Human-Capital. *American Journal of Sociology*, *94*, S95-S120. https://doi.org/10.1086/228943

Crossan, M. M., & Apaydin, M. (2010). A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. *Journal of Management Studies*, *47*(6), 1154-1191. https://doi.org/10.1111/j.1467-6486.2009.00880.x

Cuypers, I. R. P., Ertug, G., Cantwell, J., Zaheer, A., & Kilduff, M. (2020). Making connections: Social networks in international business. *Journal of International Business Studies*, *51*(5), 714-736. https://doi.org/10.1057/s41267-020-00319-9

Fleming, L., Mingo, S., & Chen, D. (2007). Collaborative brokerage, generative creativity, and creative success. *Administrative Science Quarterly*, *52*(3), 443-475. https://doi.org/10.2189/asqu.52.3.443

Genin, A. L., Tan, J., & Song, J. (2021). State governance and technological innovation in emerging economies: State-owned enterprise restructuration and institutional logic dissonance in China's high-speed train sector. *Journal of International Business Studies*, *52*(4), 621-645. https://doi.org/10.1057/s41267-020-00342-w

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy*, *37*(10), 1717-1731. https://doi.org/10.1016/j.respol.2008.08.010

Gonzalez-Brambila, C. N., Veloso, F. M., & Krackhardt, D. (2013). The impact of network embeddedness on research output. *Research Policy*, *42*(9), 1555-1567. https://doi.org/10.1016/j.respol.2013.07.008

Grigoriou, K., & Rothaermel, F. T. (2014). Structural Microfoundations of Innovation: The Role of Relational Stars. *Journal of Management*, *40*(2), 586-615. https://doi.org/10.1177/0149206313513612

Grigoriou, K., & Rothaermel, F. T. (2017). Organizing for Knowledge Generation: Internal Knowledge Networks and the Contingent Effect of External Knowledge Sourcing. *Strategic Management Journal*, *38*(2), 395-414. https://doi.org/10.1002/smj.2489

Guan, J. C., & Liu, N. (2016). Exploitative and exploratory innovations in knowledge network and collaboration network: A patent analysis in the technological field of nano-energy. *Research Policy*, *45*(1), 97-112. https://doi.org/10.1016/j.respol.2015.08.002

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203-215. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<203::Aid-smj102>3.0.Co;2-k

Halevy, N., Halali, E., & Zlatev, J. J. (2019). Brokerage and Brokering: An Integrative Review and Organizing Framework for Third Party Influence. *Academy of Management Annals*, *13*(1), 215-239. https://doi.org/10.5465/annals.2017.0024

He, J., Lyu, T., Huang, Y., & Jiang, H. (2018). Motivation structure and capacity building of technological catch-up: Experience and policy implication of China's High-Speed Rail. *Journal of Management World*, *34*(10), 191-207. https://doi.org/10.19744/j.cnki.11-1235/f.2018.10.016

Heisig, J. P., & Schaeffer, M. (2019). Why You Should Always Include a Random Slope for the Lower-Level Variable Involved in a Cross-Level Interaction. *European Sociological Review*, *35*(2), 258-279. https://doi.org/10.1093/esr/jcy053

Hemphala, J., & Magnusson, M. (2012). Networks for Innovation - But What Networks and What Innovation? *Creativity and Innovation Management*, *21*(1), 3-16. https://doi.org/10.1111/j.1467-8691.2012.00625.x

Huggins, R., & Thompson, P. (2016). Entrepreneurial networks and open innovation: the role of strategic and embedded ties. *Industry and Innovation*, *24*(4), 403-435. https://doi.org/10.1080/13662716.2016.1255598

Ibarra, H. (1993). Network Centrality, Power, and Innovation Involvement - Determinants of Technical and Administrative Roles. *Academy of Management Journal*, *36*(3), 471-501. https://doi.org/10.2307/256589

Jackson, M. O. (2008). *Social and Economic Networks*. https://doi.org/10.1515/9781400833993

Kadushin, C. (2012). *Understanding social networks : theories, concepts, and findings*. Oxford University Press.

Katila, R., & Ahuja, G. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, *45*(6), 1183-1194. https://doi.org/10.2307/3069433

Khanna, R. (2021). Aftermath of a tragedy: A star's death and coauthors' subsequent productivity. *Research Policy*, *50*(2), Article 104159. https://doi.org/10.1016/j.respol.2020.104159

Kogut, B. (2000). The network as knowledge: Generative rules and the emergence of structure. *Strategic Management Journal*, *21*(3), 405-425. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<405::Aid-smj103>3.0.Co;2-5

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, *3*(3), 383-397. https://doi.org/10.1287/orsc.3.3.383

Kwon, S. W., Rondi, E., Levin, D. Z., De Massis, A., & Brass, D. J. (2020). Network Brokerage: An Integrative Review and Future Research Agenda. *Journal of Management*, *46*(6), 1092-1120, Article 0149206320914694. https://doi.org/10.1177/0149206320914694

Lavie, D. (2007). Alliance portfolios and firm performance: A study of value creation and appropriation in the US software industry. *Strategic Management Journal*, *28*(12), 1187-1212. https://doi.org/10.1002/smj.637

Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, *49*(4), 797-818. https://doi.org/10.5465/amj.2006.22083085

Lyu, T., & Jiang, H. (2017). From Reverse Engineering to Forward Engineering—The Implications of High-Speed Railway Equipment Industry on Technological

Catch-up and Independent Innovation in the Chinese Equipment Manufacturing Industry. *Business and Management Journal*, *39*(10). https://doi.org/10.19616/j.cnki.bmj.2017.10.001

Maoret, M., Tortoriello, M., & Iubatti, D. (2020). Big Fish, Big Pond? The Joint Effect of Formal and Informal Core/Periphery Positions on the Generation of Incremental Innovations. *Organization Science*, *31*(6), 1538-1559. https://doi.org/10.1287/orsc.2020.1365

March, J. G. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science*, *2*(1), 71-87. https://doi.org/10.1287/orsc.2.1.71

McFadyen, M. A., Semadeni, M., & Cannella, A. A. (2009). Value of Strong Ties to Disconnected Others: Examining Knowledge Creation in Biomedicine. *Organization Science*, *20*(3), 552-564. https://doi.org/10.1287/orsc.1080.0388

Moliterno, T. P., & Mahony, D. M. (2011). Network Theory of Organization: A Multilevel Approach. *Journal of Management*, *37*(2), 443-467. https://doi.org/10.1177/0149206310371692

Nohria, N., & Garcia-Pont, C. (1991). Global Strategic Linkages and Industry Structure. *Strategic Management Journal*, *12*, 105-124. https://doi.org/10.1002/smj.4250120909

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, *5*(1), 14-37. https://doi.org/10.1287/orsc.5.1.14

Obstfeld, D. (2005). Social networks, the Tertius lungens and orientation involvement in innovation. *Administrative Science Quarterly*, *50*(1), 100-130. https://doi.org/10.2189/asqu.2005.50.1.100

Paruchuri, S., Goossen, M. C., & Phelps, C. (2019). Conceptual foundations of multilevel social networks. In S. E. L. Humphrey, James M. (Ed.), *The handbook of multilevel*

theory, measurement, and analysis (First Edition. ed.). American Psychological Association,.

Perry-Smith, J., & Mannucci, P. V. (2015). Social Networks, Creativity, and Entrepreneurship. In C. Shalley, M. A. Hitt, J. Zhou, J. Perry-Smith, & P. V. Mannucci (Eds.), *The Oxford Handbook of Creativity, Innovation, and Entrepreneurship*. https://doi.org/10.1093/oxfordhb/9780199927678.013.0016

Perry-Smith, J. E. (2006). Social yet creative: The role of social relationships in facilitating individual creativity. *Academy of Management Journal*, *49*(1), 85-101. <Go to ISI>://WOS:000236642400008

Perry-Smith, J. E., & Mannucci, P. V. (2017). From Creativity to Innovation: The Social Network Drivers of the Four Phases of the Idea Journey. *Academy of Management Review*, *42*(1), 53-79. https://doi.org/10.5465/amr.2014.0462

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890-913. https://doi.org/10.5465/amj.2010.52814627

Powell, W. W., Koput, K. W., & SmithDoerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, *41*(1), 116-145. https://doi.org/10.2307/2393988

Quintana-Garcia, C., & Benavides-Velasco, C. A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, *37*(3), 492-507. https://doi.org/10.1016/j.respol.2007.12.002

Raisch, S., Birkinshaw, J., Probst, G., & Tushman, M. L. (2009). Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance. *Organization Science*, *20*(4), 685-695. https://doi.org/10.1287/orsc.1090.0428

Roback, P., & Legler, J. (2021). *Beyond multiple linear regression: applied generalized linear models and multilevel models in R* (1. ed.). CRC Press.

Rosenkopf, L., & Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, *49*(6), 751-766. https://doi.org/10.1287/mnsc.49.6.751.16026

Rothaermel, F. T., & Hess, A. M. (2007). Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science*, *18*(6), 898-921. https://doi.org/10.1287/orsc.1070.0291

Sammarra, A., & Biggiero, L. (2008). Heterogeneity and specificity of inter-firm knowledge flows in innovation networks. *Journal of Management Studies*, *45*(4), 200-829. <Go to ISI>://WOS:000255529000006

Sasidharan, S., Santhanam, R., Brass, D. J., & Sambamurthy, V. (2012). The Effects of Social Network Structure on Enterprise Systems Success: A Longitudinal Multilevel Analysis. *Information Systems Research*, *23*(3), 658-678. https://doi.org/10.1287/isre.1110.0388

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126. https://doi.org/10.1287/mnsc.1060.0624

Scott, J. (1991). *Social network analysis: A handbook*. Sage Publications, Inc.

Seo, E., Song, J., & Jin, C. (2022). Heterogeneity of optimal balance between exploration and exploitation:the moderating roles of firm technological capability and industry alliance network position. *Industry and Innovation*, 1-29. https://doi.org/10.1080/13662716.2022.2036598

Singh, J. (2005). Collaborative networks as determinants of knowledge diffusion patterns. *Management Science*, *51*(5), 756-770. https://doi.org/10.1287/mnsc.1040.0349

Snijders, T. A. B., & Bosker, R. J. (2012). *Multilevel analysis : an introduction to basic and advanced multilevel modeling* (2nd ed.). Sage.

Sorensen, J. B., & Stuart, T. E. (2000). Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, *45*(1), 81-112. https://doi.org/10.2307/2666980

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management*

Journal, *21*(8), 791-811. https://doi.org/10.1002/1097-0266(200008)21:8<791::Aid-smj121>3.0.Co;2-k

Tang, C. Y. (2016). Accessed external knowledge, centrality of intra-team knowledge networks, and R&D employee creativity. *R & D Management*, *46*, 992-1005. https://doi.org/10.1111/radm.12160

Tortoriello, M., McEvily, B., & Krackhardt, D. (2015). Being a Catalyst of Innovation: The Role of Knowledge Diversity and Network Closure. *Organization Science*, *26*(2), 423-438. https://doi.org/10.1287/orsc.2014.0942

Tsai, W. P. (2001). Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, *44*(5), 996-1004. https://doi.org/10.2307/3069443

Turkina, E., & Van Assche, A. (2019). An Anatomy of Bengaluru's ICT Cluster: A Community Detection Approach. *Management and Organization Review*, *15*(3), 533-561. https://doi.org/10.1017/mor.2019.34

Venkataramani, V., Richter, A. W., & Clarke, R. (2014). Creative Benefits From Well-Connected Leaders: Leader Social Network Ties as Facilitators of Employee Radical Creativity. *Journal of Applied Psychology*, *99*(5), 966-975. https://doi.org/10.1037/a0037088

Wang, C. L., Rodan, S., Fruin, M., & Xu, X. Y. (2014). Knowledge Networks, Collaboration Networks, and Exploratory Innovation. *Academy of Management Journal*, *57*(2), 484-514. https://doi.org/10.5465/amj.2011.0917

Wang, X., van der Bij, H., & Dolfsma, W. (2020). Knowledge sharing in inter-organisational teams: the role of the advice network and the substitutive role of the formal network in an R&D alliance. *Industry and Innovation*, *27*(10), 1160-1185. https://doi.org/10.1080/13662716.2020.1754171

Wen, J. Y., Qualls, W. J., & Zeng, D. M. (2021). To explore or exploit: The influence of inter-firm R&D network diversity and structural holes on innovation outcomes. *Technovation*, *100*, Article 102178. https://doi.org/10.1016/j.technovation.2020.102178

West, B. T., Welch, K. B., & Gałecki, A. T. (2015). *Linear mixed models : a practical guide using statistical software* (2nd ed.). CRC Press, Taylor & Francis Group.

Wong, S. S., & Boh, W. F. (2014). The Contingent Effects of Social Network Sparseness and Centrality on Managerial Innovativeness. *Journal of Management Studies*, *51*(7), 1180-1203. https://doi.org/10.1111/joms.12086

Yayavaram, S., & Ahuja, G. (2008). Decomposability in knowledge structures and its impact on the usefulness of inventions and knowledge-base malleability. *Administrative Science Quarterly*, *53*(2), 333-362. https://doi.org/10.2189/asqu.53.2.333

Zaheer, A., & Bell, G. G. (2005). Benefiting from network position: Firm capabilities, structural holes, and performance. *Strategic Management Journal*, *26*(9), 809-825. https://doi.org/10.1002/smj.482

Zang, J. J. (2018). Structural holes, exploratory innovation and exploitative innovation. *Management Decision*, *56*(8), 1682-1695. https://doi.org/10.1108/md-05-2017-0485

Zappa, P., & Lomi, A. (2015). The Analysis of Multilevel Networks in Organizations: Models and Empirical Tests. *Organizational Research Methods*, *18*(3), 542-569. https://doi.org/10.1177/1094428115579225

Chapter 2
The nexus between the cultural and creative industries and the Sustainable Development Goals: A network perspective

Abstract

Scholars and policymakers have widely claimed that the cultural and creative industries (CCIs) provide positive knowledge externalities that can help address sustainable development challenges, yet questions remain about the pathways through this occurs. In this study, we hypothesize that several features of knowledge networks in CCIs relate to a location's sustainable development outcomes. We use data of ownership networks between 22,455 cultural heritage related firms across 292 cities in China to empirically test our hypotheses. We find that cities with large scale CCIs perform better in several of the Sustainable Development Goals since culture related economic activities promote employment, foster innovation, and help build sustainable communities. The local interorganizational networks related to cultural heritage contribute to the progress of the local-level Cultural Sustainable Development Goals by fostering knowledge creation and sharing within creative communities. We further explore the trans-local network ties that utilizing cultural heritage and find that trans-local network ties complement the local ones.

2.1 Introduction

At the 74th United Nations (UN) General Assembly, the year 2021 was declared the International Year of Creative Economy for Sustainable Development, an initiative that calls attention to the role of cultural and creative industries (CCIs) in achieving the Sustainable Development Goals (SDGs) (UN, 2019, p. para. 1). This announcement emphasized the critical link that the UN perceives to exist between CCIs and inclusive social development, notably through knowledge creation and dissemination. Thangavel Palanivel, Deputy Director of the Human Development Report Office, captured this sentiment in a recent quote: "[c]ultural and creative industries, which include arts and crafts, advertising, design, entertainment, architecture, books, media and software, have become a vital force in accelerating human development. They empower people to take

ownership of their own development and stimulate the innovation that can drive inclusive sustainable growth (Palanivel, 2019, p. para. 1)."

Extant scholarship has primarily pointed to the positive knowledge externalities that CCIs generate which help address sustainability challenges. Several authors have argued that CCIs are among the most creative and innovative economic activities that foster innovative solutions for sustainable challenges in today's knowledge economy (Burford et al., 2013; Hawkes, 2001; UNESCO, 2013). They help build knowledge creation engines for creative communities and cities and contribute to a sustainable development trajectory that relies on individual creativity and cultural heritage rather than natural resources (Bathelt & Cohendet, 2014; Foster, 2020; Nocca, 2017). Other scholars have pointed out that the CCIs facilitate other dimensions of sustainability by providing employment opportunities and knowledge spillovers to industries such as tourism, retail, and transportation, especially for marginalized groups and regions with limited opportunities (Li et al., 2021; Pagan et al., 2020). A third set of researchers have suggested that CCIs shape intergenerational relationships, ways of living together, and human-nature interaction (Snowball 2013; UNESCO 2001; Auclair and Fairclough 2015), which build cohesive communities through the generation of localized knowledge (Cattaneo et al., 2020).

Our main claim in this paper is that a further examination of the structure of knowledge networks in CCIs is necessary to deepen our understanding of the nexus between CCIs and sustainability. While there is strong evidence that inter-firm networks act as a fundamental channel for the transmission of tacit knowledge both within and across industries (Giuliani, 2013; Owen-Smith & Powell, 2004), their role has been largely ignored in the discussion of the link between CCIs and the SDGs, which seriously hinders our understanding of the nexus since the key process of cultural production, symbolic knowledge exchange are organized in networks (Chen et al., 2015; Wittel, 2001). Without analysis of the knowledge networks within the CCIs, our understanding of the way in which the CCIs contribute to sustainability is likely to be limited. We believe this to be particularly relevant for SDGs that are closely related to culture and innovation such as SDG 9, which emphasizes industry, innovation, and infrastructure, and SDG 11, which

focuses on sustainable cities and communities (Bathelt & Cohendet, 2014; Cattaneo et al., 2020).

Second, we lack a systematic analysis that considers whether CCIs contribute to different aspects of the sustainability simultaneously. For instance, the economic development logic through tourism is still dominant in strategies of utilizing culture resources (Giliberto & Labadi, 2022; Loulanski & Loulanski, 2011; Su & Lin, 2014). We know less about the potential synergies between economic development, empowerment of marginalized groups, and knowledge accumulation and creativity generation of local communities. To get a comprehensive understanding of the nexus between CCIs and the SDGs, we need to explore CCIs' contribution in multiple and interrelated SDGs.

Third, there is little mention of the knowledge dynamics in the CCIs, which require both local symbolic knowledge sharing and trans-local knowledge transfer and exchange in the CCI – sustainability research (Asheim et al., 2011; Bathelt & Cohendet, 2014; Martin & Moodysson, 2011). As highly knowledge intensive sectors, the CCIs are never developed in isolation but rather dependent on both extensive localized knowledge sharing and trans-local knowledge and resource access and creative talent mobility (Maskell, 2014). Taking into consideration both local and trans-local knowledge dynamics help us to get a clear understanding of the important knowledge creation and innovation mechanisms through which sustainable development becomes feasible.

This study addresses these limitations by using a knowledge network approach to conduct a systematic evaluation of the CCI-SDG nexus. Since the agreement on the SDGs by UN member states in 2015, there has been a consensus that progress in sustainability depends on the systematic integration and implementation of the 17 goals, which represent many critical and interrelated challenges in sustainable development (Griggs et al., 2013; Stafford-Smith et al., 2017). For this purpose, we focus on a special type of CCI network, which is knowledge networks related to cultural heritage in cities, and analyze its role in achieving different SDGs.

Cultural heritage refers to monuments, groups of buildings, archaeological sites that bear universal value from historical, artistic, scientific, aesthetic, ethnological, or

anthropological perspectives (UNESCO, 1972). Cultural heritage fosters local creativity and innovation in urban communities that are essential resources for every type of activity in CCIs (Cerisola, 2019). Cultural heritage attracts creative talents who then form knowledge communities and hubs where the exchange of knowledge and ideas becomes possible (Pratt, 2008; Pratt, 2013). To maximize the potential of cultural heritage for development, public and private sectors need to collectively raise awareness of the contribution of cultural heritage, to invest in the preservation of heritage sites, and to collaborate in networks to manage and operate cultural resources (Nocca, 2017; UN, 2017).

Inter-organizational relationships between organizations investing in cultural heritage and operating cultural heritage sites provide information about both public and private efforts to preserve and utilize cultural heritage. They also reveal information about the behavior of CCI actors and about the structural features of these industries.

We aim to answer three research questions: (1) How is the scale of a city's CCIs associated with the city's progress towards achieving the SDGs? (2) What are the implications of the cultural-heritage-related CCI network structure on the city's progress towards achieving the SDGs? (3) Do trans-local partnerships complement the local network in achieving the SDGs?

We empirically validate these questions using a unique manually collected dataset of networks involving 22,455 organizations related to1,355 cultural heritage sites in 292 cities across China, a country with rich cultural heritage resources. We find that cities with a denser cultural heritage related CCI network tend to make more progress towards achieving local SDGs. We also show that the scale of local CCIs contributes to a city's SDG score. Finally, cities with a higher degree of trans-local linkages demonstrate a stronger SDG performance.

Our study makes several contributions to the literature on the CCI-SDG nexus. First, this study explicitly incorporates the role of network characteristics in CCIs in the discussion of the SDGs. As emphasized by SDG 17, sustainable development requires collective action by multiple parties and cannot be realized by individual entities working in silos

without any collaboration between them (Nilsson et al., 2016; UN, 2022). This study illustrates how local actors carry out practical initiatives collectively to achieve the different goals (Petti et al., 2020; Salvia et al., 2019). Second, by focusing on knowledge networks in the CCIs across different cities in China, we contribute to the discussion of the localization of the SDGs, especially for the cities in the emerging markets (UNDP & CASS, 2020; Xu et al., 2020). Cities with different resources and capabilities often face unique sustainability challenges and develop diverse strategies and solutions, and this study shows how heterogeneous structure of cities' CCI networks contribute to local SDGs.

The study is organized as follows. Section 2 reviews the literature on the nexus between the CCIs and sustainability. The section ends with the three main hypotheses of the study. Section 3 explains the methodology of the empirical study. Section 4 presents the results of the empirical analysis. Section 5 discusses the theoretical contributions and the limitations of the study. The concluding section presents some final reflections on the theoretical and practical implications of the study.

2.2 Theory development

2.2.1 The role of cultural and creative industries

CCIs are "industries whose principal purpose is the production or reproduction, promotion, distribution, or commercialization of goods, services, and activities of a cultural, artistic, or heritage value" (UNESCO & World Bank, 2021, p. 8). Extant scholarship identifies multiple channels through which CCIs can contribute to local sustainable development (Dessein et al., 2015; Throsby, 2001; Throsby, 2017). Following prior research, we categorize into three types: direct effects, indirect facilitating role, and overarching transformative principle (Dessein et al., 2015; Soini & Dessein, 2016).

First, CCIs can directly contribute to a dynamic, robust, and sustainable society because of its close relationship with innovation and creativity, which are critical for sustainable development (Burford et al., 2013; Nocca, 2017; UNESCO, 2013). Culture is equally important as the other dimensions since everything else of a society is built upon the basis of culture, which encompasses lifestyles, ways of living together, value systems,

traditions and beliefs (Hawkes, 2001; UNESCO, 2001). Scholars thus maintain that culture should be viewed as the fourth pillar of sustainability besides economic, social, environmental dimensions (Hawkes, 2001; Soini & Birkeland, 2014).

Directly related to culture, CCIs are essentially highly knowledge intensive and creativity dependent sectors that generate new knowledge to produce innovative solutions for several grand challenges such as societal resilience, digitalization, and inequality (Ferraro et al., 2015; George et al., 2016; Štreimikienė & Kačerauskas, 2020).

CCIs facilitate dynamic knowledge processes which depend on knowledge flows (Asheim et al., 2011; Bathelt & Cohendet, 2014). As economic activities become more complex and collaborative networks extend beyond individual enterprises, the boundaries between different sectors become less clear. For instance, in CCIs, the upstream activities such as heritage management, the performing arts, and the visual arts, become intertwined with downstream areas such as design and media production through digital technologies (Handke & Towse, 2013). When knowledge from different domains is exchanged more frequently, this sparks artistic, scientific, and economic creativity and leads to innovation (Cohendet & Simon, 2017; UNCTAD & UNDP, 2008).

Second, culture can act as a facilitator for other pillars of sustainability (Luckman, 2015; Snowball, 2013; Throsby, 2001). As pointed out by Hosagrahar (2017, p. para. 1), "Placing culture at the heart of development policies is the only way to ensure a human-centred, inclusive and equitable development". The CCIs employ a large number of young talents, generate 3% of global GDP with a very fast growth rate, and contribute to the formation of creative cities (Cerisola, 2019; UN, 2019). Moreover, CCIs also create employment opportunities for marginalized communities and groups in various less creative categories such as tourism, retail, and transportation (Li et al., 2021; Pagan et al., 2020). It is estimated that one creative job in the CCIs generates 1.7 non-creative jobs (UNESCO & World Bank, 2021).

The CCIs are also an important driver of inclusivity and social equity since many of the economic activities within these industries rely on the regeneration of crafts, traditional arts, and other cultural assets of marginalized groups and communities in cities. Thus it

provides employment opportunities for local residents who have difficulty finding work elsewhere (Luckman, 2015).

Third, scholars have frequently insisted on the fundamental role of culture in shaping intergenerational relationships, lifestyles, ways of living together, value systems, traditions and beliefs, human-nature interaction, and many other critical components of our social systems (Auclair & Fairclough, 2015; Snowball, 2013; UNESCO, 2001). The concept of sustainable development explicitly addresses the balance between the needs of present societies and future generations (WCED, 1987). Thus, culture, as the overarching worldview of how people live with each other and interact with the materialized world, can be viewed as the specific presentation of sustainable development trajectory. Therefore, the analysis of culture and culture related activities helps to understand the nature, the principles, and the processes of sustainable development of different communities.

Compared to other economic sectors, CCIs rely more on individual creativity and established heritage resources and less on the exploitation of natural resources. CCIs that rely on local talents, community members, and cultural traditions also play a key role in achieving harmony between development and the local ecological environment since residents have lived in the area for generations and have the wisdom and the skills necessary to use natural and cultural resources in a sustainable way (Liu & Zhu, 2021; Yung et al., 2014).

The lifestyle shaping role of the CCIs is also reflected in numerous policies that encourage CCIs to utilize cultural resources and to transform cultural heritage sites into creative hubs, open spaces for creative activities, knowledge intermediaries, and business support networks (Pratt et al., 2019). Thus they indirectly contribute to the formation of responsible and sustainable production and consumption behaviors (Fazlagic & Skikiewicz, 2019).

Hypothesis 1: *The scale of local CCIs is positively related to a city's performance in sustainable development.*

2.2.2 The role of cultural heritage ownership networks

Networks are an important mechanism for the transmission of tacit knowledge within the CCIs (Wittel, 2001). A network is conceptualized as a set of nodes with ties between them (Brass et al., 2004). As key resources of CCI production, creativity and innovation are argued to be a result of a combination of the diverse forms of knowledge possessed by network partners (Fleming et al., 2007; Zhao & Zhou, 2018).

CCIs are inseparable from the cultural heritage of communities, cities, and nations since cultural heritage is "the origin of all forms of arts and the soul of cultural and creative industries" (UNCTAD & UNDP, 2008, p. 14). Indeed, conserving cultural heritage is fundamentally important to CCIs because cultural production and creative services constantly draw resources and inspiration from it. In our study, we acknowledge the importance of cultural heritage in developing CCIs and propose that networks related to cultural heritage represent an important knowledge creation mechanism.

In cultural heritage networks, nodes are organizations that directly operate or manage cultural heritage sites as well as shareholders of these organizations and subsidiaries of them. The ties considered are equity ownership relationships between these organizations. Equity ownership relationship is one of the strongest and most stable interorganizational network ties compared to collaborative ties such as R&D co-development and it signals "commitment and long-term coordination" (Mani & Moody, 2014, p. 1637; Nohria & Garcia-Pont, 1991). Therefore, they are more likely to facilitate interorganizational symbolic knowledge sharing that is necessary for innovation and creative activities in CCIs. For the purpose of the study, we refer to this network as "culture heritage ownership network".

Networks have been observed to play important roles in many sub-sectors in the CCIs. Uzzi and Spiro (2005) argue that networks formulated by musical artists in Broadway production groups foster creativity and generate higher economic returns. Martin and Moodysson (2011) observe that the media industry in Sweden is characterized by localized interorganizational networks that promote the exchange of context-specific symbolic knowledge. Lee (2015) also notes that networks between entrepreneurs promote

trust and thus contribute to interpersonal knowledge transfer in advertising, design, and E-commerce industries in South Korea. To summarize, a dense interorganizational network between CCI firms means timely knowledge sharing and effective interorganizational learning (Ahuja, 2000; Coleman, 1988; Schilling & Phelps, 2007).

