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Towards a new model of EU-China innovation cooperation: Bridging missing links between international university collaboration and international industry collaboration

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ABSTRACT

This paper theoretically conceptualises and empirically explores the role of international university collaboration in building transnational university–industry co-innovation networks (TUICNs) in the EU–China context, and suggests a new model of international innovation cooperation. The theoretical framework was constructed by synthesising insights from social network theory and institutional theory. The empirical exploration was based on an analysis of interviews with 18 actors engaged in EU–China innovation cooperation. The findings suggest that international university collaboration could contribute to international industry collaboration and, therefore, to the development of TUICNs by 1) matching suitable industrial partners, 2) building trust between them, 3) giving industrial actors access to new resources, (4) enhancing the reputations of international companies in their cooperation countries, and (5) creating innovative business collaboration models. The study also addresses the following paradox in innovation studies: although the vital role of universities in national/regional innovation systems has been widely studied and the global interconnectedness of innovation networks is generally acknowledged, little attention has been given to universities' engagement in transnational innovation (eco) systems. Based on the findings, recommendations for policymakers, universities and companies are provided in light of the shifting balance of challenges and opportunities presented by China to the EU.

1. Introduction

When the Horizon Europe programme called for effective ways of integrating research, innovation and their application (European Commission, 2020; Lamy et al., 2017), it also stressed prioritising international innovation cooperation and demanded more investment and wiser implementation strategies. The importance of international innovation cooperation has been further recognised by the EU and many other countries in the global response to the COVID-19 pandemic. However, compared to the proliferation of research on innovation on a national scale and innovation cooperation within the EU, the research on innovation cooperation between EU member states and third countries is lagging. The few studies that have reported the EU's innovation cooperation with third countries are mainly ad hoc (e.g. Cherry and Toit, 2018; Engel and Giorgia, 2016; Makkonen et al., 2018; Vullings et al., 2013), and the mechanisms underlying innovation cooperation remain unknown.

One of the most important but challenging cases is the EU's innovation cooperation with China. It is important because China is not only the EU's second-largest trade partner, but also has become a powerful player in science, technology and innovation (STI) (Basu et al., 2018). It is challenging not only due to the contrasting socio-economic systems of both sides (Mei et al., 2020) but also because of changing dynamics in EU–China relations. Although the EU and China have been committed to a comprehensive strategic partnership (European Commission, 2013), the European Commission's newly published *EU–China – A Strategic Outlook* points out that "the balance of challenges and opportunities presented by China has shifted" (European Commission, 2019); EU sees China as both a partner and a competitor in the economic domain.

Currently, the EU is developing a roadmap on science and technology cooperation with China that seeks to achieve two goals (Zubașcu, 2021). On the one hand, the EU wants intense cooperation with China, given the country's spectacular performance in science and technology development. On the other hand, the EU must impose stricter terms on collaboration to ensure that cooperation with China will not jeopardise the academic freedom and intellectual property rights of EU research organisations and companies. However, the two objectives are driven by different interests and logics. Thus, it is foreseeable that there will be

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more uncertainties and challenges to EU–China STI cooperation after the roadmap is launched. Therefore, deep empirical investigations and innovative theoretical thinking are urgently needed to provide helpful guidance for EU-China innovation cooperation in a new era.

To fully understand the present challenges in EU-China STI cooperation, one has to know the cooperation development in the past. The EU's and China's burgeoning interests in innovation cooperation were expedited by the signing of the *EU–China Innovation Cooperation Dialogue* in 2012, which complemented and ensured synergy with the *Agreement on Science and Technology Cooperation between the EU and China* in 1998. According to the *Joint Declaration on the EU–China Innovation Cooperation Dialogue*, 'the two Sides intend to discuss innovation strategies, jointly encourage and support cooperation on research and innovation, and to fully involve industry, universities and research institutes, to complement mutual strengths and deliver "win-win" results in the areas of human resources, skills, technology, research infrastructures, financing of innovation, exploitation of research findings, entrepreneurship and framework conditions for innovations' (European Commission, 2012, p. 2). The declaration indicates that innovation cooperation involves both industrial organisations and universities (and research institutes). The EU-China collaboration in both the industry and university sectors has been transforming in the past decade.

China's role in its industry collaboration with the EU is shifting from an important market and trade partner to an innovation partner (EU, 2016; European Union Chamber of Commerce in China, 2017). This is because China is not only the second-largest economy in the world but also has become the largest producer of scientific articles (Tollefson, 2018) and the world's second-largest research and development (R&D) spender (UNESCO, 2018). Indeed, many Europeans collaborate with Chinese partners in R&D in high-tech industries. For example, the Business Confidence Survey conducted by the European Union Chamber of Commerce in China (2021) reported that 'a mere 9% of European companies are considering moving any current or planned investment out of China, the lowest level on record' (p. 11). Despite top-down support and bottom-up enthusiasm for EU–China innovation cooperation, it is surprising that few statistics on such cooperation are reported. Some rare studies providing such information includede Wang et al. (2017), which reported 123,800 joint publications between China and 28 EU member states between 2000 and 2014, and Romagnuolo et al. (2021), which reported 140 EU–China collaboration patents in the field of personalised medicine.

EU–China university collaboration is facing increasing demands from society and stakeholders, as universities are being called on to shift the focus of their internationalisation strategies from international scholarship exchange to developing the EU–China partnership (Cai, 2019; Cai and Zheng, 2021). This echoes the notion of 'internationalisation in higher education for society' suggested by Brandenburg et al. (2020).

The transformations of EU–China cooperation in both higher education and industry will require synergy building, which is essential to building transnational innovation ecosystems (Cai et al., 2019). However, it is surprising how little interaction exists between the two areas of cooperation – higher education and industry – both in terms of policymaking and organisational practice. Moreover, synergy has not been addressed in research on EU–China innovation cooperation, as cooperation has been reported separately in universities (e.g. Fan et al., 2014) and industry (e.g. García-Herrero et al., 2017).

The research gap in EU–China innovation cooperation also reflects a paradox in innovation studies. On the one hand, there are widely shared perceptions of two tendencies: 1) innovation systems becoming globally interconnected (e.g. Liu et al., 2013; Necoechea-Mondragón et al., 2017) and 2) universities, especially their research, becoming increasingly vital to innovation systems (e.g. Brekke, 2020; Etzkowitz and Leydesdorff, 2000; Salter and Martin, 2001). On the other hand, studies on the roles of universities in innovation systems are mainly confined to national or regional contexts (Brekke, 2021), whereas the engagement of universities, especially in the form of international 'research collaboration' (Katz and Martin, 1997), in transnational innovation networks/systems has been surprisingly overlooked in the literature. Meanwhile, although international research cooperation has become an emerging domain of innovation studies, the extant literature on this topic has mainly focused on bibliometrics research and network analysis of research collaboration dynamics (Chen et al., 2019). Few studies have explored the influences of international research collaboration on international innovation cooperation in other sectors (e.g. industry).

Although no studies have directly tackled the research inquiry in this paper, there are a few that may shed some light on my research. Existing research on university and industry collaboration in international contexts focuses on two streams: 1) international corporations' collaboration with local universities in R&D activities (Liefner et al., 2019; Ma, 2019), and 2) universities' international branch campuses' roles in connecting firms from both home and host countries (Klerkx and Guimón, 2017). The first stream suggests that there is a potential for synergy building between universities and companies across geographical boundaries and identifies challenges in the synergy-building process related to trust and conflicting norms between the university and industry actors from different national contexts. It also implies that to resolve the challenges, additional actors must be involved. This led me to consider the advantage of synergy building between international university collaboration and international industry collaboration, beyond the form of joint ventures between local universities and foreign firms, in developing international innovation cooperation. The present study is more thematically similar to the second research stream. In China, joint venture institutions between foreign and domestic universities represent the deepest level of international university collaboration (Ennew and Fujia, 2009; Lin, 2020). Current research mainly reports the educational aspects of these kinds of joint venture institutions; however, other forms of international university collaboration with a strong focus on research are expected to be discovered.

The lack of research on universities' roles in international innovation cooperation is probably due to the dearth of theoretical or conceptual tools needed to elucidate the phenomenon. According to Binz and Truffer (2017, p. 1284), 'while various analytical approaches have started to conceptualize the increasing importance of international linkages between regional and national innovation systems, a comprehensive and operable analytical framework for global innovation systems is still missing'. Although Binz and Truffer (2017) tried to develop a framework for understanding innovation dynamics in transnational contexts, their framework was decidedly industry-focused and did not take universities into account.

In the context of EU–China innovation cooperation, Cai et al. (2019) called for theoretical and methodological advancement of our understanding of universities' roles in the EU's international innovation cooperation. They also developed a useful concept—transnational university–industry co-innovation networks (TUICNs), which provides a framework for understanding the roles of international university collaboration in facilitating international industry collaboration aiming at value co-creation through innovation processes. Moreover, they argued that by developing TUICNs, many challenges in international industry collaboration, such as those caused by spatial distance between industrial partners from different countries, could be resolved. Nevertheless, Cai et al. (2019) mainly identified research gaps and proposed an agenda for future research rather than offering comprehensive solutions. Overall, the literature on EU–China innovation cooperation is mostly ad hoc and not theory driven.