In line with these studies, we analyze one of the most important structural features of a network, that is, the density of a city's cultural heritage ownership network (Provan et al., 2007). Dense cultural heritage ownership networks can contribute to the cultural SDGs through three mechanisms: directly fostering knowledge sharing and innovation, indirectly empowering communities and offering more income sources, and facilitating sustainable production and consumption of firms and citizens.

Dense ownership networks related to cultural heritage means that there exist multiple pathways of communication, of knowledge sharing, and of resource access between business actors who utilize the local cultural resources. The denser a city's network related to cultural heritage is, the more creative inspiration actors will be able to gain since cultural heritage is "the origin of all forms of arts and the soul of cultural and creative industries" (UNCTAD & UNDP, 2008, p. 14). By forming multiple and cohesive interorganizational collaboration relationships, these actors become familiar with each other, learn from each other more effectively, and develop absorptive capacity that is critical for innovation (Gilsing et al., 2008; Gulati et al., 2000).

Dense ownership networks also indirectly empower marginalized groups and help build cohesive local communities by providing multiple employment opportunities and fostering trust among citizens. Network theory points out that dense networks induce trust and promote cohesion within social systems by connecting individuals more closely and reducing costs of collaboration (Coleman, 1988; Phelps, 2010).

Cattaneo et al. (2020) observe that for the regeneration of shared-living heritage in cultural contexts such as the one in Tulou in China and the one in Cascina in Italy to be successful, it is necessary to have cohesive community networks composed of local actors. Li et al. (2021) discuss a case that the local sustainable development of small villages with bulrush farms relies on investments in several interrelated activities such as arts and crafts,

agriculture, and tourism. Through interaction between groups, social cohesion becomes possible, and the wellbeing of local residents improves.

Denser ownership networks of cultural heritage also help to preserve and revitalize traditional arts and crafts that are often associated with local cultural landscapes. Investing in cultural heritage represents a circular economy practice in local development since one keyword of investment in cultural heritage is preservation, which requires regeneration and reuse of cultural resources (Foster, 2020; Foster et al., 2020).

Hypothesis 2: *The density of the cultural heritage ownership network of a city is positively related to its sustainable development performance.*

2.2.3 The role of trans-local ties

Although symbolic knowledge sharing in cultural and creative communities is largely embedded in local networks, trans-local relationships strengthen the benefits of local networks in achieving the cultural SDGs.

Although knowledge actors are embedded in local contexts, they rely on trans-local ties to access valuable resources in distant knowledge pools (Bathelt & Cohendet, 2014). This trans-local knowledge circulation helps identify what knowledge is needed for creativity and innovation where to locate relevant complementary knowledge sources (Maskell, 2014). For instance, one of the most important knowledge channels for European gaming industries is to maintain connections to other parts of the world to acquire specialized knowledge needed in game development (Chaminade et al., 2021).

Moreover, for CCIs, absence of ties to other regions means disconnection with mainstream industries and insufficient market for cultural products and services. Researchers have identified that many localized CCIs indeed have ties that extend beyond local city boundaries. Music industry players in North West England rely on connections to large metropolitans to validate the symbolic knowledge created in the region, to diffuse cultural products, and to access international markets (Watson, 2020). Similar trans-local ties have been observed in the film industries of Canada and Germany where local producers maintain connections with Hollywood (Coe, 2000; Mossig, 2008).

Hypothesis 3a: *The number of trans-local ties of a city is positively related to its sustainable development performance.*

Moreover, trans-local investment ties help build more inclusive local networks and more balanced systems of cultural production through the flexible and timely circulation of capital generated in other regions. Inter-regional ownership ties open wider market for local cultural production and help upgrade cultural resources for the city by attracting and employing more creative talents, and this in turn enhance the role of local networks (Sasaki, 2010). Trans-local investment ties also provide valuable opportunities for trans-local labor supply and mobility that are critical to address local creative talent employment precarity problems, which often impede the formation of dense social networks in CCIs (Cerisola & Panzera, 2021; Farr-Wharton et al., 2015).

Hypothesis 3b: *Trans-local ties positively moderate the relationship between dense local ownership network and sustainable development.*

To summarize, we propose three sets of hypotheses that systematically investigate the independent and moderating relationships between CCIs and the cultural SDGs.

2.3 Methodology

2.3.1 Research setting and network identification

The objective of this empirical study is to investigate how the structural features of cultural heritage ownership networks and local CCI development help achieve the cultural SDGs. China is one of the countries with the richest cultural resources and the longest tradition of utilizing local cultural heritage, and this makes it a very appropriate setting for the analysis (WHC, 2021). According to the National Administration of Cultural Heritage (NCHA), as of 2021, China had 5,292 “major historical and cultural sites protected at the national level” in more than 300 cities (NCHA, 2021). Cultural heritage sites are managed and operated by various government agencies, by public institutions, by state-owned tourism firms, or by private cultural firms at the local level.

We relied on public records to identify the operators of these cultural heritage sites and find detailed information about how they are managed. For example, we consulted the social media pages of cultural heritage operators, the official websites of government agencies, and the reports of CCI firms. We also made use of public databases such as the one created by the NCHA and the one developed by the State Administration for Market Regulation (SAMR), the National Enterprise Credit Information Publicity System (NECIPS). In total, we identified 2,114 organizations that are involved in managing 1,355 cultural heritage sites registered in the NECIPS. The other cultural heritage sites are maintained and preserved by the NCHA and its affiliations, but for these sites, there is limited publicly accessible data on the investment and operation since they are not open to the public.

To collect data on the ownership ties of these 2,114 organizations, we retrieved information on their shareholders and on the firms in which they invest. An ownership tie was identified if an equity ownership relationship exists between a firm and another firm. Following prior research, we did not distinguish the percentage of ownership but treated the ties as binary as exist or absent (Turkina & Van Assche, 2018). Since there is no consensus on how many steps of relationships should be included in this research setting, we followed the "six degrees of separation" rule of thumb popularized by Milgram (1967) and Watts and Strogatz (1998). In other words, we searched for shareholders and subsidiaries of the 1,146 cultural heritage operators whose investment ties were within the range of six steps. After this search, our dataset allowed us to represent an ownership network of 22,455 organizations with 21,898 ties between them. Finally, we assigned these 22,455 organizations to specific cities according to their registered addresses.

2.3.2 Dependent variable

We identified three mechanisms through which the CCIs contribute to sustainable development: the direct contribution, the indirect facilitating role, and the overarching transformative principle. For the direct effects, CCIs serve as knowledge intensive sectors and creative engines, which in turn contribute to local innovation and creative community building. Therefore, the CCIs contribute to SDG 9, which emphasizes industry, innovation, and infrastructure and are in line with SDG 11, which addresses the

sustainable cities and communities. For the facilitator role, the CCIs provide employment opportunities, empower marginalized groups, and help build equitable societies. Therefore, the CCIs are aligned with SDG 8, which targets decent work and economic growth, and with SDG 10, which focuses on reducing inequalities. For the fundamental role of shaping value systems, CCIs can be extremely useful, for they provide a unique circular economy approach towards responsible consumption and production, the focus of SDG 12 (Foster, 2020; Foster et al., 2020). We selected the more culture relevant SDGs 8, 9, 10, 11, and 12 and noted them as "the cultural SDGs".

As the dependent variable in this study, the cultural SDGs were given a composite score representing the progress in achieving SDGs 8, 9, 10, 11, and 12. To obtain the indicators of this progress and the composite scores, we followed the official UN guidelines specified in documents such as the Index and Dashboards Report (Sachs et al., 2018) and the Global SDG Indicator Framework (UN, 2022).

We also consulted prior research on subnational SDG progress, including the SDG Index and Dashboards Report for European Cities (Lafortune et al., 2019), the US Cities Sustainable Development Report (Lynch et al., 2019), the study of China's SDG index score at the subnational level by Xu et al. (2020), and China's Regional SDG Evaluation and Prospect Report (TUSDG & WWF, 2020).

We adopted a four-step method to obtain the composite score for the progress in achieving the cultural SDGs in Chinese cities. These four steps were (1) the indicator selection, (2) the data collection, (3) the rescaling and normalizing of the data, and (4) the aggregation into the composite score (Xu et al., 2020).

Indicator selection. First, we listed all the indicators developed by the UN, adopted by the reports on the US cities and the European cities, and utilized by the Chinese subnational reports. Since they were originally developed to measure the progress of nations in achieving the SDGs, many of the official indicators were not applicable at the city level. We omitted indicators with no available data at the local level and included as many indicators as possible. We removed indicators that were not available or that were less meaningful in Chinese contexts, ones such as drug overdose deaths, the obesity rate, the

Gini coefficient, and deaths by firearms. After these procedures, we generated a list of 34 city-level indicators for the cultural SDGs.

Data collection. We collected publicly available, recent, and reliable data on the indicators for various cities in China between 2015 and 2019 (Lafortune et al., 2019; TUSDG & WWF, 2020). The data resources used in this study included the national, provincial, and city-level statistical yearbooks for Chinese cities. We also verified missing data points and data irregularities by consulting websites of government agencies, databases of local statistical bureaus, and social media pages of the public relation departments of cities.

Rescaling and normalizing. To achieve comparability across SDGs 8, 9, 10, 11, and 12, the values obtained for each SDG needed to be rescaled and normalized. Therefore, we established the upper and lower bounds of the data and normalized them. To set the upper and the lower bounds, we took a five-step approach. First, if an indicator was adopted from the Global indicator framework, we adopted the bounds of that indicator. Second, we followed the principle of "leave no one behind" and set the bounds by absolute thresholds for SDGs, such as the indicators of the unemployment rate and the municipal waste treatment rate. Third, science-based targets and recommendations such as the WHO Air Quality Guidelines (WHO, 2021) were taken into consideration as criteria for setting the bounds. Finally, for the rest of the indicators, we used the average value of the top-five performing cities as the upper bound and the bottom 2.5th-percentile value across all the cities' values as the lower bound. After setting the upper and the lower bounds, we adopted the widely used max-min normalization by calculating the following value:

$$i' = \frac{i - i_{lower\ bound}}{i_{upper\ bound} - i_{lower\ bound}} \times 100,$$

where *i*' denotes the normalized value of a given indicator of a city, *i* is the raw value of a given indicator of a city, and $i_{lower\ bound}$ and $i_{upper\ bound}$ bound refer to the lower bound and upper bound values obtained from the previous step. For scores lower than the lower bound and exceeding the higher bound, we assigned the values 0 and 100 respectively. After this step, we normalized all the values of a city's indicators using a scale from 0 to 100.

Aggregating into the composite score. After the values of all indicators of cities were calculated, we aggregated them into a composite score to represent the overall progress towards the cultural SDGs by calculating the arithmetic mean of all indicators of a city over the five-year period between 2015 and 2019, a window chosen considered data availability and policy relevance of the SDGs framework.

Following prior research and to reflect the principle of equal importance of all aspects of the SDGs, we did not assign weights on indicators when we calculate the composite score (Xu et al., 2020). To avoid sampling bias, we did not include cities that lack a significant proportion (one third) of indicators in our final sample. For instance, a small and remote city with almost no industrial activity and limited available developmental data might falsely receive a high score in the SDGs based on its air quality and water quality indicators. After removing the cities with at least one third of the indicator values of these cities were missing, we obtained a sample of 292 cities across China.

The four municipalities directly under the central government, Beijing, Shanghai, Tianjin, and Chongqing, were also treated as cities in this study since they have similar population, area, and cultural heritage resources as big cities even though administratively they are equivalent to provinces. We excluded cities in Hong Kong SAR, Macau SAR, and Taiwan Province since they have different administrative systems and statistical frameworks from the cities located in mainland China. Table 2.1 illustrated the indicators we utilized and top-performing cities in the cultural SDGs.

Table 2.1 Cultural SDG indicators and the composite Cultural SDG score for the top 10 performing cities

SDGs	City	深圳市 (Shenzhen)	珠海市 (Zhuhai)	林芝市 (Nyingchi)	克拉玛依市 (Karamay)	湖州市 (Huzhou)	中山市 (Zhongshan)	苏州市 (Suzhou)	杭州市 (Hangzhou)	北京市 (Beijing)	宁波市 (Ningbo)
SDG 8	GDP per capita	99.7	85.0	29.4	85.5	42.6	53.2	91.3	74.0	71.1	67.2
	GDP growth rate	67.0	69.6	79.6	38.2	68.2	46.9	55.7	66.4	54.7	61.1
	Long term unemployment rate (%)	60.9	59.2	55.5	87.8	64.5	58.7	73.5	78.9	29.4	73.6
	Domestic tourism income as a proportion of GDP	0.8	5.7	22.8	3.2	30.9	2.6	6.7	15.1	11.3	10.2
SDG 9	Access to Internet at home (%)	46.6	65.6	72.2	79.9	55.7	53.1	53.2	49.7	19.3	47.7
	Patent application per ten thousand residents	100.0	99.3		18.7	73.6	94.6	92.9	71.0	72.4	68.4
	Patent (invention) granted per ten thousand residents	90.8	88.0		11.9	47.9	76.9	53.6	72.6	100.0	49.6
	Patent granted per	100.0	99.9		19.5	74.4	100.0	86.5	73.5	73.6	77.5

	ten thousand residents										
	Road passenger volumes per ten thousand residents	7.4	3.1	0.0	0.0	6.4	1.4	38.3	14.4	58.9	5.8
	Manufacturing value added as a proportion of GDP	42.0	55.3	33.8	96.0	65.6	56.1	55.9	30.5	0.2	59.6
	R&D personnel per ten thousand residents	100.0	91.9		28.1	56.6	74.2	86.9	71.6	100.0	76.9
	R&D expenditure per GDP	46.2	26.6	0.0	2.4	33.1	25.7	24.0	40.3	79.5	31.5
	Mobile phone subscription per ten thousand residents	91.3	81.2	17.6	88.9	53.4	77.4	51.7	71.8	69.7	54.5
SDG 10	Wage difference between urban residents and rural residents		62.9	54.7		78.3	98.8	59.3	67.1	27.8	71.7

	Wages as a proportion of GDP		4.2	4.3		32.4	23.2	7.7	16.3	23.1	18.8
SDG 11	PM2.5 emission	69.6	68.4	93.1	65.7	49.6	64.2	43.8	44.2	24.0	57.1
	PM10 emission	76.6	76.2	93.4	61.4	59.1	74.7	55.7	53.1	41.2	66.1
	O3_8h emission	53.6	34.9	77.2	73.8	10.5	20.5	25.5	23.2	1.6	35.6
	NO_2 emission	50.9	49.9	100.0	72.1	30.7	44.0	4.9	13.9	14.9	29.8
	SO_2 emission	92.6	92.6	97.0	92.7	78.1	87.4	81.2	84.2	91.6	83.7
	Green area and public square per ten thousand residents	16.8	24.5	83.5	81.5	9.8	5.3	15.9	17.0	16.2	7.0
	Park area per capita	24.2	34.3	27.8	11.4	27.0	21.3	18.7	18.7	24.3	11.8
	Green coverage rate of built district (%)	71.4	89.9	74.6	65.8	80.4	44.6	60.8	55.6	85.8	55.6
	Green space rate of built district (%)	58.8	92.9	64.5	61.1	76.9	46.4	55.2	52.9	88.7	52.4
	Population density	0.0	44.9	100.0	98.6	72.9	1.7	34.2	69.9	29.6	56.3
	Number of museums per ten thousand residents	14.5	0.7	34.6	9.8	15.7	2.0	6.1	11.7	5.2	12.6

	Book collection in public library	88.7	4.1	0.0	5.2	5.1	5.4	53.8	52.5	100.0	20.2
SDG 12	Municipal waste treatment rate	100.0	100.0	51.9	97.2	100.0	100.0	100.0	100.0	81.0	100.0
	Industrial solid waste recycling rate	59.2	91.5		88.2	99.0	83.2	91.9	84.2	67.6	93.8
	Industrial wastewater per manufacturing value added	95.0	81.8	100.0	85.2	65.7	75.6	70.1	67.2	92.6	83.8
	Municipal waste (10000 tons/10000 resident)	0.7	0.0	76.9	3.0	67.1	68.8	54.1	26.9	17.7	66.9
	Wastewater centralized treatment rate	92.9	93.2	80.0	86.5	89.4	94.5	76.9	88.5	83.6	48.8
	Industrial NO per manufacturing value added	100.0	95.3		76.0	77.6	94.6	89.8	94.9	98.2	94.3
	Industrial SO_2 per manufacturing value added	100.0	97.0		80.9	88.2	97.9	93.3	96.4	100.0	96.0
Composite score of the Cultural SDGs		63.1	60.9	56.5	55.5	55.5	55.1	55.0	54.9	54.6	54.3
Missing values		2	0	7	2	0	0	0	0	0	0

2.3.3 Explanatory variables

Scale of CCIs. We used the number of CCI firms per capita in a city to represent the scale of the local CCIs. We followed the Classification of Culture and Related Industries by the National Bureau of Statistics of China and selected firms registered in the NECIPS with industry codes listed in the classification (NBS, 2018).

The CCI classification used to identify CCI firms in the thesis (as in the Industrial Classification for National Economic Activities, GB/T4754—2017): 231, 232, 233, 241, 242, 243, 245, 246, 267, 347, 393, 395, 514, 524, 632, 633, 642, 712, 725, 728, 735, 749, 785, 786, 806, 861, 862, 871, 872, 873, 874, 875, 876, 877, 881, 882, 883, 884, 885, 886, 887, 889, 901, 902, 903, 905, and 909. Due to data availability, we adopted the three-digit codes rather than the four-digit classification used by the NBS.

Cultural heritage ownership network density. The traditional network density measure calculates the proportion of existing ties relative to all possible ties within a network. However, this measure is often not accurate in reflecting the actual relationship density or cohesion of networks since it tends to generate very low value of density for larger networks and high value for smaller networks (De Nooy et al., 2018). Since the network sizes of the cities in our sample vary significantly, we used average degree of organizations in a city to measure how densely connected a network is. The average degree measure did not rely on network size to calculate the network structure compared to typical density indicators (De Nooy et al., 2018).

We took two steps to obtain the variable: first, we counted degree centrality, namely number of direct ties, of each organization in a city; and second, we calculated the arithmetic mean of all organizations' degree and use the average degree as the proxy of network density.

Trans-local ties. We defined an investment tie that extended beyond the city boundaries as a trans-local tie. For instance, if a firm has four subsidiaries in its home city and one subsidiary in another city, we assign the value "1" to the firm. Then we counted the total

number of trans-local ties of all firms in a city and divided the number by the total population of the city to obtain the trans-local ties per capita.

2.3.4 Control variables

We also included several control variables to account for the potential effects of local cultural resources, economic conditions, and ownership network features.

Logged city area and *logged GDP* was used to account for potential differences in resources, capabilities, and possible opportunities for utilizing these resources since in this study we are interested in tangible cultural heritages that are essentially immovable and fixed on the land (Cerisola, 2019). Moreover, we introduced two variables *logged number of cultural heritage sites* and *percentage of operated cultural heritage sites* to account for the inventory and utilization of cultural resources. We defined those cultural heritage sites managed by organizations and open to public audiences as operated cultural heritage sites. Among more than 5,000 cultural heritage sites in China, many are directly managed by the NCHA under maintenance and not open to public audiences.

Since the tourism industry is closely related to cultural heritage, we introduced a variable *scale of tourism firms* in a city to represent the development of local tourism by dividing the total number of tourism firms by the city population (Loulanski & Loulanski, 2011; Su & Lin, 2014). We also introduced a variable average *logged registered capital* of cultural heritage related firms of a city to indicate the general financial capacity of nodes in ownership networks. Finally, we calculated the *centralization* of the cultural heritage ownership network since it represented the level of concentration of network actors in a city (Provan et al., 2007).

2.3.5 Model specification

We used multiple regression models to estimate the relationships proposed in the previous section. Variables were added step by step and relationships were tested in several models.

2.4 Results

Table 2.2 and Table 2.3 report the descriptive statistics and correlations between variables. From the values in the table, we argue that multicollinearity problem is not present since the values of the VIF for all variables were below ten.

Table 2.4 shows the results of the regression analysis. Model 1 only includes the control variables, Models 2 to 4 add the scale of CCIs, network density, and trans-local ties into the regressions respectively. Model 5 adds the interaction terms. We use Model 5 to test the interaction hypotheses. R square values at the bottom of the table indicate that compared to the model that only includes control variables, models that include explanatory variables and interaction terms improved the model fitness.

Table 2.2 Descriptive Statistics

		Min.	Max.	Mean	s.d.	VIF
1	Cultural SDGs	30.005	63.070	41.891	5.768	
2	Logged city area	7.272	12.476	9.409	0.854	1.295
3	logged GDP	4.906	10.336	7.451	0.959	2.297
4	Logged number of cultural heritage sites	0.000	4.934	2.417	0.928	1.570
5	Percentage of operated cultural heritage sites	0.000	1.000	0.235	0.196	1.237
6	Scale of tourism firms	0.596	72.667	3.839	5.181	1.401
7	Logged average registered capital	0.000	14.181	7.083	4.377	3.831
8	Network centralization	0.000	0.867	0.143	0.168	1.988
9	Scale of CCIs	1.210	68.219	7.656	8.430	3.547
10	Network density	0.000	2.367	1.052	0.787	5.045
11	Trans-local ties	0.000	5.058	0.364	0.695	2.707

N(observations) = 292.

Table 2.3 Correlations of the variables

		1	2	3	4	5	6	7	8	9	10
1	Cultural SDGs										
2	Logged city area	-0.253**									
3	logged GDP	0.408**	-0.182**								
4	Logged number of cultural heritage sites	-0.031	0.236**	0.429**							
5	Percentage of operated cultural heritage sites	0.276**	-0.086	0.345**	0.143**						
6	Scale of tourism firms	0.332**	-0.169**	0.039	0.014	0.101					
7	Logged average registered capital	0.229**	-0.079	0.529**	0.458**	0.304**	0.065				
8	Network centralization	0.039	0.010	0.043	0.188**	0.072	-0.020	0.472**			
9	Scale of CCIs	0.563**	-0.270**	0.527**	0.198**	0.328**	0.457**	0.287**	-0.067		
10	Network density	0.303**	-0.024	0.507**	0.418**	0.322**	0.119*	0.842**	0.604**	0.316**	
11	Trans-local ties	0.512**	-0.165**	0.371**	0.169**	0.319**	0.415**	0.206**	-0.107	0.781**	0.241**

Table 2.4 Results of multiple regressions on the Cultural SDGs (SDG 8-12)

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	26.73** (4.599)	30.283** (4.389)	32.793** (4.531)	32.822** (4.478)	34.843** (4.754)
Logged city area	-0.35 (0.361)	-0.052 (0.345)	-0.171 (0.348)	-0.213 (0.344)	-0.221 (0.345)
Logged city GDP	2.635** (0.39)	1.652** (0.404)	1.468** (0.412)	1.576** (0.409)	1.601** (0.412)
Logged number of cultural heritage sites	-1.556** (0.375)	-1.62** (0.355)	-1.598** (0.353)	-1.642** (0.349)	-1.647** (0.35)
Percentage of operated sites	3.342* (1.536)	1.92 (1.472)	1.621 (1.471)	1.119 (1.465)	1.157 (1.469)
Scale of tourism firms	0.331** (0.055)	0.159** (0.06)	0.146* (0.06)	0.132* (0.059)	0.123* (0.061)
Logged average registered capital of CCI firms	0.039 (0.093)	0.028 (0.088)	-0.133 (0.117)	-0.125 (0.116)	-0.126 (0.116)
Network centralization	1.764 (1.964)	3.08 (1.87)	0.722 (2.183)	1.459 (2.174)	1.287 (2.2)
Scale of CCIs (H1)		0.261** (0.044)	0.249** (0.044)	0.145** (0.058)	0.153* (0.06)
Network density (H2)			1.537* (0.745)	1.401† (0.738)	1.391† (0.739)
Trans-local ties (H3a)				1.699** (0.612)	1.741** (0.618)
Network density*Trans-local ties (H3b)					-0.303 (0.567)
R^2	0.339	0.411	0.42	0.435	0.436

N(observations)=292. Standard errors are in parentheses. ** p<0.01, * p<0.05, † p<0.10.

Hypothesis 1 proposes that the scale of local CCIs of a city contributes to the city's progress towards the cultural SDGs. In Model 2 to Model 5, the coefficients of the variable are positive; therefore, this hypothesis is supported.

Hypothesis 2 argues that a dense cultural heritage ownership network leads to a higher cultural SDG score at the city level. The positive and significant coefficients in Models 3 to 5 for the variable network density suggest that this is the case.

Hypothesis 3a argues that trans-local ties also contribute to local cultural SDGs. The significant and positive coefficients of this variable in Models 4 and 5 suggest that this is the case. The hypothesis of moderating effect by trans-local ties is not supported. Reflecting on the observation that local networks and trans-local ties contribute to local sustainability independently, we acknowledge that there could be different types of strategies to benefit from network embeddedness and adapt to local contexts (Wu & Wu, 2016).

Among the control variables, several variables reveal statistically significant relationships with the local cultural SDG progress. Economic output level of a city indeed contributes to local SDGs since a higher city level GDP means there might be more financial resources to support CCI development and cultural heritage preservation. The more cultural heritage sites a city has, the lower score it receives on the cultural SDG progress. This negative relationship is aligned with observations in the prior literature that the mere existence of cultural heritage does not foster local sustainable development and that local public and private actors need to carefully utilize cultural resources to foster local creative activities and development of CCIs (Cerisola, 2019; Kourtit & Nijkamp, 2019). The concentration of a large number of cultural heritage sites in a city also indicates the potential conflicts between industrialization and preservation of heritage. These conflicts become more complex when more heritage sites are involved since cities only possess limited resources that need to be distributed to different sectors (Fatoric & Seekamp, 2017; Yao & Han, 2016).

Also, development of tourism is showed to be positively related to cultural sustainability. Despite the critics that tourism jeopardizes local cultural diversity and poses threats on

the environment, tourism remains one of the most effective channels to transform cultural heritage into economic outcomes that can be helpful for local residents and marginalized communities (Nocca, 2017; Richards, 2011; Yang & Wall, 2009). The UN has made this point explicit by incorporating the development of tourism into one of the SDGs and has emphasized the importance of sustainable aspect of tourism in the Sustainable Development Target 8.9 "By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products" (UN, 2022, p. 10).

2.5 Additional analyses

We conducted a series of additional tests to check the robustness of the results of our study. First, we analyzed the nexus between CCI networks and each of the cultural SDGs separately. Second, we took into consideration the composition of the cultural heritage ownership networks and verified the role of the heterogeneous nodes of these networks in achieving the SDGs.

Although one advantage of the SDG framework is the comprehensive and interrelated nature of different aspects of sustainable development, it is necessary to explore which specific SDGs are more relevant to the development of local CCIs and to provide more diverse policy recommendations and organizational strategies in achieving these goals. Therefore, we ran regressions of the variables on each of the cultural SDGs as dependent variable separately to explore whether there is heterogeneity in contributions of CCI networks in achieving each of the cultural SDGs.

Descriptive statistics of and correlations between the variables in the additional analyses were provided in Table 2.5 and Table 2.6 respectively. The results of these tests are listed in Table 2.7.

Table 2.5 Descriptive Statistics of the variables in the additional analyses

	Min.	Max.	Mean	s.d.	VIF
SDG 8	6.489	59.663	34.619	10.034	
SDG 9	1.305	69.367	18.790	12.480	
SDG 10	9.619	100.000	37.859	14.108	
SDG 11	18.175	70.485	40.274	8.445	
SDG 12	29.748	94.857	78.764	10.748	
Logged city area	7.272	12.476	9.409	0.854	1.295
logged GDP	4.906	10.336	7.451	0.959	2.327
Logged number of cultural heritage sites	0.000	4.934	2.417	0.928	1.582
Percentage of operated cultural heritage sites	0.000	1.000	0.235	0.196	1.258
Scale of tourism firms	0.596	72.667	3.839	5.181	1.402
Logged average registered capital	0.000	14.181	7.083	4.377	3.882
Network centralization	0.000	0.867	0.143	0.168	1.990
Scale of CCIs	1.210	68.219	7.656	8.430	3.548
Network density	0.000	2.367	1.052	0.787	5.045
Proportion of CCI firms in cultural heritage ownership networks	0.000	1.000	0.071	0.138	1.098
Trans-local ties	0.000	5.058	0.364	0.695	2.731

N(observations SDG 8, 9, 11, 12)=292. N(observations SDG 10)=290.

Table 2.6 Correlations of the variables in the additional analyses

		1	2	3	4	5	6	7
1	SDG 8							
2	SDG 9	0.632**						
3	SDG 10	-0.361**	-0.197**					
4	SDG 11	0.202**	0.027	-0.006				
5	SDG 12	0.285**	0.186**	-0.092	-0.221**			
6	Logged city area	-0.296**	-0.395**	-0.072	0.222**	-0.227**		
7	logged GDP	0.405**	0.647**	-0.159**	-0.276**	0.412**	-0.182**	
8	Logged number of cultural heritage sites	0.112	0.196**	-0.198**	-0.313**	0.164**	0.236**	0.429**
9	Percentage of operated cultural heritage sites	0.286**	0.338**	-0.093	-0.002	0.11	-0.086	0.345**
10	Scale of tourism firms	0.417**	0.265**	-0.234**	0.268**	-0.023	-0.169**	0.039
11	Logged average registered capital	0.317**	0.391**	-0.206**	-0.154**	0.211**	-0.079	0.529**
12	Network centralization	0.044	0.03	-0.096	0.038	0.006	0.01	0.043
13	Scale of CCIs	0.509**	0.719**	-0.212**	0.102	0.088	-0.270**	0.527**
14	Network density	0.354**	0.424**	-0.242**	-0.028	0.156**	-0.024	0.507**
15	Proportion of CCI firms in cultural heritage ownership networks	-0.021	-0.071	0.007	-0.102	0.046	0.031	-0.01
16	Trans-local ties	0.481**	0.634**	-0.194**	0.158**	0.002	-0.165**	0.371**

Table 2.6 Correlations of variables in the additional analyses (continued)

		8	9	10	11	12	13	14	15
1	SDG 8								
2	SDG 9								
3	SDG 10								
4	SDG 11								
5	SDG 12								
6	Logged city area								
7	logged GDP								
8	Logged number of cultural heritage sites								
9	Percentage of operated cultural heritage sites	0.143*							
10	Scale of tourism firms	0.014	0.101						
11	Logged average registered capital	0.458**	0.304**	0.065					
12	Network centralization	0.188**	0.072	-0.02	0.472**				
13	Scale of CCIs	0.198**	0.328**	0.457**	0.287**	-0.067			
14	Network density	0.418**	0.322**	0.119*	0.842**	0.604**	0.316**		
15	Proportion of CCI firms in cultural heritage ownership networks	0.127*	0.118*	-0.004	0.197**	0.171**	-0.052	0.164**	
16	Trans-local ties	0.169**	0.319**	0.415**	0.206**	-0.107	0.781**	0.241**	-0.087

Table 2.7 Results of additional analysis (regressions on separated Cultural SDGs and distinguishing core-CCIs and supporting industries)

	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 8-12
Constant	36.301**	16.85*	63.754**	27.887**	61.188**	36.651**
	(8.288)	(7.598)	(14.412)	(7.269)	(10.226)	(4.746)
Logged city area	-1.92**	-3.144**	-1.728†	3.738**	-2.672**	-0.283
	(0.602)	(0.552)	(1.047)	(0.528)	(0.743)	(0.343)
Logged GDP	2.138**	4.142**	-0.648	-2.085**	5.56**	1.605**
	(0.718)	(0.659)	(1.249)	(0.63)	(0.886)	(0.412)
Logged number of cultural heritage sites	-0.665	-0.455	-1.075	-3.74**	0.795	-1.772**
	(0.61)	(0.559)	(1.077)	(0.535)	(0.752)	(0.355)
Percentage of operated cultural heritage sites	3.304	0.31	0.519	0.463	1.037	1.594
	(2.561)	(2.348)	(4.459)	(2.246)	(3.16)	(1.469)
Scale of tourism firms	0.424**	-0.042	-0.467*	0.316**	0.041	0.142*
	(0.107)	(0.098)	(0.187)	(0.094)	(0.132)	(0.061)
Logged average registered capital	-0.001	-0.157	-0.038	-0.235	0.115	-0.102
	(0.202)	(0.185)	(0.351)	(0.177)	(0.249)	(0.116)
Network centralization	-4.975	-0.448	2.314	4.509	-2.648	1.18
	(3.836)	(3.516)	(6.675)	(3.364)	(4.733)	(2.182)
Scale of CCIs (H1)	0.097	0.375**	-0.123	0.187*	-0.157	0.174**
	(0.105)	(0.096)	(0.186)	(0.092)	(0.129)	(0.06)
Network density (H2)	2.582*	2.891*	-2.659	2.193†	-1.177	1.335†
	(1.289)	(1.181)	(2.241)	(1.13)	(1.59)	(0.732)
Trans-local ties (H3a)	3.284**	4.291**	-1.257	1.52	-1.417	1.923**
	(1.078)	(0.988)	(1.875)	(0.945)	(1.33)	(0.624)
Network density*Trans-local ties (H3b)	-2.818**	1.05	2.708	0.286	-2.024†	-0.421
	(0.988)	(0.906)	(1.737)	(0.867)	(1.219)	(0.564)
Proportion of core-CCI firms in cultural heritage ownership networks (additional analysis)						2.298
						(2.829)
Scale of CCIs*Proportion of core-CCI firms in cultural heritage ownership networks (additional analysis)						1.519*
						(0.638)
R^2	0.433	0.692	0.133	0.384	0.248	0.45

N(observations SDG 8, 9, 11, 12)=292. N(observations SDG 10)=290. Standard errors are in parentheses. ** p<0.01, * p<0.05, † p<0.10.

In terms of the contributions of the CCIs in the separated SDGs, we find several interesting differences compared to the nexus between CCIs and the overall cultural SDGs.

The local network and the trans-local ties seem to play similar roles in fostering economic growth (SDG 8) but represent contradictory strategies since the interaction between the two significantly reduces the progress in SDG 8. We did not find evidence of the contribution of the scale of the CCIs. Aligned with empirical evidence obtained in prior studies, the additional analyses in this study also find that both local and trans-local networks contribute to local innovation (Bathelt & Cohendet, 2014; Turkina & Van Assche, 2018). This study adds to the discussion that knowledge exchange with CCIs is also an important channel to bring out innovation potentials of local business. We find that the scale of CCIs, cultural heritage networks, and trans-local ties matter for SDG 9, which suggest the direct innovation and creativity channel of the CCIs is the most prevalent. Local CCI mechanisms are also closely related to SDG 11, which emphasizes the sustainable communities. Local CCIs and local cultural heritage networks both play important roles in achieving SDG 11. However, we do not find clear evidence on the contribution of CCIs or local and trans-local networks on SDG 10 and SDG 12.

Looking at the main constructs across different SDGs, we observe that SDG 9 and SDG 11 are more sensitive to the scale of the local CCIs and network density, which might suggest the stronger contributions of the CCIs in promoting innovation and sustainable communities and cities but less effective in reducing inequality and fostering sustainable production and consumption.

Since investments related to cultural heritage are often diversified into several related domains such as CCIs, tourism, retail, and transportation infrastructure, it is possible that cultural heritage ownership networks are composed of actors from different industries (Loulanski & Loulanski, 2011). Industries such as tourism, retail, and transportation are sometimes noted as culture-related or supporting domains (UNESCO, 2009).

We distinguished the core CCIs and the supporting industries when analyzing the nodes in the cultural heritage ownership networks and explores whether the embeddedness of CCI firms within the networks makes a difference in the proposed relationships. We

propose that embeddedness of CCI firms in a city's cultural heritage ownership network contributes to the progress towards the cultural SDGs both directly by facilitating knowledge transfer in CCIs and indirectly by accessing more cultural resources and drawing inspiration from local cultural heritage.

Compared to other non-creative industries, CCIs are more sensitive to cultural trends and new technologies in social life. Thus collaboration between CCIs and supporting industries help cities build heterogeneous knowledge base for innovative strategies to better preserve and utilize cultural heritage (Santoro et al., 2020). Therefore we propose that t*he proportion of CCI firms in the cultural heritage ownership network of a city is positively related to the city's progress towards cultural SDGs*.

A high proportion of CCI firms in a city's cultural heritage ownership network indicates more localized and unique cultural resources that are of great value for developing sustainable and resilient CCIs (J. L. He et al., 2018). Location bounded cultural resources play an important role in fostering creative communities and agglomeration of creative firms because of their unique identity and cultural authenticity (He & Gebhardt, 2014; Martinez, 2017).Thus, we propose that *the embeddedness of CCI firms in cultural heritage ownership networks enhance the positive role of CCIs in achieving the cultural SDGs*.

We obtained the value of the embeddedness of CCI firms by dividing the number of CCI firms per capita by the number of nodes of the cultural heritage ownership network of a city. If all actors in the network belong to CCIs, the value was set as 1. If no CCI firm is present in the network, the value was set as 0.

Figure 2.1 visualizes the main constructs of the main tests and the additional analyses: the overall CCI scale of a city, the density of the local cultural heritage ownership network, the trans-local ties, and the embeddedness of CCI firms in the local cultural heritage ownership network. As shown in Figure 2.1, on the left is the local cultural heritage ownership network of a city that is composed of both core-CCI firms (squared nodes) and supporting firms (circle nodes). On the right, trans-local ties and nodes in other cities are added. For the purpose of clear illustration, CCI firms that are not embedded in the local cultural heritage ownership network are not presented. Hypothesis 1 thus explores the

relationship between the total number of CCI firms (squared nodes, including the ones not presented here for clearer illustration) in a city and the progress towards cultural SDGs. Hypothesis 2 investigates the density of the network presented on the left. Hypothesis 3 focuses on the relationship between the number of trans-local ties (dashed lines) and the cultural SDGs' progress. And the additional test explores the proportion of the CCI firms (squared nodes) relative to all the nodes in the network on the left.

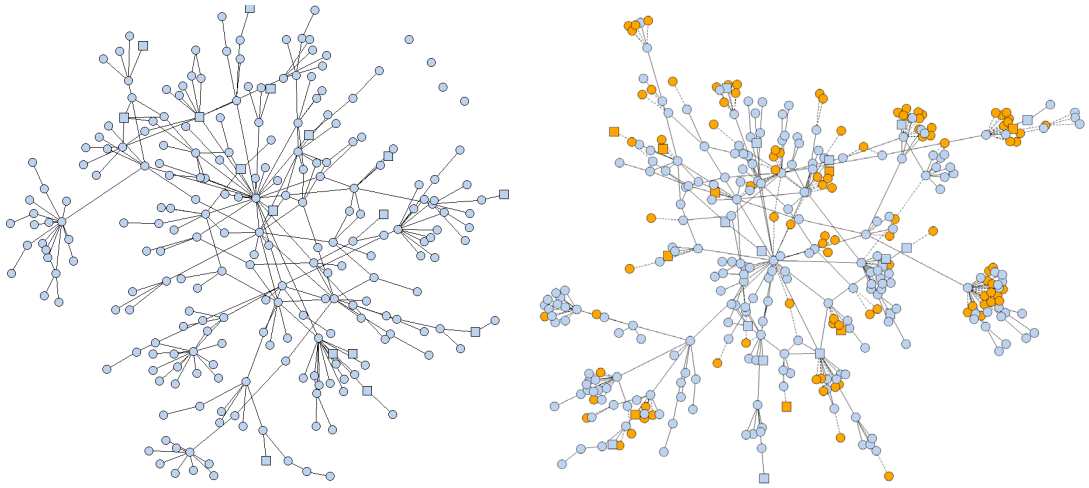


Figure 2.1 Cultural heritage ownership network of a city. Circles and squares in the figure represent nodes in the cultural heritage ownership network of a city. Squares represent CCI firms. Blue nodes represent local organizations and orange nodes represent organizations in other cities. Lines between nodes represent ownership ties. Dash lines between nodes represent trans-local ownership ties.

2.6 Discussion

Although it is widely acknowledged that culture is at the heart of sustainability, it is not always obvious how cultural heritage and CCIs are translated into drivers of sustainable development (UNESCO, 2013; Wiktor-Mach, 2020). Adopting the SDG framework provides an opportunity to answer this question because SDGs incorporate many important issues of our social systems into one comprehensive framework and acknowledge the role of culture in several of the goals and targets. The question then becomes what specific features of cultural heritage and CCIs foster sustainable development.

Aiming to provide insights on this question, this study systematically examines the roles of cultural heritage and CCIs play in achieving the SDGs at city level by adopting a network perspective. It has three main contributions to the literature on cultural heritage, CCIs, and cultural sustainability by its theoretical arguments, unique dataset, and innovative methodology.

This study has three theoretical contributions: the highlight of culture and the CCIs as the bridge between cultural heritage and sustainability, the importance of business sectors, and the localization of the SDG framework.

Prior studies have illustrated that cultural heritage is precious resources for local development by promoting creativity and innovation (Cerisola, 2019). The current study extended this line of research by explaining the critical role played by CCIs, which directly draw inspiration cultural heritage and function in a sustainable way (Foster, 2020; Pagan et al., 2020). We highlight several other potentials of the CCIs in achieving the overall progress towards SDG 8, 9, 10, 11, and 12 through different mechanisms in several aspects of our social systems (Santoro et al., 2020). The CCIs' role should not be bounded by one of the channels to transfer heritage to development outcomes; rather, they can systematically provide employment, improve local innovation, reduce inequalities, and develop economic activities. These findings lead to the conclusion that the CCIs indeed deserve to be called "the industry of tomorrow" given its contribution in building innovative and sustainable societies (UNESCO, 2021b, p. 1).

Second, we explicitly incorporate business sectors, one of the key players contributing to sustainability, into the discussion of the SDGs (Pfisterer & Van Tulder, 2021). This study thus directly addresses the limitation of the SDG framework that the vague and the unaccounted role of business sectors in achieving the goals (Lim et al., 2018; Scheyvens et al., 2016). Not only we explain how business entities in the CCIs can contribute to local development, but we also take a further step to explore the implications of the structure of cultural businesses in cities. Therefore, this study complements the widely used case study methods in the discussion of local businesses and sustainability and provides more generalizable knowledge on the topic of how businesses can contribute to achieving the SDGs.

Third, there are only limited studies on the localization of the SDGs at city level, especially for the cities in the emerging markets (UNDP & CASS, 2020; Xu et al., 2020). Since many aspects of the sustainability challenges are localized and communities often engage in diversified solutions, it is critical to monitor local SDGs and investigate the effects of local business activities on sustainability (Petti et al., 2020; Xu et al., 2020). This study builds on previous literature and illustrates that different regions and cities indeed have engaged the sustainability challenges by different strategies and have made differentiated progress towards several of the SDGs. Moreover, our study reveals that not only the progress towards the cultural SDGs are heterogeneous among cities, the achievements in different targets under the goals also vary significantly across regions. Future research on the localization of the SDGs could benefit from the arguments and the conclusions of this study and acknowledge the different possibilities of achieving the sustainability and explore and compare the effectiveness of these voluntary or involuntary strategies adopted by policymakers (Forestier & Kim, 2020).

This study also contributes to the research on city sustainability by its unique dataset of the large-scale empirical evidence collected from across 292 cities in China. Although not covering all the SDGs, the empirical analysis of this study provides a detailed assessment of five SDGs that are closely related to the CCIs and takes the first step of setting up comparable and comprehensive evaluation frameworks of city SDGs (TUSDG & WWF,

2020). Future studies could build on this study and continue to incorporate other relevant and available indicators into the evaluation of local SDGs.

We also conducted additional analyses to explore which separate SDGs are more closely related to CCIs and cultural heritage networks. The results of these analyses reveal that although CCIs and networks contribute to the overall cultural SDGs, they have differentiated roles in each of these goals and future studies can further explore these nuances and complement prior studies in the interactions, synergies, and trade-offs between different SDGs (Le Blanc, 2015; Pradhan et al., 2017; Sachs et al., 2019).

The third contribution of the study is its innovative use of network analysis, an approach that is particularly powerful in analyzing relationships between entities, to illustrate the investment relationships between business actors. We illustrate the structural features of the networks composed of business actors related to cultural heritage and explain the knowledge mechanisms through which cultural sustainability can be facilitated. We theorize that both local and trans-local network ties are relevant to local development since they contribute to knowledge sharing and innovation activities independently by fostering local knowledge communities and access to distant knowledge sources (Bathelt & Cohendet, 2014). By highlighting the cultural heritage ownership networks, local network effects, and trans-local network advantages, we draw attention to the partnerships and the collective actions of public and private sectors, as emphasized in SDG 17 (Sachs et al., 2019; Scheyvens et al., 2016).

This study also has several policy implications. First, it helps the implementation of the SDG framework locally and explore strategies for strategies and solutions for regional sustainability challenges that are more context specific and tailored to local resources and constraints.

Although coastal cities normally have a higher level of financial resources than the inner land cities, it is possible to pursue the SDGs by different strategies, just as the case of Nyingchi and Karamay cities show (Department of Tourism Development, 2017; Zhang & Gao, 2005).

Second, the development of local CCIs is shown to be relevant to local sustainable development. Thus formulating and implementing effective cultural policies that draw inspiration from local cultural resources and build dense local networks are critical factors for local sustainability.

However, this study also bears some limitations in terms of conceptualization, data availability, causal reasoning, and generalizability.

First, due to data availability, we mainly focused on culture heritage ownership networks in cities and ignored other types of interorganizational networks such as supply chain networks and strategic alliances (Borgatti & Li, 2009). Prior research suggests that embeddedness in supply chain networks both contributes to innovation of CCIs and stimulates innovation in other sectors (Bakhshi & McVittie, 2009; Shafi et al., 2019). Also, when exploring the structure of networks, we simplified the interorganizational networks in different cities, conceptualized investment ties as undirected, and did not consider weights of ties, which lose some of the possibilities of discovering interesting network dynamics (Phelps et al., 2012).

Second, we only included tangible cultural heritage in our analysis and left out intangible cultural heritage and natural heritage, which are also important factors in local sustainability development. The emphasis of the cultural SDGs limited our analysis mainly to the scope of social, economic, and cultural sustainability while the discussion of the environmental dimension is absent (Forestier & Kim, 2020). Although this approach is aligned with prior studies that chose the SDGs based on relevance, we believe a more comprehensive research design could provide better understanding of relationships between local actors' behaviors and the SDGs, after all, the key to implementing the SDGs is integration (Singh et al., 2018; Stafford-Smith et al., 2017).

Third, we do not propose strict causal relationships in our study and thus the results of the study should be viewed as tentative. Although we introduced several control variables and collected data on explanatory variables before 2019, this research design does not completely rule out the possibility of reversed causality.

Finally, results of this single-country and single-industry study can be contrasted with outcomes from more comprehensive international and cross-country study initiatives to see whether the systematic empirical evidence shows coherent or conflicting trends in different contexts (Turkina & Van Assche, 2018). We recommend future studies to address these limitations with more data and more innovative design.

2.7 Conclusion

Although cultural heritage and CCIs have been argued as highly relevant in achieving the SDGs, we lack large-scale systematic empirical evidence of how interaction and interlinkages of CCIs contribute to local SDGs. Aiming to address this limitation, this study adopted the network analysis to explore the role of the CCIs and the culture heritage ownership network in local SDG progress. We found evidence that a city's scale of the CCIs and the ownership network related to cultural heritage contribute to the overall progress in SDGs 8, 9, 10, 11, and 12. By integrating CCIs and cultural heritage ownership networks in the analytical framework, this study contributes to our understanding of the importance of linkages and interactions between local actors in achieving the cultural SDGs.

References

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, *45*(3), 425-455. https://doi.org/10.2307/2667105

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies*, *45*(7), 893-904. https://doi.org/10.1080/00343404.2010.543126

Auclair, E., & Fairclough, G. (2015). Living between past and future: An introduction to heritage and cultural sustainability. In E. Auclair & G. Fairclough (Eds.), *Theory and practice in heritage and sustainability: Between past and future*. Routledge.

Bakhshi, H., & McVittie, E. (2009). Creative supply-chain linkages and innovation: Do the creative industries stimulate business innovation in the wider economy? *Innovation-Management Policy & Practice*, *11*(2), 169-189. https://doi.org/10.5172/impp.11.2.169

Bathelt, H., & Cohendet, P. (2014). The creation of knowledge: local building, global accessing and economic development-toward an agenda. *Journal of Economic Geography*, *14*(5), 869-882. https://doi.org/10.1093/jeg/lbu027

Borgatti, S. P., & Li, X. (2009). On Social Network Analysis in a Supply Chain Context. *Journal of Supply Chain Management*, *45*(2), 5-22. https://doi.org/10.1111/j.1745-493X.2009.03166.x

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. P. (2004). Taking stock of networks and organizations: A multilevel perspective. *Academy of Management Journal*, *47*(6), 795-817. https://doi.org/10.2307/20159624

Burford, G., Hoover, E., Velasco, I., Janouskova, S., Jimenez, A., Piggot, G., Podger, D., & Harder, M. K. (2013). Bringing the "Missing Pillar" into Sustainable Development Goals: Towards Intersubjective Values-Based Indicators. *Sustainability*, *5*(7), 3035-3059. https://doi.org/10.3390/su5073035

Cattaneo, T., Giorgi, E., Flores, M., & Barquero, V. (2020). Territorial Effects of Shared-Living Heritage Regeneration. *Sustainability*, *12*(20), Article 8616. https://doi.org/10.3390/su12208616

Cerisola, S. (2019). A new perspective on the cultural heritage-development nexus: the role of creativity. *Journal of Cultural Economics*, *43*(1), 21-56. https://doi.org/10.1007/s10824-018-9328-2

Cerisola, S., & Panzera, E. (2021). Cultural and Creative Cities and Regional Economic Efficiency: Context Conditions as Catalyzers of Cultural Vibrancy and Creative Economy. *Sustainability*, *13*(13), Article 7150. https://doi.org/10.3390/su13137150

Chaminade, C., Martin, R., & McKeever, J. (2021). When regional meets global: exploring the nature of global innovation networks in the video game industry in Southern Sweden. *Entrepreneurship and Regional Development*, *33*(1-2), 131-146. https://doi.org/10.1080/08985626.2020.1736184

Chen, M. H., Chang, Y. Y., & Lee, C. Y. (2015). Creative entrepreneurs' guanxi networks and success: Information and resource. *Journal of Business Research*, *68*(4), 900-905. https://doi.org/10.1016/j.jbusres.2014.11.049

Coe, N. M. (2000). The view from out West: embeddedness, inter-personal relations and the development of an indigenous film industry in Vancouver. *Geoforum*, *31*(4), 391-407. https://doi.org/10.1016/s0016-7185(00)00005-1

Cohendet, P., & Simon, L. (2017). Concepts and models of innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 33-55). https://doi.org/10.4337/9781782548522

Coleman, J. S. (1988). Social Capital in the Creation of Human-Capital. *American Journal of Sociology*, *94*, S95-S120. https://doi.org/10.1086/228943

De Nooy, W., Mrvar, A., & Batagelj, V. (2018). *Exploratory Social Network Analysis with Pajek*. https://doi.org/10.1017/9781108565691

Department of Tourism Development. (2017). *Nyingchi to build a national sustainable development experimental zone*. http://lyfzt.xizang.gov.cn/xwzx_69/dsdt/201708/t20170831_116107.html

Dessein, J., Soini, K., Fairclough, G., Horlings, L., Battaglini, E., Birkeland, I., Duxbury, N., De Beukelaer, C., Matejić, J., & Stylianou-Lambert, T. (2015). *Culture in, for and as sustainable development: Conclusions from the COST Action IS1007 Investigating Cultural Sustainability*. University of Jyväskylä.

Farr-Wharton, B. S. R., Brown, K., Keast, R., & Shymko, Y. (2015). Reducing creative labour precarity: beyond network connections. *Management Decision*, *53*(4), 857-875. https://doi.org/10.1108/md-05-2014-0269

Fatoric, S., & Seekamp, E. (2017). Securing the Future of Cultural Heritage by Identifying Barriers to and Strategizing Solutions for Preservation under Changing Climate Conditions. *Sustainability*, *9*(11), Article 2143. https://doi.org/10.3390/su9112143

Fazlagic, J., & Skikiewicz, R. (2019). Measuring sustainable development - the creative economy perspective. *International Journal of Sustainable Development and World Ecology*, *26*(7), 635-645. https://doi.org/10.1080/13504509.2019.1651418

Ferraro, F., Etzion, D., & Gehman, J. (2015). Tackling grand challenges pragmatically: Robust action revisited. *Organization Studies*, *36*(3), 363-390.

Fleming, L., Mingo, S., & Chen, D. (2007). Collaborative brokerage, generative creativity, and creative success. *Administrative Science Quarterly*, *52*(3), 443-475. https://doi.org/10.2189/asqu.52.3.443

Forestier, O., & Kim, R. E. (2020). Cherry-picking the Sustainable Development Goals: Goal prioritization by national governments and implications for global governance. *Sustainable Development*, *28*(5), 1269-1278. https://doi.org/10.1002/sd.2082

Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources Conservation and Recycling*, *152*, Article 104507. https://doi.org/10.1016/j.resconrec.2019.104507

Foster, G., Kreinin, H., & Stagl, S. (2020). The future of circular environmental impact indicators for cultural heritage buildings in Europe. *Environmental Sciences Europe*, *32*(1), Article 141. https://doi.org/10.1186/s12302-020-00411-9

George, G., Howard-Grenville, J., Joshi, A., & Tihanyi, L. (2016). Understanding and tackling societal grand challenges through management research. *Academy of Management Journal*, *59*(6), 1880-1895.

Giliberto, F., & Labadi, S. (2022). Harnessing cultural heritage for sustainable development: an analysis of three internationally funded projects in MENA Countries. *International Journal of Heritage Studies*, *28*(2), 133-146. https://doi.org/10.1080/13527258.2021.1950026

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy*, *37*(10), 1717-1731. https://doi.org/10.1016/j.respol.2008.08.010

Giuliani, E. (2013). Network dynamics in regional clusters: Evidence from Chile. *Research Policy*, *42*(8), 1406-1419.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., & Noble, I. (2013). Sustainable development goals for people and planet. *Nature*, *495*(7441), 305-307. https://doi.org/10.1038/495305a

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203-215. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<203::Aid-smj102>3.0.Co;2-k

Handke, C., & Towse, R. (2013). Introduction. In R. Towse & C. Handke (Eds.), *Handbook on the digital creative economy* (pp. xiii, 441 pages). Edward Elgar.

Hawkes, J. (2001). *The fourth pillar of sustainability: Culture's essential role in public planning*. Common Ground.