To bridge the aforementioned research gaps, this paper posed the following research question: *How does European and Chinese university collaboration help European companies turn collaboration challenges with Chinese counterparts into opportunities through developing TUICNs?* To answer this question, a new model of EU–China innovation cooperation was proposed. The research question was addressed using the following steps. First, an analytical framework (middle-level theory) for understanding the roles of international university collaboration in the development of TUICNs was constructed by integrating insights from social network theory and institutional theory. Second, the research method was introduced. Third, an empirical investigation was used to verify and enhance theory building. The study generated five propositions concerning the role of international university collaboration in the development of TUICNs in the EU–China context. Scholarly contributions and policy recommendations are discussed in the conclusion.

2. Analytical framework: the roles of international university collaboration in building TUICNs

The construction of the analytical framework in this paper can be seen in the process of multi-level theory interactions (Fig. 1). Kezar (2006) distinguishes between four vertical levels of theory: meta-theory, grand theory, middle-level theory, and low-level theory. Kezar's key message is that there is a recursive relationship between higher- and lower-level theories: higher-level theories guide and influence theoretical development at the lower level, while lower-level theories build up to higher-level theories. In this study, a middle-level framework based on grand theories (i.e. social network theory and institutional theory) was used to guide the empirical analysis. The results of the data analysis were expected to generate propositions that would verify and strengthen the analytical framework. The innovativeness of the analytical framework lies in two of its features. First, it provides a novel approach to theorising about the mechanisms related to international university collaboration's roles in international industry collaboration by integrating social network theory and institutional theory in the context of innovation ecosystems. Second, the theoretical elaboration leads to a new model of international innovation cooperation.

2.1. Definitions of major concepts

Before theory building, some central concepts, such as *international innovation cooperation* and *TUICNs*, need to be defined. All of these concepts are understood in the context of innovation ecosystems. Cai et al. (2020, p. 2) define *innovation ecosystems* as 'co-innovation networks, in which actors from organisations concerned with the functions of knowledge production, wealth creation and norm control interact with each other in forming co-evolution and interdependent relations (both direct or indirect) in cross-geographical contexts, and, through which new ideas and approaches from various internal and external sources are integrated into a platform to generate shared values for the sustainable transformation of the society'. One key implication of this definition is that innovation ecosystems tend to be transnational. The transnational or 'multi-locational' feature of innovation ecosystems was noted by Sotarauta et al. (2016) and Carayannis et al. (2018), who stressed that knowledge flows and innovation processes take place in multiple geographical locations. The transnational dimension of innovation networks has been widely reported in innovation research (Barnard and Chaminade, 2011; Lundvall et al., 2014; Necoechea-Mondragón et al., 2017; Pandey and Desai, 2017) and geography studies (e.g., Wixted, 2009). The networks are primarily interlinked through *international innovation cooperation* between actors from multiple sectors, such as higher education, industry and government (Cai and Etzkowitz, 2020).

In this paper, international innovation cooperation is used interchangeably with *international STI cooperation*. Cai et al. (2019) argued that the success of international STI cooperation is heavily based on synergy building among actors in *TUICNs*, which are characterised by 'collaboration, coordination, co-creation, convergence and complementary[it]y' (Saragih and Tan, 2018, p. 361) as core features of innovation ecosystems (Cai et al., 2020). The key components of TUICNs are international university collaboration and international industry collaboration, as well as the links between these two kinds of collaboration. While such networks help integrate new ideas and approaches and generate new and shared values in innovation processes, it is difficult to develop full-fledged TUICNs, as the links between international university collaboration and international industry collaboration are often unclear or hidden (Cai et al., 2019).

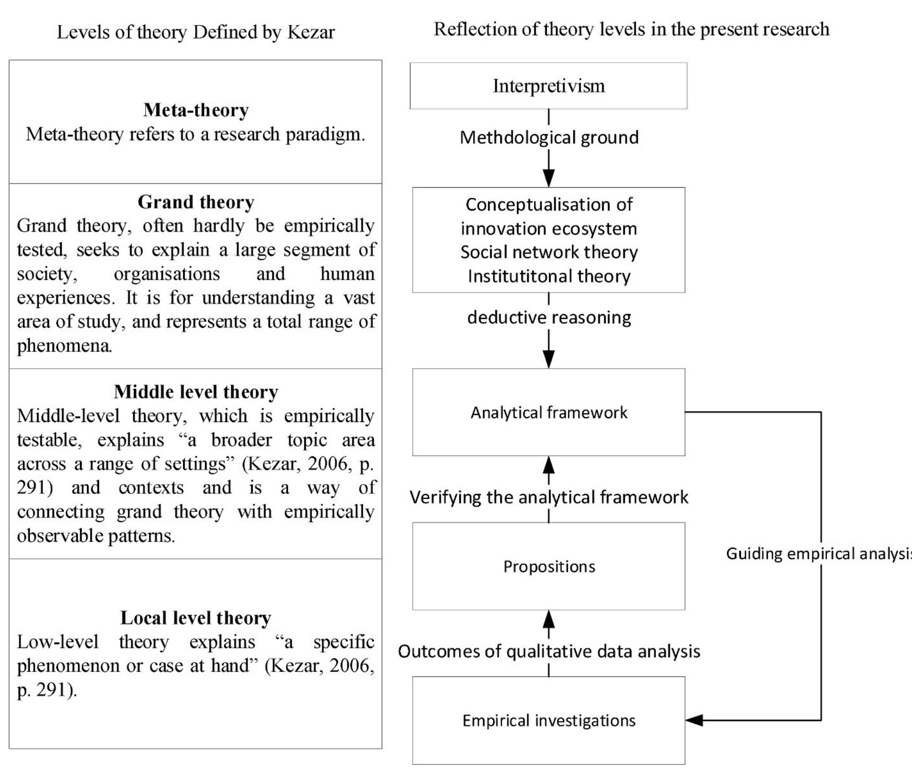

Fig. 1. Levels of theory and reflection.
Source: The author.

It should be noted that TUICNs are part of innovation ecosystems, in which other actors beyond the higher education and industry sectors are involved, which is illustrated in Fig. 2 with EU–China transnational innovation ecosystems. Compared to national/regional contexts, the geographical, social and institutional distances between actors in transnational innovation ecosystems, specifically TUICNs, are much larger. While geographical distance can hardly be altered, the dynamics of social and institutional distance, understood from the perspectives of social network theory and institutional theory, respectively, can be leveraged.

Next, an analytical framework concerning the roles of international university collaboration in facilitating the development of TUICNs was constructed. The framework focuses on how challenges associated with sparse networks and institutional distances, which characterise TUICNs, can be turned into opportunities through international university collaboration, as both social network theory and institutional theory suggest that challenges and opportunities are the two sides of the same coin of sparse networks and institutional distances.

2.2. The roles of international university collaboration in facilitating international industry partnership building: a social network theory perspective

2.2.1. Social network theory and its relevance to innovation cooperation

Social distance can be explained from the perspective of social network theory, especially insights regarding weak ties (Granovetter, 1973) and structural holes (Burt, 2000), both of which pay special attention to actors who bridge isolated networks and acknowledge their importance in innovation. Innovation requires a combination of both strong and weak ties (Abrahamson and Rosenkopf, 1997; Capaldo, 2007; Michelfelder and Kratzer, 2013), as 'weak ties aid exploration (the generation of new ideas), whereas strong ties aid exploitation (the implementation of new ideas)' (Barrie et al., 2019, p. 212). Accordingly, two types of network structures can be distinguished: dense networks and sparse networks, which are based on strong and weak ties, respectively (Kijkuit and Van Den Ende, 2007).

In dense networks, actors are fully connected via redundant channels of information flow and knowledge exchange. Such networks facilitate the establishment of a common language, mutual understanding and consensus formation, which can help coordinate collective actions by mobilising readily available trust and normatively constrained interests (Hemphälä and Magnusson, 2012). However, as they are characterised by close-knit structures, dense networks entail greater obstacles to generating new ideas and tend to exclude other actors beyond the initial densely linked groups (Obstfeld, 2005).

Sparse networks are rich in 'structural holes', which refer to discontinuities between groups of actors that have complementary sources of information (Burt, 2000). Actors bridging heterogeneous groups are likely to create new ways of thinking by selecting and synthesising valuable ideas from different groups (Burt, 2004). Thus, actors whose networks span multiple nations enjoy strategic positions can play a crucial role as brokers to connect innovation networks across national borders.

2.2.2. Challenges and opportunities of sparse networks for international industry innovation cooperation

Based on the discussions above, it can be inferred that, compared to regional/national innovation (eco)systems, the networks between university and industry actors in transnational innovation (eco)systems are likely to be more sparsely connected in a geographical sense (i.e. larger spatial distances). Alguezaui and Filieri (2010) compared the pros and cons of sparse and dense networks in terms of innovation (as the outcome of collaboration in a network). While, in general, the benefits and risks of one network are the inverses of the other, the specific challenges and opportunities of sparse networks can be summarised in Table 1.

To fully take advantage of sparse networks while mitigating related challenges, Burt (2000) suggested bringing together both sparse networks (characterised by structural holes) and dense networks (characterised by network closure): 'while brokerage across structural holes seems to be the source of added value, closure can be beneficial to realizing the value buried in the structural holes' (p. 398). The key to such combined networks is the introduction of trust, which is typically seen in dense networks, into sparse networks. Trust helps enhance the efficacy of action coordination, since intense and effective interactions are enabled in trusting social contexts (Alguezaui and Filieri, 2010; Obstfeld, 2005). Trust among collaborative actors is also essential to

Table 1
Challenges and opportunities for cooperation in sparse networks for innovation.