He, J. L., & Gebhardt, H. (2014). Space of Creative Industries: A Case Study of Spatial Characteristics of Creative Clusters in Shanghai. *European Planning Studies*, *22*(11), 2351-2368. https://doi.org/10.1080/09654313.2013.837430

He, J. L., Huang, X. J., & Xi, G. L. (2018). Urban amenities for creativity: An analysis of location drivers for photography studios in Nanjing, China. *Cities*, *74*, 310-319. https://doi.org/10.1016/j.cities.2017.12.020

Hosagrahar, J. (2017). *Culture: at the heart of SDGs*. https://en.unesco.org/courier/april-june-2017/culture-heart-sdgs

Kourtit, K., & Nijkamp, P. (2019). Creative actors and historical-cultural assets in urban regions. *Regional Studies*, *53*(7), 977-990. https://doi.org/10.1080/00343404.2018.1541077

Lafortune, G., Zoeteman, K., Fuller, G., Mulder, R., Dagevos, J., & Schmidt-Traub, G. (2019). *The 2019 SDG Index and Dashboards Report for European Cities (prototype version)*. Sustainable Development Solutions Network (SDSN) and the Brabant

Center for Sustainable Development (Telos). https://www.sdgindex.org/reports/sdg-index-and-dashboards-report-for-european-cities/

Le Blanc, D. (2015). Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. *Sustainable Development*, *23*(3), 176-187. https://doi.org/10.1002/sd.1582

Lee, M. (2015). Fostering connectivity: a social network analysis of entrepreneurs in creative industries. *International Journal of Cultural Policy*, *21*(2), 139-152. https://doi.org/10.1080/10286632.2014.891021

Li, W., Zhou, Y., & Zhang, Z. W. (2021). Culture-Led Plan for Peri-Urban Agricultural Sustainability: A Case of Pu'an Village in China. *Land*, *10*(3), Article 242. https://doi.org/10.3390/land10030242

Lim, M. M. L., Jorgensen, P. S., & Wyborn, C. A. (2018). Reframing the sustainable development goals to achieve sustainable development in the Anthropocene-a systems approach. *Ecology and Society*, *23*(3), Article 22. https://doi.org/10.5751/es-10182-230322

Liu, X., & Zhu, W. S. (2021). Sustainability approaches to Chinese landscape architecture. *Interdisciplinary Science Reviews*, *46*(4), 689-702. https://doi.org/10.1080/03080188.2021.1897748

Loulanski, T., & Loulanski, V. (2011). The sustainable integration of cultural heritage and tourism: a meta-study. *Journal of Sustainable Tourism*, *19*(7), 837-862. https://doi.org/10.1080/09669582.2011.553286

Luckman, S. (2015). *Craft and the creative economy* (2015. ed.). Palgrave Macmillan. http://whel-primo.hosted.exlibrisgroup.com/openurl/44WHELF_NLW/44WHELF_NLW_services_page?u.ignore_date_coverage=true&rft.mms_id=99958391502419

Lynch, A., LoPresti, A., & Fox, C. (2019). *The 2019 US Cities Sustainable Development Report*. Sustainable Development Solutions Network (SDSN). https://www.sustainabledevelopment.report/reports/2019-us-cities-sustainable-development-report/

Mani, D., & Moody, J. (2014). Moving beyond Stylized Economic Network Models: The Hybrid World of the Indian Firm Ownership Network. *American Journal of Sociology*, *119*(6), 1629-1669. https://doi.org/10.1086/676040

Martin, R., & Moodysson, J. (2011). Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies*, *19*(7), 1183-1203. https://doi.org/10.1080/09654313.2011.573131

Martinez, P. G. (2017). Urban authenticity at stake: A new framework for its definition from the perspective of heritage at the Shanghai Music Valley. *Cities*, *70*, 55-64. https://doi.org/10.1016/j.cities.2017.06.017

Maskell, P. (2014). Accessing remote knowledge-the roles of trade fairs, pipelines, crowdsourcing and listening posts. *Journal of Economic Geography*, *14*(5), 883-902. https://doi.org/10.1093/jeg/lbu002

Milgram, S. (1967). The small world problem. *Psychology today*, *2*(1), 60-67. http://snap.stanford.edu/class/cs224w-readings/milgram67smallworld.pdf

Mossig, I. (2008). Global networks of the motion picture industry in los angeles/hollywood using the example of their connections to the German market. *European Planning Studies*, *16*(1), 43-59. https://doi.org/10.1080/09654310701747969

NBS. (2018). *Classification of Culture and Related Industries (2018)*. http://www.stats.gov.cn/tjsj/tjbz/201805/t20180509_1598314.html

NCHA. (2021). *Data on Unmovable Cultural Relics* http://www.ncha.gov.cn/col/col2266/index.html

Nilsson, M., Griggs, D., & Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature*, *534*(7607), 320-322. https://doi.org/10.1038/534320a

Nocca, F. (2017). The Role of Cultural Heritage in Sustainable Development: Multidimensional Indicators as Decision-Making Tool. *Sustainability*, *9*(10), Article 1882. https://doi.org/10.3390/su9101882

Nohria, N., & Garcia-Pont, C. (1991). Global Strategic Linkages and Industry Structure. *Strategic Management Journal*, *12*, 105-124. https://doi.org/10.1002/smj.4250120909

Owen-Smith, J., & Powell, W. W. (2004). Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science*, *15*(1), 5-21.

Pagan, E. A., Salvatella, M. D. G., Pitarch, M. D., Munoz, A. L., Toledo, M. D. M., Ruiz, J. M., Vitella, M., Lo Cicero, G., Rottensteiner, F., Clermont, D., Dorozynski, M., Wittich, D., Vernus, P., & Puren, M. (2020). From Silk to Digital Technologies: A Gateway to New Opportunities for Creative Industries, Traditional Crafts and Designers. The SILKNOW Case. *Sustainability*, *12*(19), Article 8279. https://doi.org/10.3390/su12198279

Palanivel, T. (2019). *How cultural and creative industries can power human development in the 21st Century*. https://hdr.undp.org/content/how-cultural-and-creative-industries-can-power-human-development-21st-century

Petti, L., Trillo, C., & Makore, B. N. (2020). Cultural Heritage and Sustainable Development Targets: A Possible Harmonisation? Insights from the European Perspective. *Sustainability*, *12*(3), Article 926. https://doi.org/10.3390/su12030926

Pfisterer, S., & Van Tulder, R. (2021). Navigating Governance Tensions to Enhance the Impact of Partnerships with the Private Sector for the SDGs. *Sustainability*, *13*(1), Article 111. https://doi.org/10.3390/su13010111

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890-913. https://doi.org/10.5465/amj.2010.52814627

Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earths Future*, *5*(11), 1169-1179. https://doi.org/10.1002/2017ef000632

Pratt, A. C. (2008). Creative cities: The cultural industries and the creative class. *Geografiska Annaler Series B-Human Geography*, *90B*(2), 107-117. https://doi.org/10.1111/j.1468-0467.2008.00281.x

Pratt, A. C. (2013). Space and Place. In R. Towse & C. Handke (Eds.), *Handbook on the digital creative economy*. Edward Elgar.

Pratt, A. C., Virani, T. E., & Gill, R. (2019). Introduction. In R. Gill, A. C. Pratt, & T. E. Virani (Eds.), *Creative Hubs in Question*. https://doi.org/10.1007/978-3-030-10653-9

Provan, K. G., Fish, A., & Sydow, J. (2007). Interorganizational networks at the network level: A review of the empirical literature on whole networks. *Journal of Management*, *33*(3), 479-516. https://doi.org/10.1177/0149206307302554

Richards, G. (2011). CREATIVITY AND TOURISM The State of the Art. *Annals of Tourism Research*, *38*(4), 1225-1253. https://doi.org/10.1016/j.annals.2011.07.008

Sachs, J. D., Schmidt-Traub, G., Kroll, C., Lafortune, G., & Fuller, G. (2018). *SDG Index and Dashboards Report 2018*. Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockstrom, J. (2019). Six Transformations to achieve the Sustainable Development Goals. *Nature Sustainability*, *2*(9), 805-814. https://doi.org/10.1038/s41893-019-0352-9

Salvia, A. L., Leal, W., Brandli, L. L., & Griebeler, J. S. (2019). Assessing research trends related to Sustainable Development Goals: local and global issues. *Journal of Cleaner Production*, *208*, 841-849. https://doi.org/10.1016/j.jclepro.2018.09.242

Santoro, G., Bresciani, S., & Papa, A. (2020). Collaborative modes with Cultural and Creative Industries and innovation performance: The moderating role of heterogeneous sources of knowledge and absorptive capacity. *Technovation*, *92-93*, Article 102040. https://doi.org/10.1016/j.technovation.2018.06.003

Sasaki, M. (2010). Urban regeneration through cultural creativity and social inclusion: Rethinking creative city theory through a Japanese case study. *Cities*, *27*, S3-S9. https://doi.org/10.1016/j.cities.2010.03.002

Scheyvens, R., Banks, G., & Hughes, E. (2016). The Private Sector and the SDGs: The Need to Move Beyond `Business as Usual'. *Sustainable Development*, *24*(6), 371-382. https://doi.org/10.1002/sd.1623

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126. https://doi.org/10.1287/mnsc.1060.0624

Shafi, M., Sarker, M. N. I., & Liu, J. R. (2019). Social Network of Small Creative Firms and Its Effects on Innovation in Developing Countries. *Sage Open*, *9*(4), Article 2158244019898248. https://doi.org/10.1177/2158244019898248

Singh, G. G., Cisneros-Montemayor, A. M., Swartz, W., Cheung, W., Guy, J. A., Kenny, T. A., McOwen, C. J., Asch, R., Geffert, J. L., Wabnitz, C. C. C., Sumaila, R., Hanich, Q., & Ota, Y. (2018). A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Marine Policy*, *93*, 223-231. https://doi.org/10.1016/j.marpol.2017.05.030

Snowball, J. D. (2013). The economic, social and cultural impact of cultural heritage: methods and examples. In I. Rizzo & A. Mignosa (Eds.), *Handbook on the Economics of Cultural Heritage* (pp. 438-455). https://doi.org/10.4337/9780857931009.00036

Soini, K., & Birkeland, I. (2014). Exploring the scientific discourse on cultural sustainability. *Geoforum*, *51*, 213-223. https://doi.org/https://doi.org/10.1016/j.geoforum.2013.12.001

Soini, K., & Dessein, J. (2016). Culture-sustainability relation: Towards a conceptual framework. *Sustainability*, *8*(2), 167.

Stafford-Smith, M., Griggs, D., Gaffney, O., Ullah, F., Reyers, B., Kanie, N., Stigson, B., Shrivastava, P., Leach, M., & O'Connell, D. (2017). Integration: the key to implementing the Sustainable Development Goals. *Sustainability Science*, *12*(6), 911-919. https://doi.org/10.1007/s11625-016-0383-3

Štreimikienė, D., & Kačerauskas, T. (2020). The creative economy and sustainable development: The Baltic States. *Sustainable Development*, *28*(6), 1632-1641.

Su, Y. W., & Lin, H. L. (2014). Analysis of international tourist arrivals worldwide: The role of world heritage sites. *Tourism Management*, *40*, 46-58. https://doi.org/10.1016/j.tourman.2013.04.005

Throsby, C. D. (2001). *Economics and culture*. Cambridge University Press.

Turkina, E., & Van Assche, A. (2018). Global connectedness and local innovation in industrial clusters. *Journal of International Business Studies*, *49*(6), 706-728. https://doi.org/10.1057/s41267-018-0153-9

TUSDG, & WWF. (2020). *China's Regional SDG Evaluation and Prospect Report*. https://webadmin.wwfchina.org/storage/content/press/publication/2020/%E4%B8%AD%E5%9B%BD%E5%8F%AF%E6%8C%81%E7%BB%AD%E5%8F%91%E5%B1%95%E7%9B%AE%E6%A0%87%E7%9A%84%E5%9C%B0%E6%96%B9%E8%AF%84%E4%BB%B7%E5%92%8C%E5%B1%95%E6%9C%9B%E7%A0%94%E7%A9%B6%E6%8A%A5%E5%91%8A-0518.pdf

UN. (2017). *New Urban Agenda*. United Nations.

UN. (2019). *International Year of Creative Economy for Sustainable Development, 2021*. https://documents-dds-ny.un.org/doc/UNDOC/LTD/N19/359/41/PDF/N1935941.pdf

UN. (2022). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202022%20refinement_Eng.pdf

UNCTAD, & UNDP. (2008). *Creative economy report 2008 : the challenge of assessing the creative economy : towards informed policy-making*. United Nations. http://ssc.undp.org/creative_economy Full text English version and overview section in French and in Spanish

UNDP, & CASS. (2020). *Evaluation Report on SDG Progress in Chinese Cities (in Chinese)*. https://www.undp.org/sites/g/files/zskgke326/files/2022-06/UNDP-CH-CH%20The%20SDGs%20in%20Chinese%20Cities_%20Progress%20Asessment%20Report%202020_0.pdf

UNESCO. (1972). *Convention Concerning the Protection of the World Cultural and Natural Heritage*. https://whc.unesco.org/archive/convention-en.pdf

UNESCO. (2001). *UNESCO Universal Declaration on Cultural Diversity*. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/pdf/5_Cultural_Diversity_EN.pdf

UNESCO. (2009). *2009 UNESCO Framework for Cultural Statistics*. http://uis.unesco.org/sites/default/files/documents/unesco-framework-for-cultural-statistics-2009-en_0.pdf

UNESCO. (2013). *The Hangzhou Declaration: Placing Culture at the Heart of Sustainable Development Policies*. https://unesdoc.unesco.org/ark:/48223/pf0000221238

UNESCO. (2021). *UNESCO Roadmap for International Year of Creative Economy for Sustainable Development 2021*. https://en.unesco.org/sites/default/files/creative_economy2021-unesco-roadmapen-ok2.pdf

UNESCO, & World Bank. (2021). *Cities, Culture, Creativity: Leveraging Culture and Creativity for Sustainable Urban Development and Inclusive Growth* https://openknowledge.worldbank.org/handle/10986/35621

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*(2), 447-504. https://doi.org/10.1086/432782

Watson, A. (2020). Not all roads lead to London: insularity, disconnection and the challenge to 'regional' creative industries policy. *Regional Studies*, *54*(11), 1574-1584. https://doi.org/10.1080/00343404.2020.1738012

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world' networks. *Nature*, *393*(6684), 440-442. https://doi.org/10.1038/30918

WCED. (1987). *Our Common Future*. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

WHC. (2021). *Special Issue - World Heritage in China*. UNESCO. https://whc.unesco.org/en/review/99

WHO. (2021). *Ambient (outdoor) air pollution*. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Wiktor-Mach, D. (2020). What role for culture in the age of sustainable development? UNESCO's advocacy in the 2030 Agenda negotiations [Article]. *International Journal of Cultural Policy*, *26*(3), 312-327. https://doi.org/10.1080/10286632.2018.1534841

Wittel, A. (2001). Toward a network sociality. *Theory Culture & Society*, *18*(6), 51-+. https://doi.org/10.1177/026327601018006003

Wu, Y. Y., & Wu, S. K. (2016). Managing ambidexterity in creative industries: A survey. *Journal of Business Research*, *69*(7), 2388-2396. https://doi.org/10.1016/j.jbusres.2015.10.008

Xu, Z. C., Chau, S. N., Chen, X. Z., Zhang, J., Li, Y. J., Dietz, T., Wang, J. Y., Winkler, J. A., Fan, F., Huang, B. R., Li, S. X., Wu, S. H., Herzberger, A., Tang, Y., Hong, D. Q., Li, Y. K., & Liu, J. G. (2020). Assessing progress towards sustainable development over space and time. *Nature*, *577*(7788), 74-+. https://doi.org/10.1038/s41586-019-1846-3

Yang, L., & Wall, G. (2009). Ethnic tourism: A framework and an application. *Tourism Management*, *30*(4), 559-570. https://doi.org/10.1016/j.tourman.2008.09.008

Yao, Y., & Han, R. B. (2016). Challenging, but not Trouble-Making: cultural elites in China's urban heritage preservation. *Journal of Contemporary China*, *25*(98), 292-306. https://doi.org/10.1080/10670564.2015.1075720

Yung, E. H. K., Chan, E. H. W., & Xu, Y. (2014). Sustainable Development and the Rehabilitation of a Historic Urban District - Social Sustainability in the Case of Tianzifang in Shanghai. *Sustainable Development*, *22*(2), 95-112. https://doi.org/10.1002/sd.534

Zhang, H.-j., & Gao, Z.-g. (2005). Problems of Industry Transformation Based on Sustainable Development Ability of Resource-based City——A Case Study on Karamay City, Xinjiang. *ARID LAND GEOGRAPHY*, *28*(3), 409-413.

Zhao, J. M., & Zhou, S. Y. (2018). Social Network and Place: The Inheritance and Development of Beijing Crosstalk Performing Art. *Sustainability*, *10*(5), Article 1541. https://doi.org/10.3390/su10051541

Chapter 3
Digitalization, networks, and the survival of cultural firms in the pandemic: A multilevel study

Abstract

The cultural and creative industries (CCIs) have been noted as "industry of tomorrow", yet their development was largely disrupted by the COVID-19 pandemic. Almost all subsectors of the CCIs have been hit by the restrictions of social lives and travel. However, even in sectors such as museums and music performance that highly rely on social interaction, some firms still manage to turn the challenges into opportunities and survive the pandemic. In this study we explore two types of capabilities that contribute to the survival in the pandemic for the CCIs, namely network structure and digitalization. We observe that firms occupying a central position in their networks and digitalized CCIs are more likely to survive the pandemic.

3.1 Introduction

The cultural and creative industries (CCIs) are one of the most important contributors to the global economy because they provide employment opportunities for the youth, retain a large proportion of the international trade, and foster a sustainable growth based on creativity and innovation. It was estimated that in the year 2018, CCIs employed around 30 million people and many of them are young talents (UNESCO, 2017, 2021b). In 2019, CCIs generated exports of cultural goods and services of US$389.1 billion, doubled from the value of the year 2005, and accounted for 3% of the global GDP with an output of US$2250 billion (UNESCO, 2022). CCIs also facilitate a sustainable future since they utilize the unique renewable resource that is the human creativity and help build the intergenerational bridge between cultural heritage and digitalized society through the involvement of young talents (Pagan et al., 2020; Peukert, 2019; UNCTAD, 2019; UNESCO, 2021b).

There is a growing consensus that CCIs play a more and more important role in the interaction of cultural, social, and economic aspects of the sustainable development

(Hosagrahar, 2017; Nocca, 2017; Throsby, 2001). It is thus not surprising that CCIs have been considered as the "industry of tomorrow" (UNESCO, 2021b, p. 1). In November 2019, the UN declared the year 2021 the International Year of Creative Economy for Sustainable Development, an initiative that signifies the importance of the CCIs in employment, entrepreneurship, innovation, and social inclusion (UN, 2019).

At that time, no one could imagine an unprecedented health crisis would change the CCIs so dramatically that 10 million jobs were lost and the Gross Value Added of the industries contracted by US$750 billion in just a few months, a devastating one-third decrease in the scale of activities in these sectors (UNESCO, 2021a).

The pandemic of COVID-19 disrupts most of the activities in the global economy, but the CCIs are among the hardest hit sectors (OECD, 2020). This worsened industrial performance was caused by the collective effects of several factors such as precarious nature of CCI employment, concentration of SMEs in the sectors, reliance on social interaction and venue-based activities, social distancing measures, and restriction on travel (Comunian & England, 2020; Khlystova et al., 2022; UNESCO, 2021b; Yue, 2022).

However, just like damages and disruptions brought by the pandemic vary across industries, regions, and communities, the effects of the pandemic are not homogenous within the CCIs (Banks & O'Connor, 2021; UNESCO, 2021a). Upstream subsectors such as cultural heritage and museums that typically rely on in-person visits are forced to temporarily or permanently close because of various social distancing measures and the significant decrease of tourists (Holcombe-James, 2021; UNESCO, 2020). Venue and social interaction-based subsectors such as live music performance, movie theatre, and festivals are badly hit by the pandemic (UNESCO, 2021a). For downstream activities, such as media, design and creative services, and audio-visual services, the pandemic brings less severe damage since they are already highly digitalized and remote working is feasible and common (UNESCO, 2021a; Yue, 2022).

These observations illustrate the profound and heterogeneous impacts of the COVID-19 pandemic on different subsectors of the CCIs. They also reveal the long-existing vulnerability of the industries despite their fast growth and resilience for the last decade

(Khlystova et al., 2022). Disruption of the CCIs also enables us to reflect on the value and the contribution of culture and creativity in our social lives, mental health, and economic development (Banks & O'Connor, 2021; UNESCO & World Bank, 2021).

There remain important questions unanswered regarding the survival and resilience of the CCIs in the pandemic since mixed results have been observed on firms exposed to similar shocks. In each subsector of the CCIs, there were firms that strived to transform their business models and survive the pandemic, while others went out of business even though they were less constrained by social distancing and were able to digitalize their production and service (Khlystova et al., 2022).

These complex and intertwined effects suggest that sectorial difference alone does not explain the heterogeneous effects of the pandemic in the subsectors of the CCIs and that firms differ in their capacity to cope with the crisis even when exposed to similar threats and risks. Thus, they lead to a research question: what features of firms in the CCIs before the pandemic explain their survival in the pandemic.

Answering this question would shed light on a resilient recovery of the CCIs in the post-pandemic era, viable risk management strategies in future crises, and capacity-building initiatives for CCI firms (Sharma et al., 2020). Policy recommendations that take into consideration firms' differences would also be more relevant and tailored to specific needs of the cultural and creative firms in local contexts (Betzler et al., 2021; Francioni et al., 2017). Following prior studies on how firms cope with crises, we aim to explore this question by adopting a network perspective (Cruz & Teixeira, 2021; Escalona-Orcao et al., 2021; Fernandez et al., 2022).

We start by reviewing prior theoretical and empirical literature on what features of CCI firms explain their success or failure and propose the main hypotheses of this study. Next, we choose China as the research setting and analyze 26,643 firms in the CCIs. Then we empirically investigate validate the main hypotheses by comparing the structural and the compositional features of the two types of CCI firms. And finally, we discuss the theoretical and practical implications of the study and conclude the research.

3.2 Theory

3.2.1 Cultural and creative industries in the pandemic

Cultural and creative industries can be defined broadly as industries that "produce and distribute cultural goods or services" (UNESCO-UIS, 2009, p. 87). In this study, we adopt a more specific definition (UNESCO & World Bank, 2021, p. 8): CCIs are "industries whose principal purpose is the production or reproduction, promotion, distribution, or commercialization of goods, services, and activities of a cultural, artistic, or heritage value".

Some upstream cultural institutions, which are generally believed to rely on social interaction and in-person visits, manage to turn constrains brought by the pandemic into opportunities to innovate, to digitalize, to reach wider audiences, and to engage more inclusive cultural education (Betzler et al., 2021; Raimo et al., 2021; Rivero et al., 2020).

Although most traditional venue-based firms suffer from social distancing measures and large-scale lockdowns, some firms in these subsectors manage to continue delivering innovative products and services to the public audience who are in need of solace by cultural and creative contents during the quarantine (Rivero et al., 2020; Worsley et al., 2022).

Even in downstream subsectors where damage by the pandemic is less severe, a large number of freelancers and micro enterprise entrepreneurs experience financial distress and face risk of unemployment due to precarity of CCI employment, decrease in product and service demand, and infeasibility of working at home, and lack of government support (Comunian & England, 2020; Gu et al., 2021).

Therefore, we argue that firms' capabilities, resources, and industry differences also matter for their survival in the pandemic. In this study, we adopt a multilevel approach to analyze the relationships between firms' network features, industries they are embedded, and the survival in the pandemic for three reasons.

First, the social nature of CCIs merits the use of a network approach (Hirsch, 2000; S. L. Wang et al., 2020). Wittel (2001) argues that as we entered the information age, a network sociality emerges and is particularly visible in the CCIs, where work practices have become closely related to networking practice. Production and consumption in the CCIs have also become increasingly dependent on networks through social interaction in complex open systems (O'Connor, 2009; Potts et al., 2008). These transformations suggest that a network perspective would be both appropriate and useful in analyzing interorganizational relationships, firms strategies, and policy implementations in these sectors (Hirsch, 2000).

Second, the highly knowledge-intensive and creativity-based feature of the CCIs calls for the network analysis, which is particularly useful in explaining innovation activities in different levels of the social systems (Phelps et al., 2012; Powell et al., 1996). Networks between creative individuals and between different firms facilitate knowledge sharing, particularly the symbolic knowledge sharing that often require face-to-face social interactions and colocation of CCI firms (Asheim et al., 2011; Martin, 2013). Empirical evidence of the importance of networks on knowledge activities has been identified in several cultural and related domains such as musical production, video games, media, design, advertising, and cultural tourism (Lee, 2015; Lowe et al., 2012; Martin & Moodysson, 2011; Uzzi & Spiro, 2005).

Finally, the pandemic poses heterogeneous effects on firms in the CCIs. One apparent reason for these differentiated effects is the nature of economic activities of the subsectors (Khlystova et al., 2022). That is, if the cultural economic activities depend on physical presence and social interaction and less digitalized, the pandemic would pose more severe threats on the firm (UNESCO, 2021a). Meanwhile, with the development of digital technologies, different components of the value chain become highly intertwined in networks (Handke & Towse, 2013). Local CCIs constantly incorporate stakeholders such as the private sector, various ministries responsible for culture, education, finance, and trade, local government, and creative talents and entrepreneurs into a complex collaborative network (UNESCO, 2017). The concentration of local cultural activities

thus provides opportunities for knowledge accumulation and resource circulation in local cultural communities that aid firms to cope with pressure brought by the pandemic.

To summarize, the social and knowledge-intensive nature of the CCIs and the concentration of different subsectors in the CCIs suggest a necessity of adopting a multilevel analysis that considers both firm network features and industry level characteristics.

3.2.2 Network structure

In this study, we analyze both the structure and the composition of networks. The network structure refers to the pattern of ties among nodes (Phelps et al., 2012). Network composition refers to the attributes of nodes in terms of traits, features, and other relevant specifications (Phelps, 2010; Wasserman & Faust, 1994). We explore one of the most important network structural features of a node, namely the degree centrality.

Network theories argue that position of a node matters for resource access and information transmission (Jackson, 2008; Kadushin, 2012). One strategic position in a network is represented by the notion centrality since being central means maintaining more network ties, timely access to diverse knowledge, less decay and distortion of received information, and reaching more network partners (Borgatti, 2005; Carpenter et al., 2012). Although there exist several conceptualizations of the notion centrality, one widely used notion is the degree centrality, which counts the number of ties a focal node maintains (Ahuja, 2000; Wang et al., 2014).

Degree centrality influences organizational performance through three mechanisms. First, in inter-organizational networks, firms directly connected to many network partners are better at taking initiatives to mobilize resources such as knowledge and financial resources through multiple ties (Ahuja, 2000; Powell et al., 1996). Second, connection to a large number of network partners means exposure to multiple information sources even when firms do not engage in active searching (Guan & Liu, 2016). Exposure in turn leads to better understanding of resources and knowledge embedded in the ego network, such as the distribution, trajectory of development, and key actors (Wang et al., 2014). Third,

organizations possessing a central position are visible to many network partners and this leads to the socially derived power (Ibarra, 1993). In interorganizational networks where information acquisition is costly, firms with higher visibility are viewed as high-status and well-connected by others. Central firms thus gain the advantage of power and influence based on prestige and popularity (Kadushin, 2012).

These mechanisms also apply to the firms that occupy the central position in the CCI interorganizational networks. In music industries where production and consumption are heavily influenced by distributed networks that different firms have complementary skills and resources, maintaining more ties with other firms means better integration into the cultural value chains and more opportunities for collaboration, product promotion, and market expansion (Watson, 2020). Scholars also observe similar network effects in film industries that maintaining strong investment relationships with producers and distributors improve film production performance (Delmestri et al., 2005).

In time of crisis, central position in the network provides firms with more opportunities to mobilize financial resources in the CCI networks. First, a firm with high degree centrality in networks means that it is directly connected with more firms through interorganizational ties and thus less likely to be isolated or marginalized in the periphery of network within the cultural sectors (Grigoriou & Rothaermel, 2014). Second, obtaining multiple information sources from stable interorganizational ties helps firms to better evaluate, reflect, and react to the ever-changing business environment in the pandemic (Verma & Gustafsson, 2020). During the pandemic, false information is constantly disseminated through social media and business decisions are often influenced by uncertainties and risks expressed in biased news, gossips, and unconfirmed stories (Khlystova et al., 2022). In this sense, a central position reduces business risks and increase the adaptive capabilities of CCI firms (Aven & Bouder, 2020). Third, high social status, power, and trustworthy image derived from centrality facilitate a firm's knowledge transfer and collaboration with network partners in the CCIs during the pandemic (Luo, 2005; Tan et al., 2009). The highly knowledge-intensive nature of the CCIs means that trust and social status in the network are critical for firms to be competitive especially in the turbulent pandemic period where trust is jeopardised and communication is disrupted

(Rios-Ballesteros & Fuerst, 2021; Wasko & Faraj, 2005). Therefore, we propose that degree centrality of a CCI firm contributes to its survival.

Hypothesis 1a: *Firms with high degree centrality in the CCI network are more likely to survive the pandemic.*

3.2.3 Digitalization as network composition

Adoption of digital technology has been increasingly common in many businesses during the last decades and the CCIs are no exception (Handke & Towse, 2013; Lazzeretti et al., 2022; Mangematin et al., 2014). Digital technology has transformed several aspects of the CCIs such as business models, value chain configuration, and creative process.