Challenges	Opportunities
Impeding the intense interactions that are necessary to gain a deep understanding of ideas in an innovation process	Source of unique knowledge and innovative ideas
Creating obstacles to action coordination (a lack of trust between actors in the networks)	Free flow of information, ideas and knowledge.
Inefficient implementation of innovative ideas	Efficient knowledge exploration and recombination

Source: Adapted from Alguezaui and Filieri (2010).

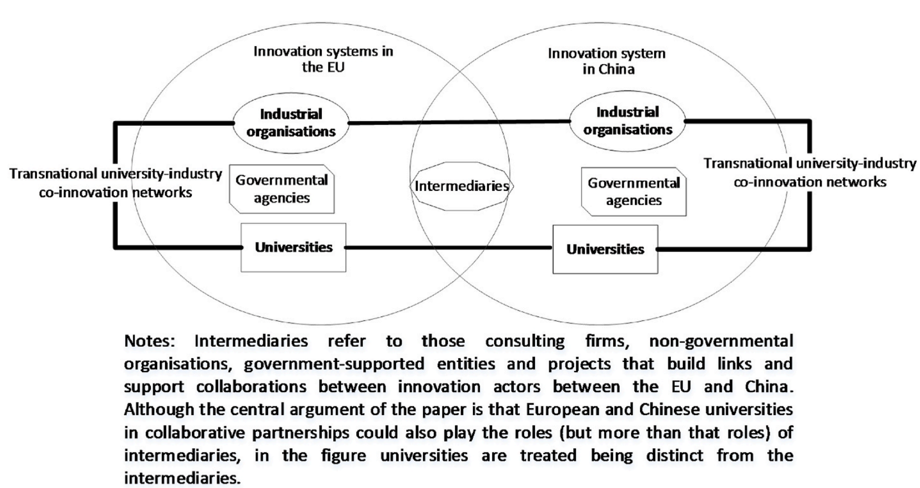

Fig. 2. TUICNs in transnational innovation ecosystems.
Source: Adapted from Cai et al. (2019).

creating shared visions (Bruce, 2002). Eboli (2015) found that sparse networks are more effective than dense networks at diffusing innovation when there is a shared vision of its benefit.

2.2.3. A social network theory perspective on the roles of international university collaboration in turning international industry collaboration challenges into opportunities

In international innovation cooperation, the industrial organisations from different countries can be seen as heterogeneous groups. Cai et al. (2019) suggested that two unfamiliar industrial organisations (with a missing link) from different countries could be connected for potential collaboration by utilising their common connections to existing university collaboration, often at the individual level (see Fig. 3). They further stressed that the ties between international university collaboration and international industry collaboration are often hidden because the links between them are unclear or the information revealing the links is obscured. Thus, by revealing such hidden ties, TUICNs can be created.

International university cooperation plays two important roles in facilitating the development of TUICNs. One is to match industrial organisations for international collaboration. As Reichert (2019) suggested in her report on the role of universities in innovation ecosystems, universities' contributions to innovation ecosystems extend from technology transfer to facilitating multi-actor co-creation. In other words, universities, as anchor organisations, can connect key actors in other sectors for value co-creation/co-innovation throughout the knowledge exchange process (Cai et al., 2020). However, a barrier to developing co-innovation networks is a lack of trust (Obstfeld, 2005), as actors from different countries can have diverse interests, perspectives and languages. Therefore, the other role of international university cooperation is to build trust between industry partners. Since international university collaboration involves relatively high levels of mutual understanding (Liu, 2017; Navracsics, 2017), it can enhance trust in international industry collaboration.

2.3. The roles of international university collaboration in leveraging institutional arbitrage in innovation cooperation: An institutional theory perspective

2.3.1. Institutional theory and its relevance to innovation cooperation

In institutional theory, a key concept for understanding different social norms across geographical locations is institutional distance, which refers to 'the difference between the regulatory, cognitive, and normative institutions of two countries' (Kostova and Zaheer, 1999, p. 71). Its antonym is 'institutional proximity' (Boschma, 2005). According to Boschma (2005), institutional proximity enables the establishment of a recognised socio-cultural, economic and political framework in which the actors are embedded. Thus, it reduces uncertainty and provides stable conditions for interactive learning and innovation. Boschma (2005) also noted that institutional proximity could harm innovation due to the problem of 'lock-in'. Therefore, institutional distance may offer solutions to lock-ins (Perkmann and Phillips, 2011).

Institutional distance can be well explained through the lens of institutional logic (Thornton et al., 2012), which is defined as 'a set of material practices and symbolic constructions' that constitute an institutional order's 'organizing principle' and that are 'available to organisations and individuals to elaborate' (Friedland and Alford, 1991, p. 248). A major argument in institutional logics theory is that multiple and contending logics provide the dynamics for potential change/-innovation in both organisations and societies (Thornton et al., 2012).

2.3.2. Challenges and opportunities for international industry innovation cooperation characterised by institutional distance

While institutional distance between industrial actors in transnational contexts can entail challenges, especially in terms of reaching a consensus in innovation collaboration (Varga, 2006), it can also entail opportunities for innovation (Boschma, 2005; Thornton et al., 2012). Perkmann and Phillips (2011) used the concept of institutional arbitrage to explain how the institutional differences between the fields of academia and industry, subject to academic and industrial logics, respectively, can be leveraged in a national context. They refer to institutional arbitrage as the practice of arranging activities in different institutional settings to benefit from institutional differences. From an institutional logics perspective, institutional arbitrage is about how to turn the challenges brought about by the tensions inherent in complex institutional contexts into opportunities when organisation members can attempt to achieve valued organisational goals across sector boundaries. Consequently, Perkmann and Phillips (2011) discovered three types of benefits of institutional arbitrage and provided related enabling mechanisms as well as opportunities from these benefits (Table 2).

2.3.3. An institutional theory perspective on the roles of international university collaboration in turning international industry collaboration challenges into opportunities

Innovation actors from different regimes are often subject to different institutional logics (Cai et al., 2019), shaped by both formal

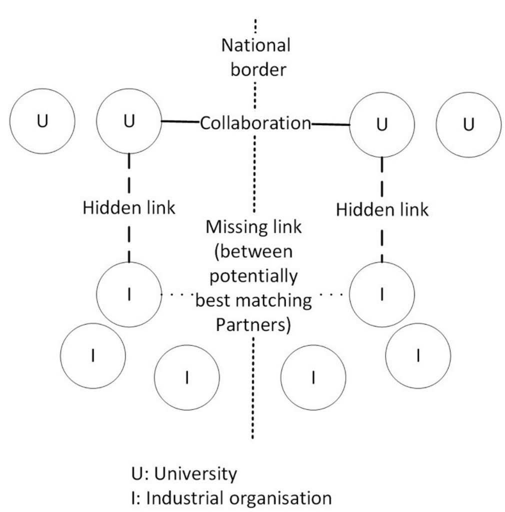

Fig. 3. TUICNs created through bridging hidden ties
Source: Adapted from Cai et al. (2019).

Table 2
Arbitrage benefits, enabling mechanisms and opportunities.

Benefits	Mechanisms	Opportunities
Resources	Diverging organisational logics generate differences in resource munificence	Access to abundant resources in other fields
	Different valuation practices generate exchange opportunities	Access to undervalued resources available in another field
	Diverging interests reduce competition and opportunism	Exploit the effects of interests and expected behaviour
Legitimacy	Association with high-status actors in other fields	Borrow from another's reputation to enhance one's reputation without inducing competition
Ideas	Signalling effects via association with values and practices in other fields	Exploit symbolic association to emphasise the desirable aspects of one's activities
	Borrow elements from other logics	Deploy in other fields as a source of novelty
	Break out taken-for-granted procedures	

Source: Adapted from Perkmann and Phillips (2011).

elements, such as laws and rules, and informal elements, such as values and routines (Boschma, 2005; Mattes, 2012). Although Perkmann and Phillips' (2011) study is based on a national context, the three mechanisms of institutional arbitrage identified in their study have generic explanatory power when it comes to people's strategic exploitation of institutional complexity, which also characterises international innovation cooperation. Therefore, these mechanisms and opportunities associated with institutional distance between universities and firms can also be used to explain the role of international university collaboration in leveraging opportunities for developing TUICNs.

2.4. Combining the roles for developing TUICNs

Structural holes and institutional distance between industrial organisations across national contexts can induce both challenges and opportunities. The roles of international university collaboration in turning international industry collaboration challenges into opportunities are summarised in Table 3 and fall into two categories: 1) bridging structural holes between industrial organisations on both sides through networking and trust building and 2) leveraging institutional arbitrage. By combining both roles, universities in international collaborative partnerships can serve as anchor organisations in developing TUICNs, which may imply a new model of international innovation cooperation.

3. Research method and research data

Since synergy building between international university collaboration and international industry collaboration is underresearched, an exploratory qualitative research method was applied, which is suitable for gaining a deep understanding of an unknown phenomenon (Creswell, 2014). Nevertheless, it was not purely inductive research, which is typically seen in the grounded theory approach, using a 'systematic set of procedures to develop an inductively derived grounded theory about a phenomenon' (Strauss and Corbin, 1990, p. 24). Rather, the analysis in this study was guided by an analytical framework, as 'the use of theory not only is an immense aid in defining the appropriate research design and data collection but also becomes the main vehicle for generalising the results of the study' (Yin, 1994, p. 32).

The data sources in this study comprised in-depth interviews that I conducted with actors involved in EU–China innovation cooperation between autumn 2017 and spring 2018. One of the challenges of this research was to identify suitable interviewees, as there is little information concerning (best) practices of synergy building between international university collaboration and international industry collaboration in the EU–China context. In addition to using my own networks, my strategy for seeking relevant practices and interviewees was to participate in events involving pioneer actors in EU–China innovation cooperation. Three criteria were applied when selecting interviewees: 1) they had to be engaged in EU–China innovation cooperation, representing either a university, industry or government; 2) their engagement in EU–China innovation cooperation had to involve multiple EU member states; and 3) the industrial fields of innovation cooperation were priorities for China and the EU.

The majority of the interviewees included in the study were participants of three events in which I also took part. Two of these events were the matchmaking tours of an EU-funded project for supporting and connecting European research, innovation and business organisations to China, which took place in October 2017 and May 2018, respectively. The third event was the Sino-Finnish Forum on Universities as Platforms for Scientific Innovation and Technology Transfer, held in November 2017. Some interviewees from these events introduced me to additional relevant informants.

Although more than 20 interviews were conducted, only 18 were included in the analysis (Table 4), as the remaining interviewees mainly talked about collaboration within the industry or university sector rather than interactions between them. All the interviews were conducted face to face using semi-structured interview questions. The main discussions in the interviews were about the interviewees' engagement in the intersections between international university collaboration and international industry collaboration, as well as their perspectives on the roles of the former in facilitating the latter. While the interview questions were principally guided by the analytical framework, the interviewees were expected to report all related matters from their perspectives. Except for one interview (with I2), all of them were audio recorded. The interviews covered university collaboration and industry collaboration between China and several EU member states, including Belgium, Germany, Finland, the Netherlands and Portugal.

All the interviews were transcribed and then coded using NVivo (qualitative data analysis software). The coding concerning the role of international university collaboration in building TUICNs was mainly guided by the analytical framework. When identifying the challenges and opportunities associated with EU–China industry collaboration, an open coding strategy was initially applied and then the challenges were categorised according to the perspectives of social networks and institutional distances.

Table 3
The roles of international university collaboration in building TUICNs.

Roles from theoretical perspectives	Specific roles	Combined roles
Bridging structural holes	1. Connecting industrial partners from different countries 2. Building trust between the industry partner organisations bridged through university collaboration	Contributes to building TUICNs
Leveraging institutional arbitrage	3. Giving industrial actors access to new resources 4. Enhancing the reputations of international companies in their cooperation countries. 5. Breaking down taken-for-granted procedures	

Source: The author.

4. The roles of universities in EU–China innovation cooperation

Guided by the analytical framework (Table 3), I empirically investigated how international university collaboration contributes to the development of TUICNs, particularly in turning international industry collaboration challenges into opportunities in the context of EU–China innovation cooperation. In the empirical study, I identified four examples of best practices regarding the role of EU–China university collaboration in turning EU–China industry cooperation challenges into opportunities, based on the analysis of the interviews. Table 5 describes the major characteristics of the examples. It also summarises the roles of international university collaboration in facilitating international industry collaboration produced by the empirical data analysis that is presented in detail below. Although only five interviewees were associated with the four examples, information from the other interviewees was also used in the analysis.

4.1. Matching industrial partners from both the EU and China

4.1.1. Challenges to be tackled

The role of international university cooperation in connecting industrial organisations from both the EU and China helps to address a particular challenge: while many European technology companies have been attracted by envisioned opportunities in China, they knew little about the situation there and thus had difficulties finding the most suitable partners. I6 emphasised how understanding the Chinese market was the basis for the success of European companies moving into China. I13 shared a similar observation:

Table 4
Description of the interviewees.

Interviewee ID	Duration of interview	Sector	Type of organisation	position	Location of workplace	Gender	Main work activities
I1	90 min	Industry	A European consulting firm in China	CEO	China	Male	Providing consulting services to European companies doing business in China
I2	20 min	Government	An EU office in China	Section head	China	Male	Supporting EU–China cooperation in STI
I3	43 min	Industry	A European firm for promoting business development	CEO	EU	Male	Facilitating business cooperation with China in technology fields
I4	42 min	University	A research centre jointly run by a Chinese university and a European university	Coordinator	China	Female	Coordinating a joint centre established by a Chinese university and a European university
I5	74 min	University	A collaboratively run university college between a Chinese university and a European university	Coordinator	China	Female	Coordinating a joint college supported by the Chinese government and the government of an EU member state
I6	52 min	Government	An EU platform for supporting European business development in China	Director	China	Male	Supporting the development of EU small- and medium-sized enterprises (SMEs) in China
I7	53 min	Government	A European country's business promotion office in China	Director	China	Male	Supporting one EU member state's business development in China
I8	33 min	Government	An EU office in China	Country representative	China	Female	Supporting EU research cooperation in China
I9	23 min	Industry	A European consulting company	Board member	EU	Female	Coordinating an EU–China STI cooperation project
I10	89 min	Industry	A company owned by a European university	CEO	EU	Male	Doing business with China for technology transfer
I11	34 min	University	A European university	Head of China Office	EU	Female	Coordinating a European university's collaboration with Chinese universities and stakeholders
I12	34 min	University	A European university	Coordinator of China Office	EU	Male	Coordinating a European university's collaboration with Chinese universities and stakeholders
I13	30 min	Industry	A European country's project for promoting business development in China	Director	EU	Male	Coordinating an information communication and technology (ICT) network between China and a European member state
I14	32 min	Industry	China branch of a European consulting firm	Director	China	Male	Coordinating an EU–China STI cooperation project
I15	49 min	University	A European university	Vice President	EU	Male	Occupying a leadership position at a European university
I16	39 min	University	A European university	Head of China Office	EU	Male	Managing technology transfer to China at a European university
I17	96 min	University	A Chinese university	Programme Coordinator	China	Female	Coordinating international collaboration of an MBA programme at a Chinese university
I18	31 min	NGO	A Chinese platform for supporting European business development in China	Director	China	Female	Providing services for European companies landing in China

Notes: EU refers to a EU member state.
Source: The author.

> *The Chinese market is ultra-competitive. Today's situation is that Chinese technology companies, including Chinese start-ups, have developed very rapidly, and one thing that these companies from [Country A] should do is try to understand what the current state of the Chinese environment is – in order not to make false assumptions.*

I3 suggested that one way to avoid making false assumptions is to collaborate with local partners in China. When European companies seek Chinese business partners for collaboration, it is important to build a partnership through someone who knows both sides (I4). In practice, the most links between European and Chinese companies were consulting firms (I1), supporting agencies (I6, I18) and other foreign entities in China (I7). Several interviewees (I1, I6, I7, I9) noted that when European companies, especially SMEs, sought Chinese counterparts for cooperation, they normally went directly to the industry sector and collaborated with the first Chinese companies that came along.

However, these partners were seldom the most suitable ones. Indeed, it was difficult for Europeans to check the credibility of their potential Chinese partners (I9). I7 warned European businesspeople: 'If they [Chinese companies] are too eager, too desperate to do business [with you], it could be because they don't have enough business here otherwise'. He further stressed that the success of European companies in the Chinese market depends on how they select their Chinese partners and build trust with them.

4.1.2. *Opportunities generated by international university collaboration*

Collaborating universities from the EU and China could help connect suitable industrial partners from both sides. In Example 1, the research group at EU1 intended to capitalise on their cutting-edge knowledge in the scientific field of SF1 in China. In so doing, EU1 needed to collaborate not only with its Chinese partner university CU1 but also with the Chinese companies connected to CU1. However, it was practically difficult for EU1 to work directly with Chinese companies. As I10 explained:

> *For Chinese companies, it is quite difficult to collaborate with universities, because it is very difficult for the Chinese local government and risk investors to understand the role of a university .... In China, academies have quite a bad reputation of being ineffective. Therefore, Chinese companies sometimes think that academic activities are like a 'money pit'; it is good to fund a university, but it doesn't produce money for society. (I10)*

Therefore, EU1 established a spin-off company — EC1, to facilitate

Table 5
Examples of best practices.