First, strategies of customer identification, value creation, and value capture have been altered and extended by various digital technologies such as online advertisement system, social platform, and influencers (Banks, 2022; Costa, 2022; Landoni et al., 2020; Li, 2020).

Second, as internet and other digital technologies brought the cultural producers and consumers closer, they have changed the structure of cultural value chains from linear mode to complex network mode (UNESCO, 2017). Some roles in the traditional cultural value chains such as brokers, managers, customers, and platforms have adapted to the networked and digitalized production, distribution, and consumption (Capron et al., 2021; Hracs, 2015; Parmentier & Mangematin, 2014).

Third, these changes have also induced significant changes in creative process and innovation activities in the CCIs for two reasons. First, digital technology makes knowledge combination and distribution easier and faster by building digital platforms, increasing data processing power, and coordinating creative collaboration (Ruling & Duymedjian, 2014; Yoo et al., 2012). Second, users and consumers have been recognized as important contributors of organizational innovation since they can provide useful feedback to improve products and services offered by firms (Ghasemzadeh et al., 2022; Hurmelinna-Laukkanen et al., 2021; Von Hippel, 1986). This effect is amplified and accelerated in digitalized CCIs since interaction between producers and users has become

much more frequent and effective thanks to virtual knowledge communities (Chandna & Salimath, 2020; Parmentier & Mangematin, 2014).

To acquire knowledge and technologies critical for organizational survival, firms often leverage and mobilize network resources (Benner & Tushman, 2003; Hoang & Rothaermel, 2010). Network theory points out that the interorganizational network is one important channel to access external knowledge and resources that are critical for organizational performance (Grigoriou & Rothaermel, 2017; Gulati et al., 2000; Phelps et al., 2012).

From the network perspective, whether a firm utilize network resources to digitalize can be revealed by analyzing the network composition of the firm's ego network. Partnership with other digital firms is an indicator of network work strategy of digitalization. Therefore, investigation of composition of its network partners would shed light on the possibility of survival in the pandemic (Santoro et al., 2020).

First, for a firm embedded in an ego network composed of more digital firms, it is easier to access useful knowledge and skillsets that are required for digitalization. Since maintaining ties is costly and requires resources, efforts, and reciprocal behaviors in the times of the pandemic when resources became extremely limited, optimized use of resources is especially necessary for survival of the CCIs (Hansen et al., 2005; Rothaermel & Alexandre, 2009; Wadhwa & Kotha, 2006). By incorporating more digital firms into the ego network, the focal firm can reduce learning costs, improve operation efficiency, and react faster to the operational pressure brought by the pandemic when adopting the digital transformation of its production and service.

Second, digital firms are premium knowledge partners and active innovators in the current knowledge economy (Ayres & Williams, 2004; Sturgeon, 2021; UNCTAD, 2019). Embeddedness in an ego network with more digital firms thus help the focal firm to stay aware of the cutting-edge knowledge, skills, and strategies in the digital age and in turn increase the capabilities to cope with disruption brought by the pandemic.

Hypothesis 1b: *Firms embedded in networks composed of higher proportion of digital firm partners are more likely to survive the pandemic.*

3.2.4 Scale of local cultural activities

In CCIs, the scale of local cultural activities is relevant to the performance of local firms since the cultural production and consumption often depend on network effects and a larger scale local industry concentration means more opportunities (Hirsch, 2000; S. L. Wang et al., 2020; Wittel, 2001). Scholars have observed that there are significant agglomeration and network economies in the production of CCIs (Pratt, 2008; Scott, 2006). Tao et al. (2019) find that the concentration of CCI activities at the city level had a positive productivity effect for Chinese CCI firms. Similarly, Scott (1997) observes that CCI production is often organized in of small- and medium-sized firms that are strongly interdependent and participate in a wide variety of external economies. Martin and Moodysson (2011) also find that cohesive local business communities formed by firms in local media industry of Sweden promote context-specific symbolic knowledge transfer.

Moreover, large scale local cultural activities provide an enabling environment for individual CCI firms to survive the crisis since they indirectly foster local creative communities, increase employment opportunities, and attract investment towards sustainable local businesses and a circular economy.

First, the CCIs are highly creative and dynamic sectors that rely on individual creativity and knowledge creation, and thus they foster the clustering of creative talents and form knowledge communities (UNESCO & World Bank, 2021). Lee (2015) argues that healthy and robust creative industries help entrepreneurs foster trust and enable knowledge sharing in advertising, design, and E-commerce industries in South Korea.

Second, besides creative jobs, the CCIs also produce employment opportunities for local labor forces in domains such as tourism and retail. It is estimated that on average one job opportunity in the CCIs can induce 1.7 related jobs (UNESCO & World Bank, 2021). This positive effect in turn improve the base condition of the development of the CCIs since investments in these sectors often require resources and government support

(Cerisola, 2019). Third, since the CCIs consume fewer natural resources and depend more on creativity and innovation, they represent a unique circular economy and drive the firms in these sectors to be more resilient and sustainable. Following these arguments and observations, we argue that when acing the pandemic, firms with dense ego networks are more likely to survive for three reasons.

Hypothesis 2a: *CCI firms belonging to larger-scale cultural activities are more likely to survive the pandemic than those that are in small-scale activities.*

3.2.5 Digitalized cultural activities

The pandemic inevitably forced many economic activities to adopt digital technologies due to the constraints of social distancing measures, lock-downs, and restricted regional and international travel that aim to slow down the transmission of the virus (Donthu & Gustafsson, 2020; Verma & Gustafsson, 2020). As sectors already profoundly transformed by digitalization even before the global crisis, unsurprisingly, the CCIs not only continue to widely utilize digital technology but also witness digital transformation within some subsectors that are more physical presence oriented or reluctant to embrace digital technology (Khlystova et al., 2022; Raimo et al., 2021; Rivero et al., 2020; UNESCO, 2021a). Indeed, scholars observe that highly digitalized subsectors such as media and gaming are less hit by the pandemic (Khlystova et al., 2022; Snowball et al., 2021).

We argue that the digitalization of a CCI firm contributes to its survival in the pandemic.

First, the more digitalized a CCI firm is, the easier it will be to reach potential consumers, extend target markets, adapt the business model to an online one in the time of crisis (Landoni et al., 2020; Li, 2020). These advantages are critical for surviving the pandemic since the volatile and shrinking cultural market means support and financial opportunities are become extremely rare and difficult to locate (OECD, 2020; UNESCO, 2021a). For instance, although large-scale venue-based activities completely halted during the lockdowns, CCIs in Liverpool city managed to deliver digital contents to consumers and

provided significant mental health support for audiences isolated in their homes (Worsley et al., 2022).

Second, the pandemic also significantly altered the channels of production and distribution of cultural products and services, and many media, gaming, and digital platform firms benefit from this change (Ryu & Cho, 2022). For firms that provide production and service that are more compatible with the online mode, the pandemic is rather a development opportunity than a survival threat thanks to their digital capabilities such as high-speed streaming, digital infrastructure readiness, and processing power (Ryu & Cho, 2022; Snowball et al., 2021). This change of cultural value chain is most evident in the case of soaring revenue of media platforms such as Netflix and Amazon Prime Video (Vlassis, 2021).

Third, CCI firms relying on digital technology are more capable of innovating and developing coping strategies during the pandemic, especially when social systems and citizens as a whole adopt and accept digital transformation. They survive the pandemic by renewing and modernizing their products and services, promoting virtual knowledge communities, and interacting with users and consumers. Empirical evidence of the innovation based on digitalization has been found in subsectors such as museums, craft and design, music, performance, and publishing (Raimo et al., 2021; Sedita & Ozeki, 2021; UNESCO, 2021a). To summarize, we argue that digitalized CCI firms are more likely to survive the pandemic.

Hypothesis 2b: *CCI firms belonging to digitalized cultural activities are more likely to survive the pandemic than those that are less digitalized.*

3.3 Methodology

3.3.1 Research setting

We empirically tested the hypotheses in the research setting of the ego network structure and composition of CCI firms in China. The choice of CCIs in China is appropriate for two reasons. First, China is a country with abundant cultural heritage and long tradition of utilizing cultural resources for development, which in turn provides condition for the

growth of the CCIs (UNCTAD & UNDP, 2008; WHC, 2021). Second, China is an emerging country with a fast-growing cultural economy in the last decade, making it possible to observe the CCI networks and to evaluate their role in the survival during the pandemic. It is estimated that the contribution of the CCIs in China's GDP increased from 2.52 percent in 2008 to 4.54 percent in 2019 (NBS, 2020).

We collected data from public databases to identify the CCI firms and details of their network structure and composition. First, we relied on the classification framework of cultural and related industries developed by the NBS (2018) and collected industry codes listed in the framework as the criteria of deciding whether a firm belongs to the CCIs. Then, we search public databases such as the National Enterprise Credit Information Publicity System (NECIPS) to obtain information of the CCI firms. Due to data availability, we excluded industry codes that are identified as partially belonging to the CCIs in the classification and used three-digit classification of CCIs rather than four-digit classification, e.g., cultural trade agents and brokers (code 5181) are excluded because the registration in the NECIPS does not specify whether a firm is a general trade agent or a specialized cultural trade agent. After this step, we generated an initial sample of 1.56 million CCI firms.

3.3.2 Network identification

A network is defined as a set of nodes and the set of ties between these nodes (Brass et al., 2004). The ownership network, revealed by equity ownership relationship between firms, is one of the strongest and the most stable interorganizational network ties (Nohria & Garcia-Pont, 1991). Equity ownership relationships between CCI firms reveal important information about public support and private investment in the sectors (Lorenzen & Taube, 2008; UN, 2017). They also reveal information about the knowledge exchange, the resource flow, and the power dynamics between different actors in the CCIs (Johns, 2006; Lee, 2015; Lowe et al., 2012). Therefore, in this study, we focus our attention on the CCI ownership networks and analyze their structural and compositional features.

To obtain data on the network ties of the firms identified CCI firms, we searched information on their shareholders and on the firms in which they invest. We mainly relied on social media pages of the firms, reports of firms, and the NECIPS to identify these equity ownership relationships. Following prior studies, we coded the ties as binary categories of presence and absence (Turkina & Van Assche, 2018). We excluded firms with no equity ownership information before 2020 and only included firms located in the provincial capital cities across China to ensure the comparability among cities (Escalona-Orcao et al., 2021). After this step, we generated the final sample of 26,643 firms located in the 31 provincial capital cities (including the four municipalities directly under the central government) of China. Firms located in Hong Kong SAR, Macau SAR, and Taiwan Province were excluded due to differences in statistical frameworks and data availability.

3.3.3 Dependent variable

We measure the survival of CCI firms by the time they continue to operate after the pandemic started in January 2020. Specifically, we counted the number of months a firm operated during the period between January 2020 and December 2021. For instance, for a CCI firm went out of business immediately after the pandemic started, the measure would be noted as 0, while a firm survived the entire first two years of the pandemic, the score would be 23.

3.3.4 Explanatory variables

Network structure. We calculated the *degree centrality* by constructing ego networks for the 26,643 CCI firms and counting ties within these networks. We measured the degree centrality of a focal firm by counting direct network ties it has with its network partners (Ahuja, 2000; Jackson, 2008).

Network composition. We relied on the recently released classification of digital industries by the National Bureau of Statistics to identify the *proportion of digital partners* embedded in a CCI firm's ego network (NBS, 2021). First, we listed all the core digital industry codes in the classification as the criteria for a digital firm. Due to data availability and consideration of relevance to the CCIs, we did not include the codes that characterize

activities that adopt digital technologies to increase production and improve efficiency, such as digital agriculture (industry code 01), digital forestry (industry code 02), and automated farming (industry code 03 and 04). Second, we searched firms that register at least one type of its business in the digital industries in the NECIPS and we retrieved 4.71 million firms that belong to digital industries. Then we compared this list of digital firms with network partners of the CCI firms in our sample and summed the network partners that belong to the digital industry. And finally, we calculated the proportion of the number of direct network partners of a focal firm that belong to the digital industries relative to the number of its direct network partners.

Scale of cultural activities. We measured the *scale of the cultural activity* to which a CCI firm belongs by counting the total number of the specific cultural activity at the three-digit industry classification level. Then we divided the total number of CCI firms by the average population of a city during the five-year period between 2015 and 2019.

Digitalized cultural activities. For the industry level variable *digitalized cultural activity*, we again relied on the classification of digital industries. We coded digitalized cultural activities as 1 and non-digitalized activities as 0.

3.3.5 Control variables

We introduced several firm and network level, industry level, and city level related control variables to reduce the alternative explanations.

First, we included two variables to account for the differences related to a firm's general capabilities. The *year of incorporation* of a firm was used to indicate the general experience and competencies of a firm (Sorensen & Stuart, 2000). We adopted the *logged registered capital* of a firm as an indicator of its general financial resources and size. We included two variables to account for the heterogeneous nature of ego network ties and nodes: *average tie duration* of a focal firm with its network partners and *average year of incorporation* of its network partners.

Third, we used whether a firm belongs to the *core cultural subsectors* (coded as 1 and related subsectors coded as 0) according to the classification by the NBS (2018) to account

for the sectorial differences among different segments of the CCIs. We also used the *logged average registered capital* of all firms belonging to the same segment of the CCIs to represent the general size of firms in local cultural activities.

Finally, the geographic location of a firm could influence the resource availability and public, private support, and digital infrastructure for CCI firm development. Therefore, we introduced several variables related to the differences of cities in which CCI firms are located to account for this possibility. We used the *logged city GDP per capita* and *average unemployment rate* between 2015 and 2019 to represent the general economic level of a city. Following prior studies, we included the *sustainability level of a city* by calculating progresses of different targets under the Sustainable Development Goal 11 (sustainable cities and communities) developed by the UN (UN, 2022). We also adopted two measures to estimate the digital infrastructure of a city: the *proportion of households with internet connection* and the *proportion of residents with mobile telephone subscription*.

3.3.6 Model specification

Since we are interested in the role of various firm, network, industry, and city level factors on the survival of the CCI firms and the level the explanatory variables are measured at three levels, it is appropriate to adopt a multilevel approach. We built the three-level models by utilizing the lmer() function in the opensource platform R (West et al., 2015). We followed prior literature on fitting multilevel models without cross-level interactions and centering practices on three-level models. We centered the firm level and industry level variables by the centering within context method and the city level variables by the grand mean method and did not assign random slopes to the explanatory variables (Brincks et al., 2017; Heisig & Schaeffer, 2019). Main variables of the study were added step by step and the hypotheses were tested in several models.

3.4 Results

Table 3.1 reports the descriptive statistics of the variables. Table 3.2 presents the correlations between variables. No excessively high correlation coefficients were

observed between the variables. Table 3.3 reports the multilevel regression results on the survival of the CCI firms.

Table 3.1 Descriptive Statistics

	Min.	Max.	Mean	s.d.
Survival	0.000	23.000	22.482	2.730
Year of incorporation	1949.000	2019.000	2012.410	7.462
Logged registered capital	-9.210	14.042	6.039	1.809
Average tie duration	1970.000	2019.000	2015.095	5.280
Average year of incorporation	1949.000	2019.000	2011.522	7.256
Degree centrality	1.000	179.000	1.810	2.626
Proportion of digital partners	0.000	1.000	0.186	0.353
Core cultural activity	0.000	1.000	0.905	0.294
Logged average registered capital	2.748	11.591	6.394	0.675
Scale of the cultural activity	0.000	11.758	8.694	2.429
Digitalized cultural activity	0.000	1.000	0.300	0.458
Logged city GDP per capita	10.889	11.906	11.639	0.255
Unemployment rate	1.380	3.820	2.470	0.971
Internet access	0.193	0.604	0.330	0.070
Mobile telephone subscription	1.002	2.394	1.654	0.322

Table 3.2 Correlations

		1	2	3	4	5
1	Survival					
2	Year of incorporation	-0.006				
3	Logged registered capital	0.059**	-0.037**			
4	Average tie duration	0.033**	0.763**	0.037**		
5	Average year of incorporation	0.028**	0.569**	-0.008	0.681**	
6	Degree centrality	0.036**	-0.139**	0.246**	-0.059**	-0.017**
7	Proportion of digital partners	-0.010	0.087**	0.006	0.074**	0.070**
8	Core cultural activity	0.005	0.397**	-0.055**	0.330**	0.282**
9	Logged average registered capital	0.023**	0.014*	0.221**	0.052**	-0.013*
10	Scale of the cultural activity	0.048**	0.133**	-0.127**	0.160**	0.159**
11	Digitalized cultural activity	-0.027**	-0.018**	0.047**	-0.050**	-0.038**
12	Logged city GDP per capita	-0.005	-0.048**	-0.075**	-0.011	0.004
13	Unemployment rate	-0.031**	-0.036**	-0.022**	-0.142**	-0.059**
14	Internet access	-0.043**	0.074**	0.026**	0.012*	0.027**
15	Mobile telephone subscription	-0.001	0.065**	-0.042**	0.122**	0.076**

Note: *p < .05. **p < .01

Table 3.2 Correlations (continued)

6	7	8	9	10	11	12	13	14
0.029**								
-0.006	0.100**							
0.086**	0.064**	0.068**						
-0.018**	-0.060**	0.251**	-0.311**					
0.042**	0.152**	0.157**	0.196**	-0.342**				
0.024**	0.006	0.087**	-0.008	0.440**	-0.046**			
-0.036**	-0.027**	-0.073**	-0.207**	-0.278**	0.166**	-0.314**		
-0.040**	0.037**	-0.081**	-0.019**	-0.465**	0.126**	-0.144**	0.126**	
0.008	0.024**	0.065**	0.076**	0.206**	-0.039**	0.469**	-0.573**	0.010

Note: *p < .05. **p < .01

Table 3.3 Results of Multilevel Modelling Analysis

Level and variable	model 1	model 2	model 3	model 4
Intercept	22.140*** (0.148)	3.000 (7.597)	22.456*** (0.266)	22.655*** (0.321)
Level 1				
Year of incorporation		-0.027*** (0.004)	-0.024*** (0.004)	-0.024*** (0.004)
Logged registered capital		0.073*** (0.010)	0.072*** (0.010)	0.072*** (0.010)
Average tie duration		0.016*** (0.006)	0.031*** (0.006)	0.031*** (0.006)
Average year of incorporation of network partners		-0.066* (0.047)	0.006† (0.003)	0.006† (0.003)
Degree centrality		0.016* (0.006)	0.016* (0.007)	0.016* (0.007)
Proportion of digital partners		-0.066 (0.047)	-0.070 (0.048)	-0.070 (0.048)
Level 2				
Core cultural activity			-0.516*** (0.156)	-0.529*** (0.156)
Logged average registered capital			0.197** (0.068)	0.184** (0.068)
Scale of the cultural activity			0.098** (0.036)	0.094* (0.036)
Digitalized cultural activity			0.406** (0.129)	0.393** (0.129)
Level 3				
Logged city GDP per capita				0.064 (0.488)
Unemployment rate				-0.388† (0.221)

Internet access				-4.653* (1.865)
Mobile telephone subscription				-0.869† (0.460)
Variance components				
σ^2int: city	1.952	1.907	1.902	1.900
σ^2int: cultural activity	0.549	0.550	0.530	0.430
σ^2 (residual variance)	6.824	6.786	6.783	6.783
Model information criteria				
–2 RE/ML log-likelihood	127879.292	127767.064	127762.151	127748.155
AIC	127887.292	127787.064	127790.151	127784.155
BIC	127920.054	127868.966	127904.815	127931.580

Note: †p<0.1. *p < .05. **p < .01. ***p < .001.

Model 1 was built to determine the necessity of using the multilevel regression.

The firm level intraclass correlation (ICC) of 0.209 and the local industry level ICC of 0.058 suggested that there is significant variation in the dependence variable between firms and industries and thus it is necessary to adopt the multilevel models (Roback & Legler, 2021; Snijders & Bosker, 2012). Model 2 added firm-level variables. Model 3 added local industry level variables. Model 4 added city level variables.

Hypotheses 1a and 1b concern the relationships between firm level factors and the survival in the pandemic. We proposed that the more network partners a firm has in its ownership network, the more likely it will survive the pandemic. The significant and positive coefficients in Models 2-4 suggest that this is the case. Hypothesis 1b discussed the positive relationship between proportion of digital partners in a firm's ego network and firm survival in the pandemic. The empirical study did not find evidence to support this hypothesis.

Hypotheses 2a and 2b looked at the role of local cultural activity. As shown in Model 3 and Model 4, embedding in a large scale of the cultural activity is positively related to the survival in the pandemic and thus the hypothesis 2a was supported. Hypothesis 2b discussed whether belonging to a digital activity contributes to the survival in the pandemic. The significant and positive coefficients in Model 3 and Model 4 suggested that digital technologies indeed contribute to the survival in the pandemic.

Several control variables showed consistently significant relationships with the survival of firms. At the firm level, older and larger firms seem to be more likely to survive the pandemic, which might suggest that indeed experience, resources, and knowledge accumulated in the past lead to capabilities of coping with crises. Ties with a shorter duration are more likely to improve the possibility of surviving the crisis. At the local cultural activity level, core cultural activities that are more traditional and less integrated with other domains are more vulnerable to the pandemic. And the average size of firms in local activities is positively related to the survival of the pandemic. At the city level, internet access showed interesting and counterintuitive negative relationship with the survival of firms in the cities. The empirical study showed that the more advanced the

level of internet infrastructure of a city, the less likely the cultural firms in the city are to survive the pandemic. The measure used in this study for internet infrastructure is very general and thus the negative relationship might suggest that there are more nuances in the relationship between city infrastructure and the capability to survive the pandemic.

3.5 Discussion and conclusion

The CCIs are noted as "the industry of tomorrow" because of their contribution in providing youth employment, fostering innovation, and sustainable growth (UNESCO, 2017). The recent COVID-19 pandemic significantly changes many aspects of our social systems, business activities are halted, travel becomes restricted, and social gathering is reduced, just to name a few (OECD, 2020). The CCIs are no exception and are among the most heavily affected domains and experience a significant decrease in the output and employment (UNESCO, 2021a). It is thus necessary to evaluate what factors contribute to the survival capabilities of firms in these industries since this discussion would provide insights on the resilience of the CCIs and help develop strategies and policies to cope with future crises.

Although there is a growing understanding that cultural activities that are less dependent on social interaction and live audiences are more likely to transform their business activities online during the pandemic, damages of the health crisis have been observed in every subsector activity of these industries (UNESCO, 2021a). These observations indicate that the influence of the pandemic on cultural activities and businesses is more complex and that we need to identify what types of capabilities and structures of these industries contribute to firm resilience during the pandemic (Comunian & England, 2020).

This study contributes to this evaluation by adopting a multilevel framework and exploring the roles of firm level, local industry level, and city level factors in surviving the pandemic (Snijders & Bosker, 2012). We propose that a firm's survival in the pandemic depends not only on its internal capabilities but also on the network it is embedded in and the cultural activities it belongs to. More specifically, we empirically tested the role of digitalization both as an inter-firm network resource and as a firm capability and find evidence of a positive relationship between digitalized firm and

survival in the pandemic. We also propose and verify that a firm's number of network partners and the number of firms with the same type of cultural activity within local industries both contribute to its survival.

This study has two main contributions to the literature on the digitalization of the CCIs and firm resilience in the global crisis such as the COVID-19 pandemic.

First, this study developed a multilevel theoretical framework to disentangle the firm level, industry level, and city level factors to clarify the contribution of network partners and digitalization on dealing with challenges brought by the pandemic. The findings of this study shed lights on which features and capabilities are relevant to firm resilience and categorize them into different levels of the social systems. Therefore, strategizing and policy making would benefit from these insights and be more customized (Sharma et al., 2020).

Second, this study is one of the first to systematically evaluate CCI firm survival and resilience in the context of the pandemic. By collecting data on various firms located in different cities across China, this study provides initial evidence of how firms embedded in different networks, located in different geographic locations, and possessing heterogeneous resources are able to survive the pandemic. These findings could serve as the basis for future research on CCI development in emerging markets.

However, this research also bears some limitations due to data availability. First, this research made several unrealistic assumptions and simplified the ego networks of the CCI firms. Following prior research, we treated network ties as binary variables between two firms, that is, a tie either exists or does not, but in reality the strength of ties often matters as much as the existence of ties (Turkina & Van Assche, 2018). Also, since our dataset includes an extremely large scale of firms, it is possible that some specific features of the firms were omitted in our model. Moreover, since our study aims to explore the role of networks of the CCI firms, we ignored the isolated firms that did not form any network ties during the observation window. These simplifications could generate biased results of the study and we recommend future scholars collect more specific data to extend the framework developed in this study.

To summarize, this study built a three-level to explore the contributions of firm level, local industry level, and city level features to the survival of CCI firms' survival in the pandemic. We emphasize two sets of characteristics: digitalization and scale of economic activities. We find that degree centrality of a firm and the scale of local cultural activities are positively related to its survival. Although we do not find evidence of the contribution of digital network partners, we observe that digitalized CCI firms are more likely to survive. These findings provide insights on what capabilities and resources are relevant to the resilience of CCI firms in the crisis.

References

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, *45*(3), 425-455. https://doi.org/10.2307/2667105

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies*, *45*(7), 893-904. https://doi.org/10.1080/00343404.2010.543126

Aven, T., & Bouder, F. (2020). The COVID-19 pandemic: how can risk science help? *Journal of Risk Research*, *23*(7-8), 849-854.

Ayres, R. U., & Williams, E. (2004). The digital economy: Where do we stand? *Technological Forecasting and Social Change*, *71*(4), 315-339. https://doi.org/10.1016/j.techfore.2003.11.001

Banks, D. A. (2022). The attention economy of authentic cities: how cities behave like influencers. *European Planning Studies*, *30*(1), 195-209. https://doi.org/10.1080/09654313.2021.1882947

Banks, M., & O'Connor, J. (2021). "A Plague upon Your Howling": art and culture in the viral emergency. *Cultural Trends*, *30*(1), 3-18. https://doi.org/10.1080/09548963.2020.1827931

Benner, M. J., & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review*, *28*(2), 238-256.

Betzler, D., Loots, E., Prokupek, M., Marques, L., & Grafenauer, P. (2021). COVID-19 and the arts and cultural sectors: investigating countries' contextual factors and early policy measures. *International Journal of Cultural Policy*, *27*(6), 796-814. https://doi.org/10.1080/10286632.2020.1842383

Borgatti, S. P. (2005). Centrality and network flow. *Social Networks*, *27*(1), 55-71. https://doi.org/10.1016/j.socnet.2004.11.008

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. P. (2004). Taking stock of networks and organizations: A multilevel perspective. *Academy of Management Journal*, *47*(6), 795-817. https://doi.org/10.2307/20159624

Brincks, A. M., Enders, C. K., Llabre, M. M., Bulotsky-Shearer, R. J., Prado, G., & Feaster, D. J. (2017). Centering predictor variables in three-level contextual models. *Multivariate behavioral research*, *52*(2), 149-163.

Capron, E., Sagot-Duvauroux, D., & Suire, R. (2021). Anatomy of a techno-creative community – the role of brokers, places, and events in the emergence of projection mapping in Nantes. *European Planning Studies*, 1-22. https://doi.org/10.1080/09654313.2021.1959901

Carpenter, M. A., Li, M., & Jiang, H. (2012). Social network research in organizational contexts: A systematic review of methodological issues and choices. *Journal of Management*, *38*(4), 1328-1361.

Cerisola, S. (2019). A new perspective on the cultural heritage-development nexus: the role of creativity. *Journal of Cultural Economics*, *43*(1), 21-56. https://doi.org/10.1007/s10824-018-9328-2

Chandna, V., & Salimath, M. S. (2020). When technology shapes community in the Cultural and Craft Industries: Understanding virtual entrepreneurship in online ecosystems. *Technovation*, *92-93*, Article 102042. https://doi.org/10.1016/j.technovation.2018.06.005

Comunian, R., & England, L. (2020). Creative and cultural work without filters: Covid-19 and exposed precarity in the creative economy. *Cultural Trends*, *29*(2), 112-128. https://doi.org/10.1080/09548963.2020.1770577

Costa, P. (2022). Valuing culture and creativity impacts in a global technological era: reshaping the analytical framework. *European Planning Studies*, 1-20.