Descriptions of the best practices examples that reflect the roles of EU–China university collaboration in turning EU–China industry cooperation challenges into opportunities					Findings from the analysis following the analytical framework (Table 3)				
Example ID and key interviewees (Interviewee IDs) engaged in the cooperation example	EU–China university collaboration	The focus and coordination of the university collaboration	EU–China industry collaboration	Links between university collaboration and industry collaboration	Roles of international university collaboration in facilitating international industry collaboration				
					1	2	3	4	5
Example 1 I10	The European university EU1 (in Country A), a global leader in the scientific field SF1, had an eight-year research collaboration with the Chinese university CU1 in SF1. EU1 is among the top 100 in the Academic Ranking of World Universities. CU1 is a 985 university (One of the top research universities in China).	• Research collaboration in a specific field • Coordinated by individual researchers	The European company EC1, a spin-off EU1 in the field of SF1, collaborated with several Chinese companies, mainly to capitalise on the knowledge produced by EU1 in the field of SF1.	EC1 was connected with its Chinese partner companies through CU1.	++	++	++	+	o
Example 2 I5	The governments of both China and Country B (an EU member state) jointly established the Sino-B College located at the Chinese university CU2 20 years ago. The college had a close collaboration with several top universities from Country B.	• Research and teaching collaboration involving multiple disciplines • Coordinated by CU2	Several companies from Country B, which sponsored the Sino-B College, e.g. through setting up chair professor positions after the name of the companies, had business collaboration with Chinese companies.	The partnership between companies from Country B and China was largely facilitated by the staff and alumni of Sino-B College.	+	+	++	++	o
Example 3 I11 and I12	The European University EU3 in Country C established the China Platform to coordinate the university's broad networking with China 15 years ago. EU3 is among the top 100 universities in the ARWU ranking. CU2 is a 985 university.	• Services facilitating EU3's and the local government's cooperation with China • Coordinated by the International Office of EU3	Local companies linked with EU3 in Country C collaborated with Chinese companies.	The professors from EU3 helped the companies in Country C connect with Chinese companies that had links with the Chinese universities with which the professors had research collaboration.	++	+	o	o	o
Example 4 I13	Several key universities in the field of ICT from Country A and China, together with some research institutes and companies, formed the Sino-A ICT Alliance 10 years ago, a project supported by the governments of China and Country A.	• R&D collaboration in the ICT field • Coordinated by the project coordinator, a university professor from Country A.	The collaborative companies from both China and Country A were members of the Sino-A ICT Alliance.	The collaborative relations between the companies from China and Country A were established through the alliance, but they also had close ties with the universities of both sides of the alliance.	o	o	o	o	++

Notes: ++ = Strongly evidenced by the examples; + = Evidenced by the examples; o = Not explicitly mentioned by interviewees. See interviewee IDs in Table 4.
Source: The author.

its business collaboration with Chinese companies. In this example, a TUICN was formed through collaborative relations between EU1 and CU1.

Similarly, in Example 3, it was mentioned that a civic engineering professor played an important role in linking companies from China and Country C through his research collaboration with a leading Chinese university in the field (I11). In Example 2, although the Sino-B College at CU2 was not directly involved in matching Chinese and European companies, many European companies' (from Country B) connections with their Chinese counterparts were facilitated by the faculty members and alumni of the college (I5).

The interview analysis discussed above led to Proposition 1: *European companies can connect with suitable Chinese industrial partners through EU–China university collaboration.*

4.2. Building trust between industry partner organisations

4.2.1. Challenges to be tackled

The role of international university collaboration in building trust between industry partners helps deal with the challenges of trust building, which is crucial for partnerships between European and Chinese companies. Building trust is costly. The relationship between collaboration and trust is also a chicken-and-egg issue: good collaboration is based on trust, but trust can only be built through long-term collaboration. As said by I7:

> *Building trust is a key issue, but it takes time. It is not built over one trip to China for two weeks or even for a few months …. We even realised that some companies had spent two or three years in China before getting their first deal.*

4.2.2. Opportunities generated by international university collaboration

Compared to a business partnership established independently or through business brokers, one bridged through EU–Chinese university collaboration can build trust more quickly. In Example 1, since EC1 (EU1's spin-off) and Chinese companies were connected via EU1 and CU1, which had a long-term research collaboration, they could effectively do business together right away without trust issues. This is in stark contrast to the experiences of many European companies working with Chinese partners that have to be patient while investing resources and time into trust building. When EC1 expanded its business in China, it developed 'a policy of only working with Chinese companies that have close ties with [EU1]'s collaborating Chinese universities' (I10).

Nevertheless, it should be noted that building trust between European and Chinese universities is also expensive and time consuming. I10 described EU1's collaboration with CU1:

> *The most important thing in China is that, first, you have to be present a lot. You have to show the Chinese partner that you are interested in them. And the Chinese university gets lots of requests for collaboration from abroad …. If we want to be successful, we have to be present. So that's why, in the first few years, we went there with our own funding, visited them, and thus we were able to establish a joint laboratory with our fund at CU1 to start the first measurement activities. And then when we got good results, slowly CU1 was able to use those results [produced by the laboratory] to ask for funding from China …. Now the funding for the joint laboratory didn't have to come from our side anymore.*

Companies from the EU and China would save both time and money if they could strategically utilise existing trust between European and Chinese universities to strengthen their collaboration. This led to Proposition 2: *European and Chinese companies connected through EU--China university collaboration can build mutual trust more quickly*.

4.3. Giving industrial actors access to new resources

4.3.1. Challenges to be tackled

The role of international university collaboration for contributing new resources to international industry collaboration helps tackle the challenge for companies in the high-tech industry: the realisation of innovative business ideas is often constrained by available financial resources. I6 noted that, as most European companies in China are SMEs, a major challenge is insufficient resources, e.g. in terms of investment capital. For this reason, 'they [the SMEs] are normally [having] a bit shorter [life cycle in China] because they don't have enough resources to stay here that long enough to try out the market' (I6). Similar views were shared by I3, who emphasised that, compared to business operations in Europe, more resources are required for European SMEs in China. He further explained this with an example:

> *If there is an official negotiation where some kind of ministers or high-level political decision-makers are with the Chinese partners, they can say that they have the resources and [to make the deal] we [companies on the European side] need to provide two million euros [as a co-investment]. [The challenges are], first of all, we don't have the two million euros, and even if* we *did, we don't have permission to make commitments on this negotiation table. (I3)*

4.3.2. Opportunities generated by international university collaboration

All four examples, particularly the first two, imply three kinds of resources from which EU–China industry collaboration can benefit by networking with EU–China university cooperation, namely 1) additional R&D resources, 2) employment investment savings, and (3) efficient use of funding for corporate image building. The first two are evidenced in Example 1. When the university and industry actors collaborated, they were entitled to apply for R&D projects that promoted university and industry collaboration. Moreover, EU1's spin-off company, EC1, had financial savings from reduced costs by hiring full-time researchers. For example, when EC1 needed to analyse business-related data in China, the company simply made a contract with EU1. As explained by I10:

> *Human resource costs are quite high for a new and small technology company …. If you have your own employees, then the costs are even higher, especially when you don't know if the business concept works or not. In the way we are operating, we can keep the cost low.*

The third kind of resource is reflected in Example 2. At Sino-B College, there were several chair professorship positions named after the companies (from Country B). These companies were motivated to sponsor the positions to promote the company's image and train the talent needed by the companies. From a financial perspective, this was a very cost-effective way of investing in corporate image building. As explained by I5:

> *In fact, [Country B]'s companies can enjoy tax benefits for donating money to the Sino-B College. However, tax reduction or exemption might not be their major consideration. Donating funds to education not only reduces the tax but also enhances their corporate image. The companies can benefit from both.*

The interview analysis discussed above led to Proposition 3: *EU--China university collaborations can provide industry partners with resources that are rarely available in the industry sector.*

4.4. Enhancing the reputation of European companies in China

4.4.1. Challenges to be tackled

The role of international university collaboration for enhancing the reputation of European companies in China is against the challenge faced by many European SMEs in China in promoting its visibility and reputation in the Chinese market. As I6 pointed out, many European SMEs come to China with good technology and prefer to focus on technology development, hoping that Chinese experts can help market their products in China. Indeed, for an 'unknown' European company, the 'Chinese market is very competitive; [if you want to be successful] you either have a very good brand that is already known in the market or you have some way to make it known very quickly' (I6). Making one product visible in the Chinese market is an all-consuming task, and 'that's why people go for [Chinese partnership] because they know a Chinese partner can help them accelerate [the process]' (I6). While leaving the marketing to their Chinese partners can be a valid strategy, European SMEs must 'view risks [of doing business in China], especially with regard to things like intellectual property rights … And [another risk is related to] how [their Chinese partners] want to be involved in the market themselves (a motivation issue) and how they have proximity to the Chinese customer (a capacity issue)' (I6).

4.4.2. Opportunities generated by international university collaboration

Being associated with prestigious universities greatly enhances European companies' reputations. An extreme case is Example 1, in which EC1, as a spin-off of EU1, immediately gained a good reputation in China because of EU1's position as a global leader in the scientific field SF1 and its long-time research collaboration with CU1. In Example 2, companies from Country B tried to enhance their reputations by sponsoring Sino-B College. As explained by I5:

> *Enterprises' investment in education can enhance the corporate image; this is one aspect. Another aspect is that [Sino-B College] holds an advisory committee meeting every year. Senior government officials and business representatives from China and [Country B] attend it. Such a meeting is equivalent to a club. Therefore, many companies are very willing to join. If you want to join such a high-level club, you need to sponsor the [Sino-B College] … Nowadays SMEs are more eager to invest in the college, e.g. by setting up chair professor positions.*

The interview analysis discussed above led to Proposition 4: *European companies, especially SMEs, can quickly establish their reputation in*

China if they are associated with prestigious European and Chinese universities via collaborative partnerships.

4.5. Breaking down taken-for-granted procedures

4.5.1. Challenges to be tackled

The role of international university collaboration in breaking down taking-for-granted procedures helps resolve the challenge faced by European companies in protecting their intellectual property (IP). Some challenges were explained by I13 — the Coordinator of the Sino-A ICT Alliance in Example 4:

> *First of all, Chinese companies patent a lot. So, one thing that a Western company needs to be aware of – they might actually violate a Chinese company's patent when going to China, which is a big risk. But the bigger risk still is that your technology becomes very much exposed when you go to China, and China is still fairly enough a copy culture …. IP protection schemes are more and more enforced in China. But, naturally, there is a delay while the Chinese government wants to of course learn – as any other government – about these new technologies.*

When European technology companies want to introduce their products in the Chinese market, the challenges mentioned above are unavoidable, though having an excellent Chinese partner can help to moderate such challenges (I13).

4.5.2. Opportunities generated by international university collaboration

To overcome these challenges, I13 presented a new business model they learned about from the practices in Example 4, in which universities and companies from both China and Country A formed a consortium, similar to the concept of TUICNs. The main ideas of the new business model were described by I13 as follows:

> *So, one good approach applying now in the medical or healthcare innovation areas is that we go science first, where we have universities as platforms. Science by nature is more open, you create new results, and you share it openly with the scientific community. And then it's up to the companies to create competitive products or unique IP based on the science. In this way, we can go to a new scientific field, so that China can add tremendous value to the global knowledge, e.g. on what analysis techniques there are, or what kinds of interventions work for people with diabetes or cardiovascular disease in the field of precision healthcare. And China is actually the world-leading country in some techniques in the field …. So, I would not always worry about the IP and copying, though we have to be aware of it, as it is a real risk. But when you understand that you can create new value that you could not create alone, it helps you find new solutions for a much larger market and a larger audience. And this could be a big competitive edge for Chinese and Europeans working together …. So, the one thing you should always ask is: 'What can we achieve together?'*

The interview analysis discussed above led to Proposition 5: *European companies are likely to develop novel business operations in China when working closely with European and Chinese universities.*

5. Towards a new model of international (EU-China) innovation cooperation

When all the roles mentioned above are combined, significant outcomes can be expected, such as resolving challenges in international industry collaboration, leveraging opportunities through building TUICNs, and envisioning a new model of EU–China innovation cooperation. These are explained below, respectively.

5.1. Resolving challenges

The challenges associated with EU–China innovation cooperation that were identified through the interview analyses are illustrated in Fig. 4. By playing all the roles mentioned above, international university collaboration can help resolve most challenges in international industry collaboration (Challenges 1, 2, 4, 6 and 7 in Fig. 4). However, the interview data do not show clear evidence that the challenges in decision-making/implementation and network sharing in China (Challenges 3 and 5 in Fig. 4) can be directly resolved through international university collaboration. Both challenges were identified through the interview analysis, as explained below.

Challenges related to decision-making/implementation are caused by normative differences between both sides, as illustrated by I3:

> *Basically, the Chinese party and our party [from Country A] come to negotiations from totally different starting points. On the Chinese side, they have already done some kind of homework regarding what can be decided before coming to a negotiation. Because of our tradition, unfortunately, we spent lots of time in different negotiations, and it takes much more time to get any kind of decision.*

When it comes to implementation, the interviewee added, 'that is the advantage on the European side because there is less possibility of change when something has been decided'. In China, there were still uncertainties during implementation, even after the issue had been decided; replacing key individuals in an organisation can significantly impact implementation.

Fig. 4. EU–China innovation cooperation challenges in the industry sector.
Source: The author.

Challenges related to network sharing are due to the unique way that people connect in China, which often hinders European companies from effectively utilising their Chinese partners' networks. Compared to Europeans, who are generally fine with sharing their networks with friends, Chinese people have a strong sense of ownership of their networks, as explained by I7:

> *If someone wants to get connected to some people in [Country A] in my network, I will just share the contact details and then let them talk to each other …. If I ask my Chinese friend to introduce me to someone in his network, he would be in that meeting when I meet the introduced person.*

5.2. The leadership and anchor roles of international university collaboration in building TUICNs

Besides mitigating challenges, international university collaboration also helps take advantage of opportunities in international industry collaboration. Most importantly, TUICNs form when all the roles of international university collaboration, as mentioned above, are combined. This distinguishes the bridging role of international university collaboration from that of other (traditional) brokers or intermediaries, which only help connect industry actors for collaboration without joining them in the innovation processes. Of course, international university collaboration could also benefit from international industry collaboration; however, this was not the focus of this study.

Examples 1 and 3 clearly demonstrate the leadership role of universities in developing TUICNs in the following two aspects: 1) university professors as visionaries and 2) universities as anchor organisations. In Example 1, one professor from EU1 was considered by I10 as a visionary because of his role in developing strategic partnerships with Chinese universities and, most importantly, due to his wisdom in utilising the university collaboration to facilitate business collaboration. In I10's words:

> *Already eight years ago, we made our investment [in building the research collaboration with CU1] for the future, and now I like the outcome of the investment …. [Our current operating model is] to make sure that our vision for the following years until 2030 will become successful because we have a long-term vision in our department …. I would not say EU1 has a long-term vision to work in China, but Professor K, the head of our group, does.*

Example 3 shows that the China Platform at EU3 played a central role in developing broad cooperation between Country C and China, involving actors from the industry and government sectors. The China Platform was not simply for coordinating EU3's collaboration with Chinese universities; it also developed a strategic partnership with the local government and chamber of commerce to support their collaboration with China. Together with the local government, they set up a liaison office in China. EU3 indeed became an anchor organisation by developing collaboration networks across the university, industry and government sectors of both sides (I11, I12).

Due to the chosen research focus and limited data, the present paper cannot fully explore TUICNs. For example, the interview analysis points out several important issues that are beyond the scope of this study.

First, building TUICNs not only requires the participation of university and industry actors across countries, but it also depends on environmental conditions and the support of other actors, which are beyond the scope of the study. For example, the interest fit between the two sides on innovation cooperation from political, science and market perspectives (I2, I6, I13, I16) can be a conditional factor affecting the development of TUICNs. The stories told by I7, I13 and I16 reflect the important role of government agencies (concerning partnership development, trust building and resource allocation) in developing TUICNs.

Second, as the study primarily focused on the European perspective when examining EU–China innovation cooperation, a full understanding of the nature of TUICNs requires investigations from both the European and the Chinese perspectives. Nevertheless, this study's findings show that in the cooperation the knowledge flow is mainly from the EU to China and that the resource flow is primarily from China to the EU.

Third, regardless of the significant potential of international university collaboration in building TUICNs, some interviewees (I11 and I12) noted that there is still much room for improvement in terms of realizing this potential and, to this end, learning from best practices and bold experimentation are needed.

5.3. Envisioning a new model of EU–China innovation cooperation

Building TUICNs can lead to a new model of international innovation cooperation. Traditional international innovation cooperation consists of two parallel collaborations in the sectors of university (including research institutes) and industry, where the connections between organisational actors in the two sectors are mainly in domestic contexts and through knowledge exchange (Cai et al., 2019). The new model is characterised by synergy building between international university (research) collaboration and international industry collaboration through bridging structural holes and leveraging institutional arbitrage. The traditional and new models of international innovation cooperation are illustrated in Fig. 5.

It should be noted that when elucidating the new model, this paper focused on the roles of international university collaboration in building TUICNs in its theory building and the European perspective in its empirical investigations. The study also implies other important issues related to the model. First, international industry collaboration can also facilitate international university collaboration. Second, the cooperation must be mutually beneficial to partners from the EU and China, since reciprocal cooperation is the foundation for sustainable international cooperation (Guimón and Narula, 2020). Third, to best facilitate the development of TUICNs, governments (in collaboration) are expected to provide supportive policies and impose normative changes. Theoretical elaboration on these ideas is needed to further enhance the new model. However, as these are beyond the scope of this paper, they must be further developed in future research.

6. Conclusion

Although the EU has attached great importance to STI cooperation with third countries and has made huge investments in it, our theoretical and empirical understanding of the nature of the EU's international STI cooperation, especially the dynamic interactions between international collaboration in university and industry sectors, is surprisingly limited. As a response to the research challenge, this paper investigated the role of international university collaboration in developing TUICNs by taking the EU–China innovation cooperation as an example. By conceptualising the phenomenon through integrating insights from social network theory and institutional theory, an analytical framework focusing on the five roles of international university collaboration in turning international industry collaboration challenges into opportunities was constructed. The basic theoretical assumption is that, while sparse networks and institutional distance can be both challenges and opportunities in international industry collaboration for innovation, international university collaboration can help largely turn the challenges into opportunities. In the process, universities can play leadership and anchor roles. The framework was applied in an analysis of interviews with 18 actors engaged in EU–China innovation cooperation. This qualitative analysis led to five tentative propositions that verified and concretised the five roles suggested in the analytical framework. Based on the findings, a new EU–China innovation cooperation model was proposed, paving the way for further strengthening and expanding the analytical framework.