Cruz, S. C. S., & Teixeira, A. A. C. (2021). Spatial analysis of new firm formation in creative industries before and during the world economic crisis. *Annals of Regional Science*, *67*(2), 385-413. https://doi.org/10.1007/s00168-021-01052-3

Delmestri, G., Montanari, F., & Usai, A. (2005). Reputation and strength of ties in predicting commercial success and artistic merit of independents in the Italian feature film industry. *Journal of Management Studies*, *42*(5), 975-1002.

Donthu, N., & Gustafsson, A. (2020). Effects of COVID-19 on business and research. *Journal of Business Research*, *117*, 284-289. https://doi.org/10.1016/j.jbusres.2020.06.008

Escalona-Orcao, A., Barrado-Timon, D. A., Escolano-Utrilla, S., Sanchez-Valverde, B., Navarro-Perez, M., Pinillos-Garcia, M., & Saez-Perez, L. A. (2021). Cultural and Creative Ecosystems in Medium-Sized Cities: Evolution in Times of Economic Crisis and Pandemic. *Sustainability*, *13*(1), Article 49. https://doi.org/10.3390/su13010049

Fernandez, J. A. S., Martinez, J. M. G., & Martin, J. M. M. (2022). An analysis of the competitiveness of the tourism industry in a context of economic recovery following the COVID19 pandemic. *Technological Forecasting and Social Change*, *174*, Article 121301. https://doi.org/10.1016/j.techfore.2021.121301

Francioni, B., Vissak, T., & Musso, F. (2017). Small Italian wine producers' internationalization: The role of network relationships in the emergence of late starters. *International Business Review*, *26*(1), 12-22. https://doi.org/10.1016/j.ibusrev.2016.05.003

Ghasemzadeh, K., Bortoluzzi, G., & Yordanova, Z. (2022). Collaborating with users to innovate: A systematic literature review. *Technovation*, *116*, Article 102487. https://doi.org/10.1016/j.technovation.2022.102487

Grigoriou, K., & Rothaermel, F. T. (2014). Structural Microfoundations of Innovation: The Role of Relational Stars. *Journal of Management*, *40*(2), 586-615. https://doi.org/10.1177/0149206313513612

Grigoriou, K., & Rothaermel, F. T. (2017). Organizing for Knowledge Generation: Internal Knowledge Networks and the Contingent Effect of External Knowledge Sourcing. *Strategic Management Journal*, *38*(2), 395-414. https://doi.org/10.1002/smj.2489

Gu, X., Domer, N., & O'Connor, J. (2021). The next normal: Chinese indie music in a post-COVID China. *Cultural Trends*, *30*(1), 63-74. https://doi.org/10.1080/09548963.2020.1846122

Guan, J. C., & Liu, N. (2016). Exploitative and exploratory innovations in knowledge network and collaboration network: A patent analysis in the technological field of nano-energy. *Research Policy*, *45*(1), 97-112. https://doi.org/10.1016/j.respol.2015.08.002

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203-215. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<203::Aid-smj102>3.0.Co;2-k

Handke, C., & Towse, R. (2013). Introduction. In R. Towse & C. Handke (Eds.), *Handbook on the digital creative economy* (pp. xiii, 441 pages). Edward Elgar.

Hansen, M. T., Mors, M. L., & Løvås, B. (2005). Knowledge sharing in organizations: Multiple networks, multiple phases. *Academy of Management Journal*, *48*(5), 776-793.

Heisig, J. P., & Schaeffer, M. (2019). Why You Should Always Include a Random Slope for the Lower-Level Variable Involved in a Cross-Level Interaction. *European Sociological Review*, *35*(2), 258-279. https://doi.org/10.1093/esr/jcy053

Hirsch, P. M. (2000). Cultural industries revisited. *Organization Science*, *11*(3), 356-361. https://doi.org/10.1287/orsc.11.3.356.12498

Hoang, H., & Rothaermel, F. T. (2010). Leveraging internal and external experience: exploration, exploitation, and R&D project performance. *Strategic Management Journal*, *31*(7), 734-758.

Holcombe-James, I. (2021). Digital access, skills, and dollars: applying a framework to digital exclusion in cultural institutions. *Cultural Trends*, 1-17. https://doi.org/10.1080/09548963.2021.1972282

Hosagrahar, J. (2017). *Culture: at the heart of SDGs*. https://en.unesco.org/courier/april-june-2017/culture-heart-sdgs

Hracs, B. J. (2015). Cultural Intermediaries in the Digital Age: The Case of Independent Musicians and Managers in Toronto. *Regional Studies*, *49*(3), 461-475. https://doi.org/10.1080/00343404.2012.750425

Hurmelinna-Laukkanen, P., Natti, S., & Pikkarainen, M. (2021). Orchestrating for lead user involvement in innovation networks. *Technovation*, *108*, Article 102326. https://doi.org/10.1016/j.technovation.2021.102326

Ibarra, H. (1993). Network Centrality, Power, and Innovation Involvement - Determinants of Technical and Administrative Roles. *Academy of Management Journal*, *36*(3), 471-501. https://doi.org/10.2307/256589

Jackson, M. O. (2008). *Social and Economic Networks*. https://doi.org/10.1515/9781400833993

Johns, J. (2006). Video games production networks': value capture, power relations and embeddedness. *Journal of Economic Geography*, *6*(2), 151-180. https://doi.org/10.1093/jeg/lbi001

Kadushin, C. (2012). *Understanding social networks : theories, concepts, and findings*. Oxford University Press.

Khlystova, O., Kalyuzhnova, Y., & Belitski, M. (2022). The impact of the COVID-19 pandemic on the creative industries: A literature review and future research agenda. *Journal of Business Research*, *139*, 1192-1210. https://doi.org/10.1016/j.jbusres.2021.09.062

Landoni, P., Dell'era, C., Frattini, F., Petruzzelli, A. M., Verganti, R., & Manelli, L. (2020). Business model innovation in cultural and creative industries: Insights from three leading mobile gaming firms. *Technovation*, *92-93*, Article 102084. https://doi.org/10.1016/j.technovation.2019.102084

Lazzeretti, L., Oliva, S., Innocenti, N., & Capone, F. (2022). Rethinking culture and creativity in the digital transformation. *European Planning Studies*, 1-9. https://doi.org/10.1080/09654313.2022.2052018

Lee, M. (2015). Fostering connectivity: a social network analysis of entrepreneurs in creative industries. *International Journal of Cultural Policy*, *21*(2), 139-152. https://doi.org/10.1080/10286632.2014.891021

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation*, *92-93*, Article 102012. https://doi.org/10.1016/j.technovation.2017.12.004

Lorenzen, M., & Taube, F. A. (2008). Breakout from Bollywood? The roles of social networks and regulation in the evolution of Indian film industry. *Journal of International Management*, *14*(3), 286-299. https://doi.org/10.1016/j.intman.2008.01.004

Lowe, M. S., Williams, A. M., Shaw, G., & Cudworth, K. (2012). Self-organizing innovation networks, mobile knowledge carriers and diasporas: insights from a

pioneering boutique hotel chain. *Journal of Economic Geography*, *12*(5), 1113-1138. https://doi.org/10.1093/jeg/lbs021

Luo, J.-D. (2005). Particularistic trust and general trust: A network analysis in chinese organizations [1]. *Management and Organization Review*, *1*(3), 437-458.

Mangematin, V., Sapsed, J., & Schussler, E. (2014). Disassembly and reassembly: An introduction to the Special Issue on digital technology and creative industries. *Technological Forecasting and Social Change*, *83*, 1-9. https://doi.org/10.1016/j.techfore.2014.01.002

Martin, R. (2013). Differentiated Knowledge Bases and the Nature of Innovation Networks. *European Planning Studies*, *21*(9), 1418-1436. https://doi.org/10.1080/09654313.2012.755836

Martin, R., & Moodysson, J. (2011). Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies*, *19*(7), 1183-1203. https://doi.org/10.1080/09654313.2011.573131

NBS. (2018). *Classification of Culture and Related Industries (2018)*. http://www.stats.gov.cn/tjsj/tjbz/201805/t20180509_1598314.html

NBS. (2020). *China Statistical Yearbook on Culture and Related Industries*. China Statistics Press.

NBS. (2021). *Classification of Digital Economy and Its Core Industries (2018)*. http://www.stats.gov.cn/tjgz/tzgb/202106/t20210603_1818129.html

Nocca, F. (2017). The Role of Cultural Heritage in Sustainable Development: Multidimensional Indicators as Decision-Making Tool. *Sustainability*, *9*(10), Article 1882. https://doi.org/10.3390/su9101882

O'Connor, J. (2009). Creative industries: a new direction? *International Journal of Cultural Policy*, *15*(4), 387-402.

OECD. (2020). *Culture shock: COVID-19 and the cultural and creative sectors*. https://www.oecd.org/coronavirus/policy-responses/culture-shock-covid-19-and-the-cultural-and-creative-sectors-08da9e0e/

Pagan, E. A., Salvatella, M. D. G., Pitarch, M. D., Munoz, A. L., Toledo, M. D. M., Ruiz, J. M., Vitella, M., Lo Cicero, G., Rottensteiner, F., Clermont, D., Dorozynski, M., Wittich, D., Vernus, P., & Puren, M. (2020). From Silk to Digital Technologies: A

Gateway to New Opportunities for Creative Industries, Traditional Crafts and Designers. The SILKNOW Case. *Sustainability*, *12*(19), Article 8279. https://doi.org/10.3390/su12198279

Parmentier, G., & Mangematin, V. (2014). Orchestrating innovation with user communities in the creative industries. *Technological Forecasting and Social Change*, *83*, 40-53. https://doi.org/10.1016/j.techfore.2013.03.007

Peukert, C. (2019). The next wave of digital technological change and the cultural industries. *Journal of Cultural Economics*, *43*(2), 189-210. https://doi.org/10.1007/s10824-018-9336-2

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890-913. https://doi.org/10.5465/amj.2010.52814627

Potts, J., Cunningham, S., Hartley, J., & Ormerod, P. (2008). Social network markets: a new definition of the creative industries. *Journal of Cultural Economics*, *32*(3), 167-185.

Powell, W. W., Koput, K. W., & SmithDoerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, *41*(1), 116-145. https://doi.org/10.2307/2393988

Pratt, A. C. (2008). Creative cities: The cultural industries and the creative class. *Geografiska Annaler Series B-Human Geography*, *90B*(2), 107-117. https://doi.org/10.1111/j.1468-0467.2008.00281.x

Raimo, N., De Turi, I., Ricciardelli, A., & Vitolla, F. (2021). Digitalization in the cultural industry: evidence from Italian museums. *International Journal of Entrepreneurial Behavior & Research*. https://doi.org/10.1108/ijebr-01-2021-0082

Rios-Ballesteros, N., & Fuerst, S. (2021). Exploring the enablers and microfoundations of international knowledge transfer. *Journal of Knowledge Management*. https://doi.org/10.1108/jkm-04-2021-0344

Rivero, P., Navarro-Neri, I., Garcia-Ceballos, S., & Aso, B. (2020). Spanish Archaeological Museums during COVID-19 (2020): An Edu-Communicative Analysis of Their Activity on Twitter through the Sustainable Development Goals. *Sustainability*, *12*(19), Article 8224. https://doi.org/10.3390/su12198224

Roback, P., & Legler, J. (2021). *Beyond multiple linear regression : applied generalized linear models and multilevel models in* (1. ed.). CRC Press.

Rothaermel, F. T., & Alexandre, M. T. (2009). Ambidexterity in Technology Sourcing: The Moderating Role of Absorptive Capacity. *Organization Science*, *20*(4), 759-780. https://doi.org/10.1287/orsc.1080.0404

Ruling, C. C., & Duymedjian, R. (2014). Digital bricolage: Resources and coordination in the production of digital visual effects. *Technological Forecasting and Social Change*, *83*, 98-110. https://doi.org/10.1016/j.techfore.2013.05.003

Ryu, S., & Cho, D. (2022). The show must go on? The entertainment industry during (and after) COVID-19. *Media Culture & Society*, *44*(3), 591-600, Article 01634437221079561. https://doi.org/10.1177/01634437221079561

Santoro, G., Bresciani, S., & Papa, A. (2020). Collaborative modes with Cultural and Creative Industries and innovation performance: The moderating role of heterogeneous sources of knowledge and absorptive capacity. *Technovation*, *92-93*, Article 102040. https://doi.org/10.1016/j.technovation.2018.06.003

Scott, A. (1997). The Cultural Economy of Cities. *International Journal of Urban and Regional Research*, *21*(2), 323-339.

Scott, A. J. (2006). Creative cities: Conceptual issues and policy questions. *Journal of Urban Affairs*, *28*(1), 1-17. https://doi.org/10.1111/j.0735-2166.2006.00256.x

Sedita, S. R., & Ozeki, T. (2021). Path renewal dynamics in the Kyoto kimono cluster: how to revitalize cultural heritage through digitalization. *European Planning Studies*, 1-19. https://doi.org/10.1080/09654313.2021.1972938

Sharma, P., Leung, T. Y., Kingshott, R. P. J., Davcik, N. S., & Cardinali, S. (2020). Managing uncertainty during a global pandemic: An international business perspective. *Journal of Business Research*, *116*, 188-192. https://doi.org/10.1016/j.jbusres.2020.05.026

Snijders, T. A. B., & Bosker, R. J. (2012). *Multilevel analysis : an introduction to basic and advanced multilevel modeling* (2nd ed.). Sage.

Snowball, J., Tarentaal, D., & Sapsed, J. (2021). Innovation and diversity in the digital cultural and creative industries. *Journal of Cultural Economics*, *45*(4), 705-733. https://doi.org/10.1007/s10824-021-09420-9

Sorensen, J. B., & Stuart, T. E. (2000). Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, *45*(1), 81-112. https://doi.org/10.2307/2666980

Sturgeon, T. J. (2021). Upgrading strategies for the digital economy. *Global Strategy Journal*, *11*(1), 34-57. https://doi.org/10.1002/gsj.1364

Tan, J., Yang, J., & Veliyath, R. (2009). Particularistic and system trust among small and medium enterprises: A comparative study in China's transition economy. *Journal of Business Venturing*, *24*(6), 544-557.

Tao, J., Ho, C.-Y., Luo, S., & Sheng, Y. (2019). Agglomeration economies in creative industries. *Regional Science and Urban Economics*, *77*, 141-154.

Throsby, C. D. (2001). *Economics and culture*. Cambridge University Press.

Turkina, E., & Van Assche, A. (2018). Global connectedness and local innovation in industrial clusters. *Journal of International Business Studies*, *49*(6), 706-728. https://doi.org/10.1057/s41267-018-0153-9

UN. (2017). *New Urban Agenda*. United Nations.

UN. (2019). *International Year of Creative Economy for Sustainable Development, 2021*. https://documents-dds-ny.un.org/doc/UNDOC/LTD/N19/359/41/PDF/N1935941.pdf

UN. (2022). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202022%20refinement_Eng.pdf

UNCTAD. (2019). *Digital Economy Report 2019: Value Creation and Capture: Implications for Developing Countries*. https://unctad.org/system/files/official-document/der2019_en.pdf

UNCTAD, & UNDP. (2008). *Creative economy report 2008 : the challenge of assessing the creative economy : towards informed policy-making*. United Nations. http://ssc.undp.org/creative_economy Full text English version and overview section in French and in Spanish

UNESCO-UIS. (2009). *2009 UNESCO Framework for Cultural Statistics*. http://uis.unesco.org/sites/default/files/documents/unesco-framework-for-cultural-statistics-2009-en_0.pdf

UNESCO. (2017). *Re|shaping cultural policies: advancing creativity for development, 2005 Convention global report, 2018*. https://unesdoc.unesco.org/ark:/48223/pf0000260592

UNESCO. (2020). *Museums around the world in the face of COVID-19*. https://unesdoc.unesco.org/ark:/48223/pf0000373530

UNESCO. (2021a). *Cultural and creative industries in the face of COVID-19: an economic impact outlook*. https://unesdoc.unesco.org/ark:/48223/pf0000377863

UNESCO. (2021b). *UNESCO Roadmap for International Year of Creative Economy for Sustainable Development 2021*. https://en.unesco.org/sites/default/files/creative_economy2021-unesco-roadmapen-ok2.pdf

UNESCO. (2022). *Re|shaping policies for creativity: addressing culture as a global public good*. https://unesdoc.unesco.org/ark:/48223/pf0000380474

UNESCO, & World Bank. (2021). *Cities, Culture, Creativity : Leveraging Culture and Creativity for Sustainable Urban Development and Inclusive Growth* https://openknowledge.worldbank.org/handle/10986/35621

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*(2), 447-504. https://doi.org/10.1086/432782

Verma, S., & Gustafsson, A. (2020). Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. *Journal of Business Research*, *118*, 253-261.

Vlassis, A. (2021). Global online platforms, COVID-19, and culture: The global pandemic, an accelerator towards which direction? *Media Culture & Society*, *43*(5), 957-969, Article 0163443721994537. https://doi.org/10.1177/0163443721994537

Von Hippel, E. (1986). LEAD USERS - A SOURCE OF NOVEL PRODUCT CONCEPTS. *Management Science*, *32*(7), 791-805. https://doi.org/10.1287/mnsc.32.7.791

Wadhwa, A., & Kotha, S. (2006). Knowledge creation through external venturing: Evidence from the telecommunications equipment manufacturing industry. *Academy of Management Journal*, *49*(4), 819-835. <Go to ISI>://WOS:000240503600013

Wang, C. L., Rodan, S., Fruin, M., & Xu, X. Y. (2014). Knowledge Networks, Collaboration Networks, and Exploratory Innovation. *Academy of Management Journal*, *57*(2), 484-514. https://doi.org/10.5465/amj.2011.0917

Wang, S. L., Gu, Q., Von Glinow, M. A., & Hirsch, P. (2020). Cultural industries in international business research: Progress and prospect. *Journal of International Business Studies*, *51*(4), 665-692. https://doi.org/10.1057/s41267-020-00306-0

Wasko, M. M., & 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., & Faust, K. (1994). *Social Network Analysis*. https://doi.org/10.1017/cbo9780511815478

Watson, A. (2020). Not all roads lead to London: insularity, disconnection and the challenge to 'regional' creative industries policy. *Regional Studies*, *54*(11), 1574-1584. https://doi.org/10.1080/00343404.2020.1738012

West, B. T., Welch, K. B., & Gałecki, A. T. (2015). *Linear mixed models : a practical guide using statistical software* (2nd ed.). CRC Press, Taylor & Francis Group.

Wittel, A. (2001). Toward a network sociality. *Theory Culture & Society*, *18*(6), 51-+. https://doi.org/10.1177/026327601018006003

World Heritage Centre. (2021). *Special Issue - World Heritage in China*. UNESCO. https://whc.unesco.org/en/review/99

Worsley, J., Billington, J., Balabanova, E., & Watkins, M. (2022). Regional Innovation in Arts Provision Spawned by COVID-19: "It Became a Lifeline for a Lot of People Who Are Stuck at Home". *Frontiers in Public Health*, *10*, Article 753973. https://doi.org/10.3389/fpubh.2022.753973

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. *Organization Science*, *23*(5), 1398-1408. https://doi.org/10.1287/orsc.1120.0771

Yue, A. (2022). Conjunctions of resilience and the Covid-19 crisis of the creative cultural industries. *International Journal of Cultural Studies*, Article 13678779221091293. https://doi.org/10.1177/13678779221091293

Conclusion

This thesis addresses the under-explored links between multilevel networks, innovation and creativity, and sustainable development by conducting network analysis in two knowledge-intensive industries in an emerging market. The three main chapters of the thesis focus on the performance implication of multilevel features of knowledge networks, the contribution of cultural heritage networks to the SDG progress, and the capabilities of the CCI firms to survive the pandemic respectively.

This thesis combines theories and arguments developed in network analysis, economic geography, and innovation literatures to develop comprehensive frameworks that aim to provide a better understanding of innovation in networks and its role in dealing sustainability challenges (Asheim et al., 2011; Bathelt & Cohendet, 2014; Phelps et al., 2012).

The empirical study conducted on the railway industry shed light on the proposed relationships that multilevel network structures have heterogeneous implications on innovation performance. In the second chapter, the empirical analysis on the CCIs extends the conclusion of the first chapter analyzes the contribution of CCI networks related to cultural heritage across 294 cities to local SDGs in China. The empirical study of the last chapter examines the capabilities of 26,643 CCI firms to survive the pandemic.

Chapter 1 builds the theoretical foundation of the relationships between multilevel network structures and innovation performance. It explores the roles of two important network structural features, brokerage and density, in three level networks composed of patent networks, interpersonal networks, and interorganizational networks. It distinguishes the effects of network density of different networks and confirms the consistent role of network brokerage in delivering innovation outcomes. By adopting a multilevel framework, this study explains the heterogeneous contributions of different types of networks and sheds light on strategies of utilizing resources embedded in networks that nest into each other (Paruchuri et al., 2019). This study highlights that for organizations aiming to innovate that multilevel knowledge networks are crucial in

knowledge creation and that firms need to acknowledge the potential heterogeneity of network implications. By laying the theoretical foundation that innovation depends on networks, this chapter provides the overarching framework for the subsequent chapters.

Chapter 2 discusses the relationships between CCI networks and local SDG progress. This study identifies three mechanisms through which the CCIs can be beneficial for local social, economic, and cultural development, namely the direct innovation and creativity path, the indirect employment provider, and the overarching lifestyle shaping role (UNESCO & World Bank, 2021). Using the cultural heritage related CCI ownership networks in 294 cities in China as the research setting, this study illustrates that the scale of CCIs and the density of local cultural heritage ownership networks contribute to the progress of sustainable development. Moreover, it highlights the dynamics of trans-local knowledge creation and indicates that trans-local network ties also matter for local sustainability since they bring novel knowledge and complementary resources.

Chapter 3 examines the resilience of the CCI firms in the COVID-19 pandemic. One of the challenges faced by the CCIs is the restriction of in person social contact, which makes the performance and operation of cultural activities extremely difficult. Thus this study argues that digitalization is one of the critical conditions for CCI firms to survive the crisis (Comunian & England, 2020; Li, 2020; OECD, 2020). Building on the theoretical frameworks and empirical evidence obtained in the first two chapters, this study extends the argument that knowledge networks help firms to get necessary knowledge and resources to the context of the pandemic. The multilevel analysis of both firm level and industry level factors supports the propositions. By obtaining empirical results of how CCI firms cope with the pandemic by new technologies and network strategies, this study concludes the thesis by testing the network effectiveness in one of the most challenging crises that seriously undermines the progress towards sustainable future and offers practical implications on how to develop capabilities to survive the challenges.

This thesis as a holistic study has two important implications. First, it builds comprehensive multilevel frameworks that not only incorporate organizational level performance but also regional development. After carefully arguing that organizational

networks can be viewed as multilevel systems and constructing a three-level network composed of patent, individual, and interorganizational networks, the first chapter provides empirical evidence that different layers of networks collectively and heterogeneously contribute to organizational performance (Paruchuri et al., 2019). The thesis also explores beyond the organizational level and discusses important societal challenges that require collaboration within knowledge networks at regional level. Given the concentration of knowledge activities in urban communities, this dual consideration of both organizational and city development helps provide a whole picture of the implications of networks at different levels of our social systems.

Second, this thesis brings together innovation and sustainability by highlighting the role of knowledge networks. There is a growing consensus that many of the grand challenges in our societies require innovative and creative solutions (UNESCO, 2021). This thesis contributes to this discussion by pointing out several knowledge mechanisms at different levels of knowledge activities through building networks. Three mechanisms through which knowledge networks link innovative actors, organizational performance, and societal development are identified in this thesis: the direct knowledge transfer channel that provides knowledge and resources, the indirect spillover that boosts local community building, and the overarching value system building that guide citizens towards sustainable lifestyles (Auclair & Fairclough, 2015; George et al., 2016; Štreimikienė & Kačerauskas, 2020; UN, 2019). These mechanisms provide insights on the interactive and synergetic nature of relying on economic actors, networks between entities, and knowledge circulation within local communities to build sustainable communities and cities. It thus moves beyond actor centric development logics and takes the complex and systematic nature of partnership and collaboration into the consideration, which leads to a more thorough understanding of the possible strategies towards a sustainable future (UN, 2022).

This thesis has several limitations that should be treated with caution and addressed by future research. Although the data for the chapters were collected in different industries, they are all from a single emerging market and thus the generalizability is limited if no comparative studies on other research settings were conducted. Due to data availability,

this thesis mostly relies on secondary public data sources and thus selection bias cannot be ruled out and strict causality mechanisms are not readily feasible. Future studies can build on the theoretical frameworks built in this thesis and examine similar network dynamics in different industries and countries to obtain a comprehensive understanding of the relationships between networks, innovation, and sustainability.

References

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. Regional Studies, 45(7), 893-904. https://doi.org/10.1080/00343404.2010.543126

Auclair, E., & Fairclough, G. (2015). Living between past and future: An introduction to heritage and cultural sustainability. In E. Auclair & G. Fairclough (Eds.), Theory and practice in heritage and sustainability: Between past and future. Routledge.

Bathelt, H., & Cohendet, P. (2014). The creation of knowledge: local building, global accessing and economic development-toward an agenda. Journal of Economic Geography, 14(5), 869-882. https://doi.org/10.1093/jeg/lbu027

Comunian, R., & England, L. (2020). Creative and cultural work without filters: Covid-19 and exposed precarity in the creative economy. Cultural Trends, 29(2), 112-128. https://doi.org/10.1080/09548963.2020.1770577

George, G., Howard-Grenville, J., Joshi, A., & Tihanyi, L. (2016). Understanding and tackling societal grand challenges through management research. Academy of Management Journal, 59(6), 1880-1895.

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. Technovation, 92-93, Article 102012. https://doi.org/10.1016/j.technovation.2017.12.004

OECD. (2020). Culture shock: COVID-19 and the cultural and creative sectors. https://www.oecd.org/coronavirus/policy-responses/culture-shock-covid-19-and-the-cultural-and-creative-sectors-08da9e0e/

Paruchuri, S., Goossen, M. C., & Phelps, C. (2019). Conceptual foundations of multilevel social networks. In S. E. L. Humphrey, James M. (Ed.), The handbook of multilevel

theory, measurement, and analysis (First Edition. ed.). American Psychological Association,.

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. Journal of Management, 38(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Štreimikienė, D., & Kačerauskas, T. (2020). The creative economy and sustainable development: The Baltic States. Sustainable Development, 28(6), 1632-1641.

UN. (2019). International Year of Creative Economy for Sustainable Development, 2021. https://documents-dds-ny.un.org/doc/UNDOC/LTD/N19/359/41/PDF/N1935941.pdf

UN. (2022). Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202022%20refinement_Eng.pdf

UNESCO. (2021). UNESCO Roadmap for International Year of Creative Economy for Sustainable Development 2021. https://en.unesco.org/sites/default/files/creative_economy2021-unesco-roadmapen-ok2.pdf

UNESCO, & World Bank. (2021). Cities, Culture, Creativity: Leveraging Culture and Creativity for Sustainable Urban Development and Inclusive Growth https://openknowledge.worldbank.org/handle/10986/35621

Bibliography

Acedo, F. J., Barroso, C., Casanueva, C., & Galan, J. L. (2006). Co-authorship in management and organizational studies: An empirical and network analysis. *Journal of Management Studies*, *43*(5), 957-983. https://doi.org/10.1111/j.1467-6486.2006.00625.x

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, *45*(3), 425-455. https://doi.org/10.2307/2667105

Ahuja, G., Lampert, C. M., & Tandon, V. (2008). Moving Beyond Schumpeter: Management Research on the Determinants of Technological Innovation. *Academy of Management Annals*, *2*(1), 1-98. https://doi.org/10.5465/19416520802211446

Almeida, P., & Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, *45*(7), 905-917. https://doi.org/10.1287/mnsc.45.7.905

Argote, L., & Ingram, P. (2000). Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes*, *82*(1), 150-169. https://doi.org/10.1006/obhd.2000.2893

Argote, L., & Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science*, *22*(5), 1123-1137. https://doi.org/10.1287/orsc.1100.0621

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies*, *45*(7), 893-904. https://doi.org/10.1080/00343404.2010.543126

Auclair, E., & Fairclough, G. (2015). Living between past and future: An introduction to heritage and cultural sustainability. In E. Auclair & G. Fairclough (Eds.), *Theory and practice in heritage and sustainability: Between past and future*. Routledge.