It should be mentioned that in the four examples of best practices selected to demonstrate the role of EU–China university collaboration for facilitating EU–China industry collaboration, what they had in

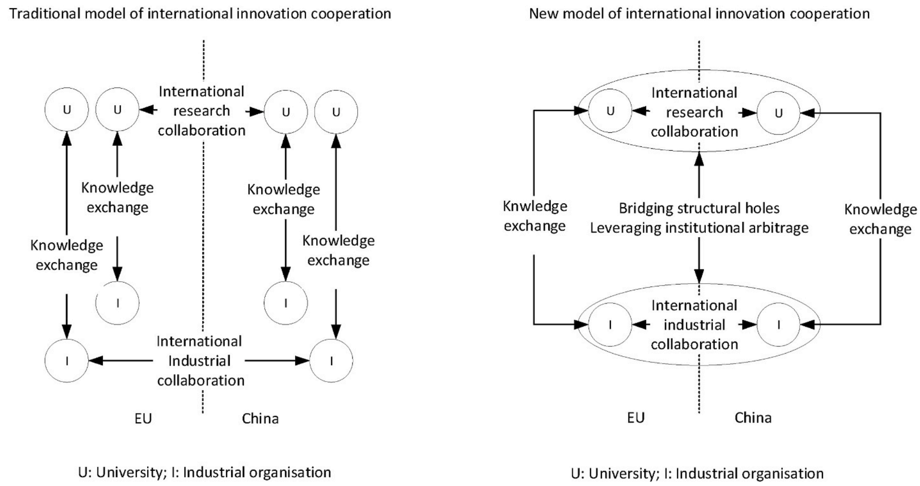

Fig. 5. Traditional and new models of international innovation cooperation.
Source: The author.

common was that the university collaborations were all engaged in applied research fields. This is understandable, as companies are more interested in technologies or research results that can be immediately put into production and markets. Moreover, the universities from both the EU and China sides in the four examples were all prestigious research universities. It can be inferred that prestigious universities may be better at performing their roles, e.g. in terms of trust building and image enhancement; however, more research is needed to verify this.

Besides offering both theoretical and empirical explanations of the role of international university collaboration in facilitating EU–China innovation cooperation, this paper makes two other contributions to the extant literature. First, it addresses a paradox in innovation studies. While there are many discussions in the literature on both the vital role of universities in national/regional innovation systems and the tendency of innovation systems to become globally interconnected, little research attention has been given to the engagement of universities, particularly international university collaboration, in transnational innovation (eco) systems. As a pioneering study, this paper integrates two disconnected research areas, namely international university collaboration and international industry collaboration. Second, it not only justifies the call by Brandenburg et al. (2020) for linking internationalisation in higher education to global societal engagement with empirical evidence but also provides initial theoretical accounts of the 'internationalisation in higher education for society' (Brandenburg et al., 2020), using the roles of international university collaboration in developing TUICNs as an example..

This study has three limitations. First, as it investigated an area with little information on where the most relevant cases and actors exist, it was impossible to identify representative cases beforehand, which would have been methodologically preferable. In the study, I found most of the interviewees in various events on EU–China STI cooperation, and representative examples (best practices) were only identified during the data analysis stage. For this reason, the number of interviewees in each example was limited. While the information provided by the interviewees confirms the theoretical assumptions developed in the paper, each example can be further investigated in the future with more informants representing different aspects of the cooperation. Second, the patterns concerning the interactions between cooperation in university and industry sectors in the EU–China context cannot be fully explored by a qualitative investigation due to the complex nature and large scale of the interactions. Thus, statistical analyses and even big data analyses, as suggested by Cai et al. (2019), are required to further probe the field. Third, although the findings of the empirical investigation in the EU–-China context may shed light on the EU's STI cooperation with third countries, the degree of universality is limited by the context. The propositions yielded by the study need to be further tested in other settings.

The findings of the study lead to the following recommendations for policymakers, universities and companies. First, there should be more dialogue between two areas of policymaking: EU–China higher education cooperation and EU–China industry cooperation. European universities have already developed profound collaborations with Chinese universities through huge investments in recent decades that has mainly concentrated on research, education and mobility. Take into account European universities' collaboration with China would help to develop strategies for industry collaboration on both sides, which would multiply profits from the same investment. Second, European universities and companies, especially those in the same countries or regions, should strengthen their communications/interactions not only to promote local economic development but also to develop joint China strategies/actions if they both have an interest in cooperation with China. Third, to realise the potential of EU–China university collaboration in EU–China innovation cooperation, innovative services provided by governmental agencies or through publicly funded projects should be envisioned. For instance, in the EU, agencies that facilitate international university collaborations could include the engagement of university collaboration to link European industrial actors in third countries as their service scope. In China, services provided by regional governments to attract foreign companies could be expanded to attract both companies and universities from a target country.

At the time of writing this paper, EU–China relations are challenged by the current COVID-19 pandemic and the rapidly changing relationship between the world's major powers. In the eyes of the EU, China has shifted from being primarily a comprehensive strategic partner to a system rival (European Commission, 2019). The EU Chamber of Commerce in China (2020) wrote that 'China-based European companies find themselves navigating in the dark' (p. 1). However, as China will remain an important country for knowledge production and as a market for Europe, EU–China innovation cooperation will not cease. Therefore, both the EU and China are seeking new ways of innovation collaboration. The model proposed in this paper may be worthy of consideration. For instance, in the current situation, it is essential to utilise university collaboration, which is less affected by geopolitics (Lee and Haupt, 2020), to help international industry collaboration maximise rewards while minimising risks. Hopefully, this paper serves as an icebreaking effort on the role of international university collaboration in EU–China innovation cooperation and will encourage more researchers to explore this research area.

Declaration of competing interest

None.

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References

Abrahamson, E., Rosenkopf, L., 1997. Social network effects on the extent of innovation diffusion: a computer simulation. Organ. Sci. 8, 289–309.

Alguezaui, S., Filieri, R., 2010. Investigating the role of social capital in innovation: sparse versus dense network. J. Knowl. Manag. 14, 891–909.

Barnard, H., Chaminade, C., 2011. Global Innovation Networks: towards a Taxonomy. CIRCLE Working Paper 2011.

Barrie, J., Zawdie, G., João, E., 2019. Assessing the role of triple helix system intermediaries in nurturing an industrial biotechnology innovation network. J. Clean. Prod. 214, 209–223.

Basu, A., Foland, P., Holdridge, G., Shelton, R.D., 2018. China's rising leadership in science and technology: quantitative and qualitative indicators. Scientometrics 117, 249–269.

Binz, C., Truffer, B., 2017. Global Innovation Systems—a conceptual framework for innovation dynamics in transnational contexts. Res. Pol. 46, 1284–1298.

Boschma, R., 2005. Proximity and innovation: a critical assessment. Reg. Stud. 39, 61–74.

Brandenburg, U., de Wit, H., Jones, E., Leask, B., Drobner, A., 2020. Internationalisation in Higher Education for Society (IHES). Concept Good Practice. DAAD, Bonn.

Brekke, T., 2020. What Do We Know about the University Contribution to Regional Economic Development? A Conceptual Framework. International Regional Science Review, 0160017620909538.

Brekke, T., 2021. What do we know about the university contribution to regional economic development? A conceptual framework. Int. Reg. Sci. Rev. 44, 229–261.

Bruce, D.M., 2002. J. Agric. Environ. Ethics 15, 279–289.

Burt, R.S., 2000. The network structure of social capital. Res. Organ. Behav. 22, 345–423.

Burt, R.S., 2004. Structural holes and good ideas. Am. J. Sociol. 110, 349–399.

Cai, Y., 2019. China-Europe Higher Education Cooperation: Opportunities and Challenges. Front. Educ. China 14, 167–179.

Cai, Y., Etzkowitz, H., 2020. Theorizing the Triple Helix model: Past, present, and future. Triple Helix 7, 189–226.

Cai, Y., Ferrer, B.R., Lastra, J.L.M., 2019. Building university-industry Co-innovation networks in transnational innovation ecosystems: towards a transdisciplinary approach of integrating social sciences and artificial intelligence. Sustainability 11, 1–23.

Cai, Y., Ma, J., Chen, Q., 2020. Higher education in innovation ecosystems. Sustainability 12, 4376.

Cai, Y., Zheng, G., 2021. China's Policies and Practices with Respect to Higher Education Cooperation with the EU. In: Balbachevsky, E., Cai, Y., Eggins, H., Shenderova, S. (Eds.), Building Higher Education Cooperation with the EU: Challenges and Opportunities from Four Continents. Brill/Sense, Leiden/Boston, pp. 68–85.

Capaldo, A., 2007. Network structure and innovation: the leveraging of a dual network as a distinctive relational capability. Strat. Manag. J. 28, 585–608.

Carayannis, E.G., Grigoroudis, E., Campbell, D.F.J., Meissner, D., Stamati, D., 2018. The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. R. Manag. 48, 148–162.

Chen, K., Zhang, Y., Fu, X., 2019. International research collaboration: an emerging domain of innovation studies? Res. Pol. 48, 149–168.

Cherry, A., Toit, D.d., 2018. In: Andrew, Cherry, James, Haselip, Ralphs, G., Wagner, I.E. (Eds.), Africa-Europe Research and Innovation Cooperation: Global Challenges, Bi-regional Responses. Palgrave Macmillan, Cham, Switzerland, pp. 3–20.

Creswell, J.W., 2014. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications, Los Angeles, London, New Delhi, Singapore.

Eboli, M., 2015. Diffusion of innovations in dense and sparse networks. Qual. Quantity 49, 1559–1571.

Engel, P.G.H., Giorgia, G., 2016. Science and Innovation for Development: A Study into the Contribution and Complementarity of EU Internationalresearch and Innovation Cooperation with Developing Countries in FP7 (2007-2013.

Ennew, C.T., Fujia, Y., 2009. Foreign Universities in China: a case study. Eur. J. Educ. 44, 21–36.

Etzkowitz, H., Leydesdorff, L., 2000. The dynamics of innovation: from national systems and "mode 2" to a triple helix of university-industry-government relations. Res. Pol. 29, 109–123.

EU, 2016. Roadmap for EU-China S&T Cooperation. European Commission, Brussels.

EU Chamber of Commerce in China, 2020. European Business in China Business Confidence Survey 2020 European Business in China Business Confidence Survey 2020.

European Commission, 2012. Joint Declaration on the European Union-China Innovation Cooperation Dialogue. European Commission, Brussels.

European Commission, 2013. EU-China 2020 Strategic Agenda for Cooperation.

European Commission, 2019. EU-China – A Strategic Outlook. European Commission, Brussels.

European Commission, 2020. Horizon Europe, the EU Research and Innovation Programme 2021-2027 General Overview. European Commission.

European Union Chamber of Commerce in China, 2017. European Business in China–Business Confidence Survey. European Union Chamber of Commerce in China.

European Union Chamber of Commerce in China, 2021. European Buisiness in China: Business Confidence Survey 2021. European Union Chamber of Commerce in China, Beijing.

Fan, C., Christmann-Budian, S., Seus, S., 2014. Research and Innovation Cooperation between the European Union and China. European Commission, Brussels.

Friedland, R., Alford, R.R., 1991. Bringing society back in: symbols, practices, and institutional contradictions. In: Powell, W.W., DiMaggio, P. (Eds.), The New Institutionalism in Organizational Analysis. University of Chicago Press, Chicago, pp. 232–263.

García-Herrero, A., Kwok, K.C., Xiangdong, L., Summers, T., Yansheng, Z., 2017. EU–China Economic Relations to 2025 Building a Common Future. The Royal Institute of International Affairs, London.

Granovetter, M.S., 1973. The strength of weak ties. Am. J. Sociol. 78, 1360–1380.

Guimón, J., Narula, R., 2020. When developing countries meet transnational universities: searching for complementarity and dealing with dual embeddedness. J. Stud. Int. Educ. 24, 314–336.

Hemphälä, J., Magnusson, M., 2012. Networks for innovation – but what networks and what innovation? Creativ. Innovat. Manag. 1, 3–16.

Katz, J.S., Martin, B.R., 1997. What is research collaboration? Res. Pol. 26, 1–18.

Kezar, A., 2006. To use or not use theory: is that the question? In: Smart, J.C. (Ed.), Higher Education Handbook of Theory and Research. Springer, Dordrecht, pp. 283–344.

Kijkuit, B., Van Den Ende, J., 2007. The organizational life of an idea: integrating social network, creativity and decision-making perspectives. J. Manag. Stud. 44, 863–882.

Klerkx, L., Guimón, J., 2017. Attracting foreign R&D through international centres of excellence: early experiences from Chile. Sci. Publ. Pol. 44, 763–774.

Kostova, T., Zaheer, S., 1999. Organizational legitimacy under conditions of complexity: the case of the multinational enterprise. Acad. Manag. Rev. 24, 64–81.

Lamy, P., Brudermüller, M., Ferguson, M., Friis, L., Garmendia, C., Gray, I., Gulliksen, J., Kulmala, H., Maher, N., Fagundes, M.P., Woźniak, L.A., Fuchs, M.Ž., 2017. LAB – FAB – APP Investing in the European Future We Want: Report of the Independent High Level Group on Maximising the Impact of EU Research & Innovation Programmes. Directorate-General for Research and Innovation, European Commission, Brussels.

Lee, J.J., Haupt, J.P., 2020. Scientific collaboration on COVID-19 amidst geopolitical tensions between the US and China. J. High Educ. 1–27.

Liefner, I., Si, Y.-F., Schäfer, K., 2019. A latecomer firm's R&D collaboration with advanced country universities and research institutes: the case of Huawei in Germany. Technovation 86–87, 3–14.

Lin, J., 2020. Chinese-foreign Cooperation in Running Schools. Routledge, London.

Liu, J., Chaminade, C., Asheim, B., 2013. The geography and structure of global innovation networks: a knowledge base perspective. Eur. Plann. Stud. 21, 1456–1473.

Liu, Y., 2017. Speech at Fourth Meeting of China-EU High-Level People-To-People Dialogue Held in Shanghai on 14 November 2017.

Lundvall, B.-Å., Jurowetzki, R., Lema, R., 2014. Combining the global value chain and the innovation system perspectives – A new agenda for globelics research? Asialics Int. Conf 2014. Daegu, Korea.

Ma, J., 2019. Developing joint R&D institutes between Chinese universities and international enterprises in China's innovation system. A Case at Tsinghua University 11, 1–25. Sustainability.

Makkonen, T., Williams, A.M., Weidenfeld, A., Kaisto, V., 2018. Cross-border knowledge transfer and innovation in the European neighbourhood: tourism cooperation at the Finnish-Russian border. Tourism Manag. 68, 140–151.

Mattes, J., 2012. Dimensions of proximity and knowledge bases: innovation between spatial and non-spatial factors. Reg. Stud. 46, 1085–1099.

Mei, L., Rodríguez, H., Chen, J., 2020. Responsible innovation in the contexts of the European union and China: differences, challenges and opportunities. Global Trans. 2, 1–3.

Michelfelder, I., Kratzer, J., 2013. Why and how combining strong and weak ties within a single interorganizational R&D collaboration outperforms other collaboration structures. J. Prod. Innovat. Manag. 30, 1159–1177.

Navracsics, T., 2017. Speech at Fourth Meeting of China-EU High-Level People-To-People Dialogue Held in Shanghai on 14 November 2017.

Necoechea-Mondragón, H., Pineda-Domínguez, D., Pérez-Reveles, L., Soto-Flores, R., 2017. Critical factors for participation in global innovation networks. Empirical evidence from the Mexican nanotechnology sector. Technol. Forecast. Soc. Change 114, 293–312.

Obstfeld, D., 2005. Social networks, the tertius iungens orientation, and involvement in innovation. Adm. Sci. Q. 50, 100–130.

Pandey, N., Desai, P.N., 2017. Exploring 'global innovation networks' in bio clusters: a case of genome valley in hyderabad, India. J. Sci. Res. 6, 23–35.

Perkmann, M., Phillips, N., 2011. Leveraging Institutional Distance: Institutional Arbitrage in University-Industry Relations. New Institutionalism - 7th Workshop Lyon, France.

Reichert, S., 2019. The Role of Universities in Regional Innovation Ecosystems. EUA, Brussels.

Romagnuolo, I., Mariut, C., Mazzoni, A., Santis, G.d., Moltzen, E., Ballensiefen, W., Lange, C., Frosini, A., D'Errico, G., 2021. Sino-European science and technology collaboration on personalized medicine: overview, trends and future perspectives. Pers. Med. 16.

Salter, A.J., Martin, B.R., 2001. The economic benefits of publicly funded basic research: a critical review. Res. Pol. 30, 509–532.
Saragih, H.S., Tan, J.D., 2018. Co-innovation: a review and conceptual framework. Int. J. Bus. Innovat. Res. 17, 361–377.
Sotarauta, M., Heinonen, T., Sorvisto, P., Kolehmainen, J., 2016. Innovation Ecosystems, Competences and Leadership: Human Spare Parts and Venture Finance Ecosystems under Scrutiny. Tekes – the Finnish Funding Agency for Innovation, Helsinki.
Strauss, A.L., Corbin, J.M., 1990. Basics of Qualitative Research : Grounded Theory Procedures and Techniques. Sage Publications, Newbury Park, Calif.
Thornton, P.H., Ocasio, W., Lounsbury, M., 2012. The Institutional Logics Perspective : a New Approach to Culture, Structure and Process. Oxford University Press, Oxford.
Tollefson, J., 2018. China declared world's largest producer of scientific articles. Nature 553.
UNESCO, 2018. R&D Data Release, 28 June 2018. Unesco Institute for Statistics.
Varga, A., 2006. The spatial dimension of innovation and growth: empirical research methodology and policy analysis. Eur. Plann. Stud. 14, 1171–1186.
Vullings, W., Boekholt, P., Til, J.v., Steinz, H., Cunningham, P., Flanagan, K., ERAWATCH Network ASBL country correspondents, 2013. Overview of International Science, Technology and Innovation Cooperation between Member States and Countries outside the EU and the Development of a Future Monitoring Mechanism. European Commission, Brussels.
Wang, L., Wang, X., Philipsen, N.J., 2017. Network structure of scientific collaborations between China and the EU member states. Scientometrics 113, 765–781.
Wixted, B., 2009. Innovation System Frontiers: Cluster Networks and Global Value. Springer Berlin Heidelberg.
Yin, R.K., 1994. Case Study Research: Design and Methods, second ed. SAGE Publications, Thousand Oaks.
Zubașcu, F., 2021. EU rewrites rulebook on science and technology cooperation with the rest of the world. Sci. Business. https://sciencebusiness.net/technology-strategy-board/news/eu-rewrites-rulebook-science-and-technology-cooperation-rest-world. (Accessed 24 November 2021).