Aven, T., & Bouder, F. (2020). The COVID-19 pandemic: how can risk science help? *Journal of Risk Research*, *23*(7-8), 849-854.

Ayres, R. U., & Williams, E. (2004). The digital economy: Where do we stand? *Technological Forecasting and Social Change*, *71*(4), 315-339. https://doi.org/10.1016/j.techfore.2003.11.001

Azoulay, P., Zivin, J. S. G., & Wang, J. L. (2010). Superstar Extinction. *Quarterly Journal of Economics*, *125*(2), 549-589. https://doi.org/10.1162/qjec.2010.125.2.549

Bakhshi, H., & McVittie, E. (2009). Creative supply-chain linkages and innovation: Do the creative industries stimulate business innovation in the wider economy? *Innovation-Management Policy & Practice*, *11*(2), 169-189. https://doi.org/10.5172/impp.11.2.169

Balachandran, S., & Hernandez, E. (2018). Networks and Innovation: Accounting for Structural and Institutional Sources of Recombination in Brokerage Triads. *Organization Science*, *29*(1), 80-99. https://doi.org/10.1287/orsc.2017.1165

Banks, D. A. (2022). The attention economy of authentic cities: how cities behave like influencers. *European Planning Studies*, *30*(1), 195-209. https://doi.org/10.1080/09654313.2021.1882947

Banks, M., & O'Connor, J. (2021). "A Plague upon Your Howling": art and culture in the viral emergency. *Cultural Trends*, *30*(1), 3-18. https://doi.org/10.1080/09548963.2020.1827931

Bathelt, H., & Cohendet, P. (2014). The creation of knowledge: local building, global accessing and economic development-toward an agenda. *Journal of Economic Geography*, *14*(5), 869-882. https://doi.org/10.1093/jeg/lbu027

Bathelt, H., & Li, P.-F. (2014). Global cluster networks—foreign direct investment flows from Canada to China. *Journal of Economic Geography*, *14*(1), 45-71. https://www.jstor.org/stable/26158716

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, *28*(1), 31-56. https://doi.org/10.1191/0309132504ph469oa

Beaudry, C., & Allaoui, S. (2012). Impact of public and private research funding on scientific production: The case of nanotechnology. *Research Policy*, *41*(9), 1589-1606. https://doi.org/10.1016/j.respol.2012.03.022

Beckman, C. M., Haunschild, P. R., & Phillips, D. J. (2004). Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. *Organization Science*, *15*(3), 259-275. https://doi.org/10.1287/orsc.1040.0065

Benner, M. J., & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review*, *28*(2), 238-256.

Bergenholtz, C., & Waldstrøm, C. (2011). Inter-Organizational Network Studies—A Literature Review. *Industry and Innovation*, *18*(6), 539-562. https://doi.org/10.1080/13662716.2011.591966

Betzler, D., Loots, E., Prokupek, M., Marques, L., & Grafenauer, P. (2021). COVID-19 and the arts and cultural sectors: investigating countries' contextual factors and early policy measures. *International Journal of Cultural Policy*, *27*(6), 796-814. https://doi.org/10.1080/10286632.2020.1842383

Bizzi, L. (2013). The Dark Side of Structural Holes: A Multilevel Investigation. *Journal of Management*, *39*(6), 1554-1578. https://doi.org/10.1177/0149206312471385

Bjork, J., Di Vincenzo, F., Magnusson, M., & Mascia, D. (2011). The Impact of Social Capital on Ideation. *Industry and Innovation*, *18*(6), 631-647. https://doi.org/10.1080/13662716.2011.591976

Borgatti, S. P. (2005). Centrality and network flow. *Social Networks*, *27*(1), 55-71. https://doi.org/10.1016/j.socnet.2004.11.008

Borgatti, S. P., & Li, X. (2009). On Social Network Analysis in a Supply Chain Context. *Journal of Supply Chain Management*, *45*(2), 5-22. https://doi.org/10.1111/j.1745-493X.2009.03166.x

Brandes, U., Borgatti, S. P., & Freeman, L. C. (2016). Maintaining the duality of closeness and betweenness centrality. *Social Networks*, *44*, 153-159. https://doi.org/10.1016/j.socnet.2015.08.003

Brass, D. J. (2022). New Developments in Social Network Analysis. *Annual Review of Organizational Psychology and Organizational Behavior*, *9*(1), 225-246. https://doi.org/10.1146/annurev-orgpsych-012420-090628

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. P. (2004). Taking stock of networks and organizations: A multilevel perspective. *Academy of Management Journal*, *47*(6), 795-817. https://doi.org/10.2307/20159624

Brennecke, J., & Rank, O. (2017). The firm's knowledge network and the transfer of advice among corporate inventors-A multilevel network study. *Research Policy*, *46*(4), 768-783. https://doi.org/10.1016/j.respol.2017.02.002

Brennecke, J., & Stoemmer, N. (2018). The Network-Performance Relationship in Knowledge-Intensive ContextsA Meta-Analysis and Cross-Level Comparison. *Human Resource Management*, *57*(1), 11-36. https://doi.org/10.1002/hrm.21823

Brincks, A. M., Enders, C. K., Llabre, M. M., Bulotsky-Shearer, R. J., Prado, G., & Feaster, D. J. (2017). Centering predictor variables in three-level contextual models. *Multivariate behavioral research*, *52*(2), 149-163.

Burford, G., Hoover, E., Velasco, I., Janouskova, S., Jimenez, A., Piggot, G., Podger, D., & Harder, M. K. (2013). Bringing the "Missing Pillar" into Sustainable Development Goals: Towards Intersubjective Values-Based Indicators. *Sustainability*, *5*(7), 3035-3059. https://doi.org/10.3390/su5073035

Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*. Harvard University Press.

Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, *110*(2), 349-399. https://doi.org/10.1086/421787

Capron, E., Sagot-Duvauroux, D., & Suire, R. (2021). Anatomy of a techno-creative community – the role of brokers, places, and events in the emergence of projection mapping in Nantes. *European Planning Studies*, 1-22. https://doi.org/10.1080/09654313.2021.1959901

Carnabuci, G., & Operti, E. (2013). Where Do Firms' Recombinant Capabilities Come From? Intraorganizational Networks, Knowledge, and Firms' Ability to Innovate Through Technological Recombination. *Strategic Management Journal*, *34*(13), 1591-1613. https://doi.org/10.1002/smj.2084

Carpenter, M. A., Li, M., & Jiang, H. (2012). Social network research in organizational contexts: A systematic review of methodological issues and choices. *Journal of Management*, *38*(4), 1328-1361.

Cattaneo, T., Giorgi, E., Flores, M., & Barquero, V. (2020). Territorial Effects of Shared-Living Heritage Regeneration. *Sustainability*, *12*(20), Article 8616. https://doi.org/10.3390/su12208616

Cerisola, S. (2019). A new perspective on the cultural heritage-development nexus: the role of creativity. *Journal of Cultural Economics*, *43*(1), 21-56. https://doi.org/10.1007/s10824-018-9328-2

Cerisola, S., & Panzera, E. (2021). Cultural and Creative Cities and Regional Economic Efficiency: Context Conditions as Catalyzers of Cultural Vibrancy and Creative Economy. *Sustainability*, *13*(13), Article 7150. https://doi.org/10.3390/su13137150

Chaminade, C., Martin, R., & McKeever, J. (2021). When regional meets global: exploring the nature of global innovation networks in the video game industry in Southern Sweden. *Entrepreneurship and Regional Development*, *33*(1-2), 131-146. https://doi.org/10.1080/08985626.2020.1736184

Chandna, V., & Salimath, M. S. (2020). When technology shapes community in the Cultural and Craft Industries: Understanding virtual entrepreneurship in online ecosystems. *Technovation*, *92-93*, Article 102042. https://doi.org/10.1016/j.technovation.2018.06.005

Chen, M. H., Chang, Y. Y., & Lee, C. Y. (2015). Creative entrepreneurs' guanxi networks and success: Information and resource. *Journal of Business Research*, *68*(4), 900-905. https://doi.org/10.1016/j.jbusres.2014.11.049

China Railway Society. (1999). Societies. In China Railway Society (Ed.), *China Railway Yeabook*. China Railway Publishing House.

Coe, N. M. (2000). The view from out West: embeddedness, inter-personal relations and the development of an indigenous film industry in Vancouver. *Geoforum*, *31*(4), 391-407. https://doi.org/10.1016/s0016-7185(00)00005-1

Cohendet, P., Parmentier, G., & Simon, L. (2017). Managing knowledge, creativity and innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 197-214). https://doi.org/10.4337/9781782548522

Cohendet, P., & Simon, L. (2017). Concepts and models of innovation. In L. Simon, H. Bathelt, P. Cohendet, & S. Henn (Eds.), *The Elgar Companion to Innovation and Knowledge Creation* (pp. 33-55). https://doi.org/10.4337/9781782548522

Coleman, J. S. (1988). Social Capital in the Creation of Human-Capital. *American Journal of Sociology*, *94*, S95-S120. https://doi.org/10.1086/228943

Comunian, R., & England, L. (2020). Creative and cultural work without filters: Covid-19 and exposed precarity in the creative economy. *Cultural Trends*, *29*(2), 112-128. https://doi.org/10.1080/09548963.2020.1770577

Costa, P. (2022). Valuing culture and creativity impacts in a global technological era: reshaping the analytical framework. *European Planning Studies*, 1-20.

Crossan, M. M., & Apaydin, M. (2010). A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. *Journal of Management Studies*, *47*(6), 1154-1191. https://doi.org/10.1111/j.1467-6486.2009.00880.x

Cruz, S. C. S., & Teixeira, A. A. C. (2021). Spatial analysis of new firm formation in creative industries before and during the world economic crisis. *Annals of Regional Science*, *67*(2), 385-413. https://doi.org/10.1007/s00168-021-01052-3

Cuypers, I. R. P., Ertug, G., Cantwell, J., Zaheer, A., & Kilduff, M. (2020). Making connections: Social networks in international business. *Journal of International Business Studies*, *51*(5), 714-736. https://doi.org/10.1057/s41267-020-00319-9

De Nooy, W., Mrvar, A., & Batagelj, V. (2018). *Exploratory Social Network Analysis with Pajek*. https://doi.org/10.1017/9781108565691

Delmestri, G., Montanari, F., & Usai, A. (2005). Reputation and strength of ties in predicting commercial success and artistic merit of independents in the Italian feature film industry. *Journal of Management Studies*, *42*(5), 975-1002.

Department of Tourism Development. (2017). *Nyingchi to build a national sustainable development experimental zone*. http://lyfzt.xizang.gov.cn/xwzx_69/dsdt/201708/t20170831_116107.html

Dessein, J., Soini, K., Fairclough, G., Horlings, L., Battaglini, E., Birkeland, I., Duxbury, N., De Beukelaer, C., Matejić, J., & Stylianou-Lambert, T. (2015).

Culture in, for and as sustainable development: Conclusions from the COST Action IS1007 Investigating Cultural Sustainability. University of Jyväskylä.

Donthu, N., & Gustafsson, A. (2020). Effects of COVID-19 on business and research. *Journal of Business Research*, *117*, 284-289. https://doi.org/10.1016/j.jbusres.2020.06.008

Escalona-Orcao, A., Barrado-Timon, D. A., Escolano-Utrilla, S., Sanchez-Valverde, B., Navarro-Perez, M., Pinillos-Garcia, M., & Saez-Perez, L. A. (2021). Cultural and Creative Ecosystems in Medium-Sized Cities: Evolution in Times of Economic Crisis and Pandemic. *Sustainability*, *13*(1), Article 49. https://doi.org/10.3390/su13010049

Farr-Wharton, B. S. R., Brown, K., Keast, R., & Shymko, Y. (2015). Reducing creative labour precarity: beyond network connections. *Management Decision*, *53*(4), 857-875. https://doi.org/10.1108/md-05-2014-0269

Fatoric, S., & Seekamp, E. (2017). Securing the Future of Cultural Heritage by Identifying Barriers to and Strategizing Solutions for Preservation under Changing Climate Conditions. *Sustainability*, *9*(11), Article 2143. https://doi.org/10.3390/su9112143

Fazlagic, J., & Skikiewicz, R. (2019). Measuring sustainable development - the creative economy perspective. *International Journal of Sustainable Development and World Ecology*, *26*(7), 635-645. https://doi.org/10.1080/13504509.2019.1651418

Fernandez, J. A. S., Martinez, J. M. G., & Martin, J. M. M. (2022). An analysis of the competitiveness of the tourism industry in a context of economic recovery following the COVID19 pandemic. *Technological Forecasting and Social Change*, *174*, Article 121301. https://doi.org/10.1016/j.techfore.2021.121301

Ferraro, F., Etzion, D., & Gehman, J. (2015). Tackling grand challenges pragmatically: Robust action revisited. *Organization Studies*, *36*(3), 363-390.

Fleming, L., Mingo, S., & Chen, D. (2007). Collaborative brokerage, generative creativity, and creative success. *Administrative Science Quarterly*, *52*(3), 443-475. https://doi.org/10.2189/asqu.52.3.443

Forestier, O., & Kim, R. E. (2020). Cherry-picking the Sustainable Development Goals: Goal prioritization by national governments and implications for global

governance. *Sustainable Development*, *28*(5), 1269-1278. https://doi.org/10.1002/sd.2082

Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources Conservation and Recycling*, *152*, Article 104507. https://doi.org/10.1016/j.resconrec.2019.104507

Foster, G., Kreinin, H., & Stagl, S. (2020). The future of circular environmental impact indicators for cultural heritage buildings in Europe. *Environmental Sciences Europe*, *32*(1), Article 141. https://doi.org/10.1186/s12302-020-00411-9

Francioni, B., Vissak, T., & Musso, F. (2017). Small Italian wine producers' internationalization: The role of network relationships in the emergence of late starters. *International Business Review*, *26*(1), 12-22. https://doi.org/10.1016/j.ibusrev.2016.05.003

Gao, Y. (2022). The Belt and Road Initiative and cascading innovation in China's domestic railway ecosystem [Article]. *Journal of International Business Policy*, *5*(2), 236-258. https://doi.org/10.1057/s42214-022-00132-1

Genin, A. L., Tan, J., & Song, J. (2021). State governance and technological innovation in emerging economies: State-owned enterprise restructuration and institutional logic dissonance in China's high-speed train sector. *Journal of International Business Studies*, *52*(4), 621-645. https://doi.org/10.1057/s41267-020-00342-w

George, G., Howard-Grenville, J., Joshi, A., & Tihanyi, L. (2016). Understanding and tackling societal grand challenges through management research. *Academy of Management Journal*, *59*(6), 1880-1895.

Ghasemzadeh, K., Bortoluzzi, G., & Yordanova, Z. (2022). Collaborating with users to innovate: A systematic literature review. *Technovation*, *116*, Article 102487. https://doi.org/10.1016/j.technovation.2022.102487

Giliberto, F., & Labadi, S. (2022). Harnessing cultural heritage for sustainable development: an analysis of three internationally funded projects in MENA Countries. *International Journal of Heritage Studies*, *28*(2), 133-146. https://doi.org/10.1080/13527258.2021.1950026

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies:

Technological distance, betweenness centrality and density. *Research Policy*, *37*(10), 1717-1731. https://doi.org/10.1016/j.respol.2008.08.010

Giuliani, E. (2013). Network dynamics in regional clusters: Evidence from Chile. *Research Policy*, *42*(8), 1406-1419.

Gonzalez-Brambila, C. N., Veloso, F. M., & Krackhardt, D. (2013). The impact of network embeddedness on research output. *Research Policy*, *42*(9), 1555-1567. https://doi.org/10.1016/j.respol.2013.07.008

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., & Noble, I. (2013). Sustainable development goals for people and planet. *Nature*, *495*(7441), 305-307. https://doi.org/10.1038/495305a

Grigoriou, K., & Rothaermel, F. T. (2014). Structural Microfoundations of Innovation: The Role of Relational Stars. *Journal of Management*, *40*(2), 586-615. https://doi.org/10.1177/0149206313513612

Grigoriou, K., & Rothaermel, F. T. (2017). Organizing for Knowledge Generation: Internal Knowledge Networks and the Contingent Effect of External Knowledge Sourcing. *Strategic Management Journal*, *38*(2), 395-414. https://doi.org/10.1002/smj.2489

Gu, X., Domer, N., & O'Connor, J. (2021). The next normal: Chinese indie music in a post-COVID China. *Cultural Trends*, *30*(1), 63-74. https://doi.org/10.1080/09548963.2020.1846122

Guan, J. C., & Liu, N. (2016). Exploitative and exploratory innovations in knowledge network and collaboration network: A patent analysis in the technological field of nano-energy. *Research Policy*, *45*(1), 97-112. https://doi.org/10.1016/j.respol.2015.08.002

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203-215. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<203::Aid-smj102>3.0.Co;2-k

Halevy, N., Halali, E., & Zlatev, J. J. (2019). Brokerage and Brokering: An Integrative Review and Organizing Framework for Third Party Influence. *Academy of Management Annals*, *13*(1), 215-239. https://doi.org/10.5465/annals.2017.0024

Handke, C., & Towse, R. (2013). Introduction. In R. Towse & C. Handke (Eds.), *Handbook on the digital creative economy* (pp. xiii, 441 pages). Edward Elgar.

Hansen, M. T., Mors, M. L., & Løvås, B. (2005). Knowledge sharing in organizations: Multiple networks, multiple phases. *Academy of Management Journal*, *48*(5), 776-793.

Hawkes, J. (2001). *The fourth pillar of sustainability: Culture's essential role in public planning*. Common Ground.

He, J., Lyu, T., Huang, Y., & Jiang, H. (2018). Motivation structure and capacity building of technological catch-up: Experience and policy implication of China's High-Speed Rail. *Journal of Management World*, *34*(10), 191-207. https://doi.org/10.19744/j.cnki.11-1235/f.2018.10.016

He, J. L., & Gebhardt, H. (2014). Space of Creative Industries: A Case Study of Spatial Characteristics of Creative Clusters in Shanghai. *European Planning Studies*, *22*(11), 2351-2368. https://doi.org/10.1080/09654313.2013.837430

He, J. L., Huang, X. J., & Xi, G. L. (2018). Urban amenities for creativity: An analysis of location drivers for photography studios in Nanjing, China. *Cities*, *74*, 310-319. https://doi.org/10.1016/j.cities.2017.12.020

Heisig, J. P., & Schaeffer, M. (2019). Why You Should Always Include a Random Slope for the Lower-Level Variable Involved in a Cross-Level Interaction. *European Sociological Review*, *35*(2), 258-279. https://doi.org/10.1093/esr/jcy053

Hemphala, J., & Magnusson, M. (2012). Networks for Innovation - But What Networks and What Innovation? *Creativity and Innovation Management*, *21*(1), 3-16. https://doi.org/10.1111/j.1467-8691.2012.00625.x

Hirsch, P. M. (2000). Cultural industries revisited. *Organization Science*, *11*(3), 356-361. https://doi.org/10.1287/orsc.11.3.356.12498

Hoang, H., & Rothaermel, F. T. (2010). Leveraging internal and external experience: exploration, exploitation, and R&D project performance. *Strategic Management Journal*, *31*(7), 734-758.

Holcombe-James, I. (2021). Digital access, skills, and dollars: applying a framework to digital exclusion in cultural institutions. *Cultural Trends*, 1-17. https://doi.org/10.1080/09548963.2021.1972282

Hosagrahar, J. (2017). *Culture: at the heart of SDGs*. https://en.unesco.org/courier/april-june-2017/culture-heart-sdgs

Hracs, B. J. (2015). Cultural Intermediaries in the Digital Age: The Case of Independent Musicians and Managers in Toronto. *Regional Studies*, *49*(3), 461-475. https://doi.org/10.1080/00343404.2012.750425

Huggins, R., & Thompson, P. (2016). Entrepreneurial networks and open innovation: the role of strategic and embedded ties. *Industry and Innovation*, *24*(4), 403-435. https://doi.org/10.1080/13662716.2016.1255598

Hurmelinna-Laukkanen, P., Natti, S., & Pikkarainen, M. (2021). Orchestrating for lead user involvement in innovation networks. *Technovation*, *108*, Article 102326. https://doi.org/10.1016/j.technovation.2021.102326

Ibarra, H. (1993). Network Centrality, Power, and Innovation Involvement - Determinants of Technical and Administrative Roles. *Academy of Management Journal*, *36*(3), 471-501. https://doi.org/10.2307/256589

Jackson, M. O. (2008). *Social and Economic Networks*. https://doi.org/10.1515/9781400833993

Johns, J. (2006). Video games production networks': value capture, power relations and embeddedness. *Journal of Economic Geography*, *6*(2), 151-180. https://doi.org/10.1093/jeg/lbi001

Kadushin, C. (2012). *Understanding social networks : theories, concepts, and findings*. Oxford University Press.

Katila, R., & Ahuja, G. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, *45*(6), 1183-1194. https://doi.org/10.2307/3069433

Khanna, R. (2021). Aftermath of a tragedy: A star's death and coauthors' subsequent productivity. *Research Policy*, *50*(2), Article 104159. https://doi.org/10.1016/j.respol.2020.104159

Khlystova, O., Kalyuzhnova, Y., & Belitski, M. (2022). The impact of the COVID-19 pandemic on the creative industries: A literature review and future research agenda. *Journal of Business Research*, *139*, 1192-1210. https://doi.org/10.1016/j.jbusres.2021.09.062

Kogut, B. (2000). The network as knowledge: Generative rules and the emergence of structure. *Strategic Management Journal*, *21*(3), 405-425. https://doi.org/10.1002/(sici)1097-0266(200003)21:3<405::Aid-smj103>3.0.Co;2-5

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, *3*(3), 383-397. https://doi.org/10.1287/orsc.3.3.383

Kourtit, K., & Nijkamp, P. (2019). Creative actors and historical-cultural assets in urban regions. *Regional Studies*, *53*(7), 977-990. https://doi.org/10.1080/00343404.2018.1541077

Kwon, S. W., Rondi, E., Levin, D. Z., De Massis, A., & Brass, D. J. (2020). Network Brokerage: An Integrative Review and Future Research Agenda. *Journal of Management*, *46*(6), 1092-1120, Article 0149206320914694. https://doi.org/10.1177/0149206320914694

Lafortune, G., Zoeteman, K., Fuller, G., Mulder, R., Dagevos, J., & Schmidt-Traub, G. (2019). *The 2019 SDG Index and Dashboards Report for European Cities (prototype version)*. Sustainable Development Solutions Network (SDSN) and the Brabant Center for Sustainable Development (Telos). https://www.sdgindex.org/reports/sdg-index-and-dashboards-report-for-european-cities/

Landoni, P., Dell'era, C., Frattini, F., Petruzzelli, A. M., Verganti, R., & Manelli, L. (2020). Business model innovation in cultural and creative industries: Insights from three leading mobile gaming firms. *Technovation*, *92-93*, Article 102084. https://doi.org/10.1016/j.technovation.2019.102084

Lavie, D. (2007). Alliance portfolios and firm performance: A study of value creation and appropriation in the US software industry. *Strategic Management Journal*, *28*(12), 1187-1212. https://doi.org/10.1002/smj.637

Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, *49*(4), 797-818. https://doi.org/10.5465/amj.2006.22083085

Lazzeretti, L., Oliva, S., Innocenti, N., & Capone, F. (2022). Rethinking culture and creativity in the digital transformation. *European Planning Studies*, 1-9. https://doi.org/10.1080/09654313.2022.2052018

Le Blanc, D. (2015). Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. *Sustainable Development*, *23*(3), 176-187. https://doi.org/10.1002/sd.1582

Lee, M. (2015). Fostering connectivity: a social network analysis of entrepreneurs in creative industries. *International Journal of Cultural Policy*, *21*(2), 139-152. https://doi.org/10.1080/10286632.2014.891021

Levin, D. Z., & Cross, R. (2004). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science*, *50*(11), 1477-1490.

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation*, *92-93*, Article 102012. https://doi.org/10.1016/j.technovation.2017.12.004

Li, W., Zhou, Y., & Zhang, Z. W. (2021). Culture-Led Plan for Peri-Urban Agricultural Sustainability: A Case of Pu'an Village in China. *Land*, *10*(3), Article 242. https://doi.org/10.3390/land10030242

Lim, M. M. L., Jorgensen, P. S., & Wyborn, C. A. (2018). Reframing the sustainable development goals to achieve sustainable development in the Anthropocene-a systems approach. *Ecology and Society*, *23*(3), Article 22. https://doi.org/10.5751/es-10182-230322

Liu, X., & Zhu, W. S. (2021). Sustainability approaches to Chinese landscape architecture. *Interdisciplinary Science Reviews*, *46*(4), 689-702. https://doi.org/10.1080/03080188.2021.1897748

Lorenzen, M., & Taube, F. A. (2008). Breakout from Bollywood? The roles of social networks and regulation in the evolution of Indian film industry. *Journal of*

International Management, *14*(3), 286-299. https://doi.org/10.1016/j.intman.2008.01.004

Loulanski, T., & Loulanski, V. (2011). The sustainable integration of cultural heritage and tourism: a meta-study. *Journal of Sustainable Tourism*, *19*(7), 837-862. https://doi.org/10.1080/09669582.2011.553286

Lowe, M. S., Williams, A. M., Shaw, G., & Cudworth, K. (2012). Self-organizing innovation networks, mobile knowledge carriers and diasporas: insights from a pioneering boutique hotel chain. *Journal of Economic Geography*, *12*(5), 1113-1138. https://doi.org/10.1093/jeg/lbs021

Luckman, S. (2015). *Craft and the creative economy* (2015. ed.). Palgrave Macmillan. http://whel-primo.hosted.exlibrisgroup.com/openurl/44WHELF_NLW/44WHELF_NLW_services_page?u.ignore_date_coverage=true&rft.mms_id=99958391502419

Luo, J.-D. (2005). Particularistic trust and general trust: A network analysis in chinese organizations [1]. *Management and Organization Review*, *1*(3), 437-458.

Lynch, A., LoPresti, A., & Fox, C. (2019). *The 2019 US Cities Sustainable Development Report*. Sustainable Development Solutions Network (SDSN). https://www.sustainabledevelopment.report/reports/2019-us-cities-sustainable-development-report/

Lyu, T., & Jiang, H. (2017). From Reverse Engineering to Forward Engineering—The Implications of High-Speed Railway Equipment Industry on Technological Catch-up and Independent Innovation in the Chinese Equipment Manufacturing Industry. *Business and Management Journal*, *39*(10). https://doi.org/10.19616/j.cnki.bmj.2017.10.001

Mangematin, V., Sapsed, J., & Schussler, E. (2014). Disassembly and reassembly: An introduction to the Special Issue on digital technology and creative industries. *Technological Forecasting and Social Change*, *83*, 1-9. https://doi.org/10.1016/j.techfore.2014.01.002

Mani, D., & Moody, J. (2014). Moving beyond Stylized Economic Network Models: The Hybrid World of the Indian Firm Ownership Network. *American Journal of Sociology*, *119*(6), 1629-1669. https://doi.org/10.1086/676040

Maoret, M., Tortoriello, M., & Iubatti, D. (2020). Big Fish, Big Pond? The Joint Effect of Formal and Informal Core/Periphery Positions on the Generation of Incremental Innovations. *Organization Science*, *31*(6), 1538-1559. https://doi.org/10.1287/orsc.2020.1365

March, J. G. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science*, *2*(1), 71-87. https://doi.org/10.1287/orsc.2.1.71

Martin, R. (2013). Differentiated Knowledge Bases and the Nature of Innovation Networks. *European Planning Studies*, *21*(9), 1418-1436. https://doi.org/10.1080/09654313.2012.755836

Martin, R., & Moodysson, J. (2011). Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies*, *19*(7), 1183-1203. https://doi.org/10.1080/09654313.2011.573131

Martinez, P. G. (2017). Urban authenticity at stake: A new framework for its definition from the perspective of heritage at the Shanghai Music Valley. *Cities*, *70*, 55-64. https://doi.org/10.1016/j.cities.2017.06.017

Maskell, P. (2014). Accessing remote knowledge-the roles of trade fairs, pipelines, crowdsourcing and listening posts. *Journal of Economic Geography*, *14*(5), 883-902. https://doi.org/10.1093/jeg/lbu002

McFadyen, M. A., Semadeni, M., & Cannella, A. A. (2009). Value of Strong Ties to Disconnected Others: Examining Knowledge Creation in Biomedicine. *Organization Science*, *20*(3), 552-564. https://doi.org/10.1287/orsc.1080.0388

Milgram, S. (1967). The small world problem. *Psychology today*, *2*(1), 60-67. http://snap.stanford.edu/class/cs224w-readings/milgram67smallworld.pdf

Moliterno, T. P., & Mahony, D. M. (2011). Network Theory of Organization: A Multilevel Approach. *Journal of Management*, *37*(2), 443-467. https://doi.org/10.1177/0149206310371692

Mossig, I. (2008). Global networks of the motion picture industry in los angeles/hollywood using the example of their connections to the German market. *European Planning Studies*, *16*(1), 43-59. https://doi.org/10.1080/09654310701747969

NBS. (2018). *Classification of Culture and Related Industries (2018)*. http://www.stats.gov.cn/tjsj/tjbz/201805/t20180509_1598314.html

NBS. (2020). *China Statistical Yearbook on Culture and Related Industries*. China Statistics Press.

NBS. (2021). *Classification of Digital Economy and Its Core Industries (2018)*. http://www.stats.gov.cn/tjgz/tzgb/202106/t20210603_1818129.html

NCHA. (2021). *Data on Unmovable Cultural Relics* http://www.ncha.gov.cn/col/col2266/index.html

Nilsson, M., Griggs, D., & Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature*, *534*(7607), 320-322. https://doi.org/10.1038/534320a

Nocca, F. (2017). The Role of Cultural Heritage in Sustainable Development: Multidimensional Indicators as Decision-Making Tool. *Sustainability*, *9*(10), Article 1882. https://doi.org/10.3390/su9101882

Nohria, N., & Garcia-Pont, C. (1991). Global Strategic Linkages and Industry Structure. *Strategic Management Journal*, *12*, 105-124. https://doi.org/10.1002/smj.4250120909

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, *5*(1), 14-37. https://doi.org/10.1287/orsc.5.1.14

O'Connor, J. (2009). Creative industries: a new direction? *International Journal of Cultural Policy*, *15*(4), 387-402.

Obstfeld, D. (2005). Social networks, the Tertius lungens and orientation involvement in innovation. *Administrative Science Quarterly*, *50*(1), 100-130. https://doi.org/10.2189/asqu.2005.50.1.100

OECD. (2020). *Culture shock: COVID-19 and the cultural and creative sectors*. https://www.oecd.org/coronavirus/policy-responses/culture-shock-covid-19-and-the-cultural-and-creative-sectors-08da9e0e/

Owen-Smith, J., & Powell, W. W. (2004). Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science*, *15*(1), 5-21.

Pagan, E. A., Salvatella, M. D. G., Pitarch, M. D., Munoz, A. L., Toledo, M. D. M., Ruiz, J. M., Vitella, M., Lo Cicero, G., Rottensteiner, F., Clermont, D., Dorozynski, M., Wittich, D., Vernus, P., & Puren, M. (2020). From Silk to Digital Technologies: A Gateway to New Opportunities for Creative Industries, Traditional Crafts and Designers. The SILKNOW Case. *Sustainability*, *12*(19), Article 8279. https://doi.org/10.3390/su12198279

Palanivel, T. (2019). *How cultural and creative industries can power human development in the 21st Century*. https://hdr.undp.org/content/how-cultural-and-creative-industries-can-power-human-development-21st-century

Parmentier, G., & Mangematin, V. (2014). Orchestrating innovation with user communities in the creative industries. *Technological Forecasting and Social Change*, *83*, 40-53. https://doi.org/10.1016/j.techfore.2013.03.007

Paruchuri, S., Goossen, M. C., & Phelps, C. (2019). Conceptual foundations of multilevel social networks. In S. E. L. Humphrey, James M. (Ed.), *The handbook of multilevel theory, measurement, and analysis* (First Edition. ed.). American Psychological Association,.

Perry-Smith, J., & Mannucci, P. V. (2015). Social Networks, Creativity, and Entrepreneurship. In C. Shalley, M. A. Hitt, J. Zhou, J. Perry-Smith, & P. V. Mannucci (Eds.), *The Oxford Handbook of Creativity, Innovation, and Entrepreneurship*. https://doi.org/10.1093/oxfordhb/9780199927678.013.0016

Perry-Smith, J. E. (2006). Social yet creative: The role of social relationships in facilitating individual creativity. *Academy of Management Journal*, *49*(1), 85-101. <Go to ISI>://WOS:000236642400008

Perry-Smith, J. E., & Mannucci, P. V. (2017). From Creativity to Innovation: The Social Network Drivers of the Four Phases of the Idea Journey. *Academy of Management Review*, *42*(1), 53-79. https://doi.org/10.5465/amr.2014.0462

Petti, L., Trillo, C., & Makore, B. N. (2020). Cultural Heritage and Sustainable Development Targets: A Possible Harmonisation? Insights from the European Perspective. *Sustainability*, *12*(3), Article 926. https://doi.org/10.3390/su12030926

Peukert, C. (2019). The next wave of digital technological change and the cultural industries. *Journal of Cultural Economics*, *43*(2), 189-210. https://doi.org/10.1007/s10824-018-9336-2

Pfisterer, S., & Van Tulder, R. (2021). Navigating Governance Tensions to Enhance the Impact of Partnerships with the Private Sector for the SDGs. *Sustainability*, *13*(1), Article 111. https://doi.org/10.3390/su13010111

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166. https://doi.org/10.1177/0149206311432640

Phelps, C. C. (2010). A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation. *Academy of Management Journal*, *53*(4), 890-913. https://doi.org/10.5465/amj.2010.52814627

Potts, J., Cunningham, S., Hartley, J., & Ormerod, P. (2008). Social network markets: a new definition of the creative industries. *Journal of Cultural Economics*, *32*(3), 167-185.

Powell, W. W., Koput, K. W., & SmithDoerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, *41*(1), 116-145. https://doi.org/10.2307/2393988

Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earths Future*, *5*(11), 1169-1179. https://doi.org/10.1002/2017ef000632

Pratt, A. C. (2008). Creative cities: The cultural industries and the creative class. *Geografiska Annaler Series B-Human Geography*, *90B*(2), 107-117. https://doi.org/10.1111/j.1468-0467.2008.00281.x

Pratt, A. C. (2013). Space and Place. In R. Towse & C. Handke (Eds.), *Handbook on the digital creative economy*. Edward Elgar.

Pratt, A. C., Virani, T. E., & Gill, R. (2019). Introduction. In R. Gill, A. C. Pratt, & T. E. Virani (Eds.), *Creative Hubs in Question*. https://doi.org/10.1007/978-3-030-10653-9

Provan, K. G., Fish, A., & Sydow, J. (2007). Interorganizational networks at the network level: A review of the empirical literature on whole networks. *Journal of Management*, *33*(3), 479-516. https://doi.org/10.1177/0149206307302554

Quintana-Garcia, C., & Benavides-Velasco, C. A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, *37*(3), 492-507. https://doi.org/10.1016/j.respol.2007.12.002

Raimo, N., De Turi, I., Ricciardelli, A., & Vitolla, F. (2021). Digitalization in the cultural industry: evidence from Italian museums. *International Journal of Entrepreneurial Behavior & Research*. https://doi.org/10.1108/ijebr-01-2021-0082

Raisch, S., Birkinshaw, J., Probst, G., & Tushman, M. L. (2009). Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance. *Organization Science*, *20*(4), 685-695. https://doi.org/10.1287/orsc.1090.0428

Richards, G. (2011). CREATIVITY AND TOURISM The State of the Art. *Annals of Tourism Research*, *38*(4), 1225-1253. https://doi.org/10.1016/j.annals.2011.07.008

Rios-Ballesteros, N., & Fuerst, S. (2021). Exploring the enablers and microfoundations of international knowledge transfer. *Journal of Knowledge Management*. https://doi.org/10.1108/jkm-04-2021-0344

Rivero, P., Navarro-Neri, I., Garcia-Ceballos, S., & Aso, B. (2020). Spanish Archaeological Museums during COVID-19 (2020): An Edu-Communicative Analysis of Their Activity on Twitter through the Sustainable Development Goals. *Sustainability*, *12*(19), Article 8224. https://doi.org/10.3390/su12198224

Roback, P., & Legler, J. (2021). *Beyond multiple linear regression: applied generalized linear models and multilevel models in R* (1. ed.). CRC Press.

Rosenkopf, L., & Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, *49*(6), 751-766. https://doi.org/10.1287/mnsc.49.6.751.16026

Rothaermel, F. T., & Alexandre, M. T. (2009). Ambidexterity in Technology Sourcing: The Moderating Role of Absorptive Capacity. *Organization Science*, *20*(4), 759-780. https://doi.org/10.1287/orsc.1080.0404

Rothaermel, F. T., & Hess, A. M. (2007). Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science*, *18*(6), 898-921. https://doi.org/10.1287/orsc.1070.0291

Ruling, C. C., & Duymedjian, R. (2014). Digital bricolage: Resources and coordination in the production of digital visual effects. *Technological Forecasting and Social Change*, *83*, 98-110. https://doi.org/10.1016/j.techfore.2013.05.003

Ryu, S., & Cho, D. (2022). The show must go on? The entertainment industry during (and after) COVID-19. *Media Culture & Society*, *44*(3), 591-600, Article 01634437221079561. https://doi.org/10.1177/01634437221079561

Sachs, J. D., Schmidt-Traub, G., Kroll, C., Lafortune, G., & Fuller, G. (2018). *SDG Index and Dashboards Report 2018*. Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockstrom, J. (2019). Six Transformations to achieve the Sustainable Development Goals. *Nature Sustainability*, *2*(9), 805-814. https://doi.org/10.1038/s41893-019-0352-9

Salvia, A. L., Leal, W., Brandli, L. L., & Griebeler, J. S. (2019). Assessing research trends related to Sustainable Development Goals: local and global issues. *Journal of Cleaner Production*, *208*, 841-849. https://doi.org/10.1016/j.jclepro.2018.09.242

Sammarra, A., & Biggiero, L. (2008). Heterogeneity and specificity of inter-firm knowledge flows in innovation networks. *Journal of Management Studies*, *45*(4), 200-829. <Go to ISI>://WOS:000255529000006

Santoro, G., Bresciani, S., & Papa, A. (2020). Collaborative modes with Cultural and Creative Industries and innovation performance: The moderating role of heterogeneous sources of knowledge and absorptive capacity. *Technovation*, *92-93*, Article 102040. https://doi.org/10.1016/j.technovation.2018.06.003

Sasaki, M. (2010). Urban regeneration through cultural creativity and social inclusion: Rethinking creative city theory through a Japanese case study. *Cities*, *27*, S3-S9. https://doi.org/10.1016/j.cities.2010.03.002

Sasidharan, S., Santhanam, R., Brass, D. J., & Sambamurthy, V. (2012). The Effects of Social Network Structure on Enterprise Systems Success: A Longitudinal Multilevel Analysis. *Information Systems Research*, *23*(3), 658-678. https://doi.org/10.1287/isre.1110.0388

Scheyvens, R., Banks, G., & Hughes, E. (2016). The Private Sector and the SDGs: The Need to Move Beyond `Business as Usual'. *Sustainable Development*, *24*(6), 371-382. https://doi.org/10.1002/sd.1623

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126. https://doi.org/10.1287/mnsc.1060.0624

Scott, A. (1997). The Cultural Economy of Cities. *International Journal of Urban and Regional Research*, *21*(2), 323-339.

Scott, A. J. (2006). Creative cities: Conceptual issues and policy questions. *Journal of Urban Affairs*, *28*(1), 1-17. https://doi.org/10.1111/j.0735-2166.2006.00256.x

Scott, J. (1991). *Social network analysis: A handbook*. Sage Publications, Inc.

Sedita, S. R., & Ozeki, T. (2021). Path renewal dynamics in the Kyoto kimono cluster: how to revitalize cultural heritage through digitalization. *European Planning Studies*, 1-19. https://doi.org/10.1080/09654313.2021.1972938

Seo, E., Song, J., & Jin, C. (2022). Heterogeneity of optimal balance between exploration and exploitation:the moderating roles of firm technological capability and industry alliance network position. *Industry and Innovation*, 1-29. https://doi.org/10.1080/13662716.2022.2036598

Shafi, M., Sarker, M. N. I., & Liu, J. R. (2019). Social Network of Small Creative Firms and Its Effects on Innovation in Developing Countries. *Sage Open*, *9*(4), Article 2158244019898248. https://doi.org/10.1177/2158244019898248

Sharma, P., Leung, T. Y., Kingshott, R. P. J., Davcik, N. S., & Cardinali, S. (2020). Managing uncertainty during a global pandemic: An international business

perspective. *Journal of Business Research*, *116*, 188-192. https://doi.org/10.1016/j.jbusres.2020.05.026

Singh, G. G., Cisneros-Montemayor, A. M., Swartz, W., Cheung, W., Guy, J. A., Kenny, T. A., McOwen, C. J., Asch, R., Geffert, J. L., Wabnitz, C. C. C., Sumaila, R., Hanich, Q., & Ota, Y. (2018). A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Marine Policy*, *93*, 223-231. https://doi.org/10.1016/j.marpol.2017.05.030

Singh, J. (2005). Collaborative networks as determinants of knowledge diffusion patterns. *Management Science*, *51*(5), 756-770. https://doi.org/10.1287/mnsc.1040.0349

Snijders, T. A. B., & Bosker, R. J. (2012). *Multilevel analysis : an introduction to basic and advanced multilevel modeling* (2nd ed.). Sage.

Snowball, J., Tarentaal, D., & Sapsed, J. (2021). Innovation and diversity in the digital cultural and creative industries. *Journal of Cultural Economics*, *45*(4), 705-733. https://doi.org/10.1007/s10824-021-09420-9

Snowball, J. D. (2013). The economic, social and cultural impact of cultural heritage: methods and examples. In I. Rizzo & A. Mignosa (Eds.), *Handbook on the Economics of Cultural Heritage* (pp. 438-455). https://doi.org/10.4337/9780857931009.00036

Soini, K., & Birkeland, I. (2014). Exploring the scientific discourse on cultural sustainability. *Geoforum*, *51*, 213-223. https://doi.org/https://doi.org/10.1016/j.geoforum.2013.12.001

Soini, K., & Dessein, J. (2016). Culture-sustainability relation: Towards a conceptual framework. *Sustainability*, *8*(2), 167.

Sorensen, J. B., & Stuart, T. E. (2000). Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, *45*(1), 81-112. https://doi.org/10.2307/2666980

Stafford-Smith, M., Griggs, D., Gaffney, O., Ullah, F., Reyers, B., Kanie, N., Stigson, B., Shrivastava, P., Leach, M., & O'Connell, D. (2017). Integration: the key to implementing the Sustainable Development Goals. *Sustainability Science*, *12*(6), 911-919. https://doi.org/10.1007/s11625-016-0383-3

Štreimikienė, D., & Kačerauskas, T. (2020). The creative economy and sustainable development: The Baltic States. *Sustainable Development*, *28*(6), 1632-1641.

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management Journal*, *21*(8), 791-811. https://doi.org/10.1002/1097-0266(200008)21:8<791::Aid-smj121>3.0.Co;2-k

Sturgeon, T. J. (2021). Upgrading strategies for the digital economy. *Global Strategy Journal*, *11*(1), 34-57. https://doi.org/10.1002/gsj.1364

Su, Y. W., & Lin, H. L. (2014). Analysis of international tourist arrivals worldwide: The role of world heritage sites. *Tourism Management*, *40*, 46-58. https://doi.org/10.1016/j.tourman.2013.04.005

Tan, J., Yang, J., & Veliyath, R. (2009). Particularistic and system trust among small and medium enterprises: A comparative study in China's transition economy. *Journal of Business Venturing*, *24*(6), 544-557.

Tang, C. Y. (2016). Accessed external knowledge, centrality of intra-team knowledge networks, and R&D employee creativity. *R & D Management*, *46*, 992-1005. https://doi.org/10.1111/radm.12160

Tao, J., Ho, C.-Y., Luo, S., & Sheng, Y. (2019). Agglomeration economies in creative industries. *Regional Science and Urban Economics*, *77*, 141-154.

Throsby, C. D. (2001). *Economics and culture*. Cambridge University Press.

Throsby, D. (2017). Culturally sustainable development: theoretical concept or practical policy instrument? *International Journal of Cultural Policy*, *23*(2), 133-147.

Tortoriello, M., McEvily, B., & Krackhardt, D. (2015). Being a Catalyst of Innovation: The Role of Knowledge Diversity and Network Closure. *Organization Science*, *26*(2), 423-438. https://doi.org/10.1287/orsc.2014.0942

Tsai, W. P. (2001). Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, *44*(5), 996-1004. https://doi.org/10.2307/3069443

Turkina, E., & Van Assche, A. (2018). Global connectedness and local innovation in industrial clusters. *Journal of International Business Studies*, *49*(6), 706-728. https://doi.org/10.1057/s41267-018-0153-9

Turkina, E., & Van Assche, A. (2019). An Anatomy of Bengaluru's ICT Cluster: A Community Detection Approach. *Management and Organization Review*, *15*(3), 533-561. https://doi.org/10.1017/mor.2019.34

TUSDG, & WWF. (2020). *China's Regional SDG Evaluation and Prospect Report*. https://webadmin.wwfchina.org/storage/content/press/publication/2020/%E4%B8%AD%E5%9B%BD%E5%8F%AF%E6%8C%81%E7%BB%AD%E5%8F%91%E5%B1%95%E7%9B%AE%E6%A0%87%E7%9A%84%E5%9C%B0%E6%96%B9%E8%AF%84%E4%BB%B7%E5%92%8C%E5%B1%95%E6%9C%9B%E7%A0%94%E7%A9%B6%E6%8A%A5%E5%91%8A-0518.pdf

UN. (2017). *New Urban Agenda*. United Nations.

UN. (2019). *International Year of Creative Economy for Sustainable Development, 2021*. https://documents-dds-ny.un.org/doc/UNDOC/LTD/N19/359/41/PDF/N1935941.pdf

UN. (2022). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202022%20refinement_Eng.pdf

UNCTAD. (2019). *Digital Economy Report 2019: Value Creation and Capture: Implications for Developing Countries*. https://unctad.org/system/files/official-document/der2019_en.pdf

UNCTAD, & UNDP. (2008). *Creative economy report 2008 : the challenge of assessing the creative economy : towards informed policy-making*. United Nations. http://ssc.undp.org/creative_economy Full text English version and overview section in French and in Spanish

UNDP, & CASS. (2020). *Evaluation Report on SDG Progress in Chinese Cities (in Chinese)*. https://www.undp.org/sites/g/files/zskgke326/files/2022-06/UNDP-CH-

CH%20The%20SDGs%20in%20Chinese%20Cities_%20Progress%20Asessment%20Report%202020_0.pdf

UNESCO-UIS. (2009). *2009 UNESCO Framework for Cultural Statistics*. http://uis.unesco.org/sites/default/files/documents/unesco-framework-for-cultural-statistics-2009-en_0.pdf

UNESCO. (1972). *Convention Concerning the Protection of the World Cultural and Natural Heritage*. https://whc.unesco.org/archive/convention-en.pdf

UNESCO. (2001). *UNESCO Universal Declaration on Cultural Diversity*. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/pdf/5_Cultural_Diversity_EN.pdf

UNESCO. (2009). *2009 UNESCO Framework for Cultural Statistics*. http://uis.unesco.org/sites/default/files/documents/unesco-framework-for-cultural-statistics-2009-en_0.pdf

UNESCO. (2013). *The Hangzhou Declaration: Placing Culture at the Heart of Sustainable Development Policies*. https://unesdoc.unesco.org/ark:/48223/pf0000221238

UNESCO. (2017). *Re|shaping cultural policies: advancing creativity for development, 2005 Convention global report, 2018*. https://unesdoc.unesco.org/ark:/48223/pf0000260592

UNESCO. (2020). *Museums around the world in the face of COVID-19*. https://unesdoc.unesco.org/ark:/48223/pf0000373530

UNESCO. (2021a). *Cultural and creative industries in the face of COVID-19: an economic impact outlook*. https://unesdoc.unesco.org/ark:/48223/pf0000377863

UNESCO. (2021b). *UNESCO Roadmap for International Year of Creative Economy for Sustainable Development 2021*. https://en.unesco.org/sites/default/files/creative_economy2021-unesco-roadmapen-ok2.pdf

UNESCO. (2022). *Re|shaping policies for creativity: addressing culture as a global public good*. https://unesdoc.unesco.org/ark:/48223/pf0000380474

UNESCO, & World Bank. (2021). *Cities, Culture, Creativity: Leveraging Culture and Creativity for Sustainable Urban Development and Inclusive Growth* https://openknowledge.worldbank.org/handle/10986/35621

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*(2), 447-504. https://doi.org/10.1086/432782

Venkataramani, V., Richter, A. W., & Clarke, R. (2014). Creative Benefits From Well-Connected Leaders: Leader Social Network Ties as Facilitators of Employee Radical Creativity. *Journal of Applied Psychology*, *99*(5), 966-975. https://doi.org/10.1037/a0037088

Verma, S., & Gustafsson, A. (2020). Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. *Journal of Business Research*, *118*, 253-261.

Vlassis, A. (2021). Global online platforms, COVID-19, and culture: The global pandemic, an accelerator towards which direction? *Media Culture & Society*, *43*(5), 957-969, Article 0163443721994537. https://doi.org/10.1177/0163443721994537

Von Hippel, E. (1986). LEAD USERS - A SOURCE OF NOVEL PRODUCT CONCEPTS. *Management Science*, *32*(7), 791-805. https://doi.org/10.1287/mnsc.32.7.791

Wadhwa, A., & Kotha, S. (2006). Knowledge creation through external venturing: Evidence from the telecommunications equipment manufacturing industry. *Academy of Management Journal*, *49*(4), 819-835. <Go to ISI>://WOS:000240503600013

Wang, C. L., Rodan, S., Fruin, M., & Xu, X. Y. (2014). Knowledge Networks, Collaboration Networks, and Exploratory Innovation. *Academy of Management Journal*, *57*(2), 484-514. https://doi.org/10.5465/amj.2011.0917

Wang, S. L., Gu, Q., Von Glinow, M. A., & Hirsch, P. (2020). Cultural industries in international business research: Progress and prospect. *Journal of International Business Studies*, *51*(4), 665-692. https://doi.org/10.1057/s41267-020-00306-0

Wang, X., van der Bij, H., & Dolfsma, W. (2020). Knowledge sharing in inter-organisational teams: the role of the advice network and the substitutive role of

the formal network in an R&D alliance. *Industry and Innovation*, *27*(10), 1160-1185. https://doi.org/10.1080/13662716.2020.1754171

Wasko, M. M., & 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., & Faust, K. (1994). *Social Network Analysis*. https://doi.org/10.1017/cbo9780511815478

Watson, A. (2020). Not all roads lead to London: insularity, disconnection and the challenge to 'regional' creative industries policy. *Regional Studies*, *54*(11), 1574-1584. https://doi.org/10.1080/00343404.2020.1738012

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world' networks. *Nature*, *393*(6684), 440-442. https://doi.org/10.1038/30918

WCED. (1987). *Our Common Future*. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Wen, J. Y., Qualls, W. J., & Zeng, D. M. (2021). To explore or exploit: The influence of inter-firm R&D network diversity and structural holes on innovation outcomes. *Technovation*, *100*, Article 102178. https://doi.org/10.1016/j.technovation.2020.102178

West, B. T., Welch, K. B., & Gałecki, A. T. (2015). *Linear mixed models : a practical guide using statistical software* (2nd ed.). CRC Press, Taylor & Francis Group.

WHC. (2021). *Special Issue - World Heritage in China*. UNESCO. https://whc.unesco.org/en/review/99

WHO. (2021). *Ambient (outdoor) air pollution*. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Wiktor-Mach, D. (2020). What role for culture in the age of sustainable development? UNESCO's advocacy in the 2030 Agenda negotiations [Article]. *International Journal of Cultural Policy*, *26*(3), 312-327. https://doi.org/10.1080/10286632.2018.1534841

Wittel, A. (2001). Toward a network sociality. *Theory Culture & Society*, *18*(6), 51-+. https://doi.org/10.1177/026327601018006003

Wong, S. S., & Boh, W. F. (2014). The Contingent Effects of Social Network Sparseness and Centrality on Managerial Innovativeness. *Journal of Management Studies*, *51*(7), 1180-1203. https://doi.org/10.1111/joms.12086

Worsley, J., Billington, J., Balabanova, E., & Watkins, M. (2022). Regional Innovation in Arts Provision Spawned by COVID-19: "It Became a Lifeline for a Lot of People Who Are Stuck at Home". *Frontiers in Public Health*, *10*, Article 753973. https://doi.org/10.3389/fpubh.2022.753973

Wu, Y. Y., & Wu, S. K. (2016). Managing ambidexterity in creative industries: A survey. *Journal of Business Research*, *69*(7), 2388-2396. https://doi.org/10.1016/j.jbusres.2015.10.008

Xu, Z. C., Chau, S. N., Chen, X. Z., Zhang, J., Li, Y. J., Dietz, T., Wang, J. Y., Winkler, J. A., Fan, F., Huang, B. R., Li, S. X., Wu, S. H., Herzberger, A., Tang, Y., Hong, D. Q., Li, Y. K., & Liu, J. G. (2020). Assessing progress towards sustainable development over space and time. *Nature*, *577*(7788), 74-+. https://doi.org/10.1038/s41586-019-1846-3

Yang, L., & Wall, G. (2009). Ethnic tourism: A framework and an application. *Tourism Management*, *30*(4), 559-570. https://doi.org/10.1016/j.tourman.2008.09.008

Yao, Y., & Han, R. B. (2016). Challenging, but not Trouble-Making: cultural elites in China's urban heritage preservation. *Journal of Contemporary China*, *25*(98), 292-306. https://doi.org/10.1080/10670564.2015.1075720

Yayavaram, S., & Ahuja, G. (2008). Decomposability in knowledge structures and its impact on the usefulness of inventions and knowledge-base malleability. *Administrative Science Quarterly*, *53*(2), 333-362. https://doi.org/10.2189/asqu.53.2.333

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. *Organization Science*, *23*(5), 1398-1408. https://doi.org/10.1287/orsc.1120.0771

Yue, A. (2022). Conjunctions of resilience and the Covid-19 crisis of the creative cultural industries. *International Journal of Cultural Studies*, Article 13678779221091293. https://doi.org/10.1177/13678779221091293

Yung, E. H. K., Chan, E. H. W., & Xu, Y. (2014). Sustainable Development and the Rehabilitation of a Historic Urban District - Social Sustainability in the Case of Tianzifang in Shanghai. *Sustainable Development*, *22*(2), 95-112. https://doi.org/10.1002/sd.534

Zaheer, A., & Bell, G. G. (2005). Benefiting from network position: Firm capabilities, structural holes, and performance. *Strategic Management Journal*, *26*(9), 809-825. https://doi.org/10.1002/smj.482

Zang, J. J. (2018). Structural holes, exploratory innovation and exploitative innovation. *Management Decision*, *56*(8), 1682-1695. https://doi.org/10.1108/md-05-2017-0485

Zappa, P., & Lomi, A. (2015). The Analysis of Multilevel Networks in Organizations: Models and Empirical Tests. *Organizational Research Methods*, *18*(3), 542-569. https://doi.org/10.1177/1094428115579225

Zhang, H.-j., & Gao, Z.-g. (2005). Problems of Industry Transformation Based on Sustainable Development Ability of Resource-based City——A Case Study on Karamay City, Xinjiang. *ARID LAND GEOGRAPHY*, *28*(3), 409-413.

Zhao, J. M., & Zhou, S. Y. (2018). Social Network and Place: The Inheritance and Development of Beijing Crosstalk Performing Art. *Sustainability*, *10*(5), Article 1541. https://doi.org/10.3390/su10051541