Technological Forecasting & Social Change xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

The actors and relations in evolving networks: The determinants of inter-regional technology transaction in China

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ARTICLE INFO

Keywords:
Technology transaction
Inter-regional network
Social network analysis
Quadratic Assignment Procedure (QAP)
Centrality

ABSTRACT

This paper investigates the actors- and relations-based mechanisms within the evolutionary process of inter-regional network using a unique database of China's technology transaction between regions. The results show that a focal region's level of technological and economic development has a significantly positive influence on its network position, and the narrow economic and technology gap between two regions has a positive influence on inter-regional technology transactions, although the evidence for the economic gap's influence is weak. That is, technological and economic factors could influence the evolutionary process of inter-regional networking based on technology transactions at the actor and relation level besides geographical proximity and preferential attachment.

1. Introduction

A focal region's rate of innovation and growth significantly depend on its ability to use external knowledge (Mukherji and Silberman, 2013). Inter-regional relations, while increasing knowledge diversity on a local knowledge basis, are crucial for regional innovation (Boschma and Ter Wal, 2007; Gertler and Levitte, 2005). The inter-regional network of innovation has been a useful approach for understanding the transmission of codified knowledge and formal contractual collaborations (Morescalchi et al., 2015). Particularly, the mechanisms that influence the formation and evolution of relationships between regions remain a research issue demanding attention.

Indeed, there are several interpretations for the formation and evolution of inter-regional networks. *Geographical proximity* is a primary mechanism of inter-regional relations. A strongly held belief in regional innovation studies is that 'geography matters', not only geographical proximity but also relevant cultural, social, and cognitive proximities matter for knowledge transmission, which is central to regional innovation (Boschma, 2005; Capello and Caragliu, 2012). *Preferential attachment* is a primary mechanism of network evolution, which could explain the emergence of a "core-periphery" structure among regions as a process of network growth (Barrat et al., 2005; Guimera and Amaral, 2004). In particular, network evolution is understood as an entry process of new nodes connecting with a certain probability to existing nodes depending on the latter's connectivity (Barabási and Albert, 1999). Innovators are increasingly attracted by large innovation "hub" regions which combine local agglomeration economies with centrality advantages in knowledge and social networks, also known as preferential attachment or the "rich get richer" effect (Morescalchi et al., 2015).

However, the evolutionary process of inter-regional networking is a very complex process, and one mechanism such as geographical proximity from the perspective of economic geography or preferential attachment from the perspective of network science could only explain part of the process (Sun and Liu, 2016). Obviously, geographical proximity and preferential attachment consider only a part of network relations. As we know, the content is the issue of crucial importance for organizations to create inter-regional relations. The technological and economic factors are primary determinants of forming inter-regional relations of technology transfer.

Technological comparability and compatibility are more important than spatial distance. Maggioni and Uberti (2007) suggested that knowledge flows easily between similar regions according to their scientific, technological and sectoral characteristics. Scherngell and Barber (2009) found striking evidence that geographical factors are important determinants of cross-regional collaboration intensities, but the effect of technological proximity is stronger. Similarly, as for the proximity and network effects, Marrocu et al. (2013) found that technological proximity outperforms the geographic one, whilst a limited role is played by social and organizational networks. Mukherji and Silberman's (2013) results showed that technological compatibility is more important than spatial distance in explaining knowledge flows

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http://dx.doi.org/10.1016/j.techfore.2017.08.005
Received 23 October 2016; Received in revised form 29 June 2017; Accepted 14 August 2017

between U.S. areas.

Economic level and structure are other interpretations for inter-regional technolgocial relations. Maurseth and Verspagen (2002) showed that knowledge flows measured by patent citations between European regions are industry specific and occur most often between regions that are specialised in industrial sectors with specific technological linkages between them. Paci and Usai (2009) suggested that knowledge flows proxy by patent citations across European regions tend to be related to characteristics - such as production structure, economic conditions and technological efforts of the origin and destination regions. Zhang et al. (2016) found with patent license data that most technologies are transferred from provinces with greater R & D input to economically developed provinces within China. Although many less-developed provinces have begun participating in regional technology exchange networks, the scale of technology exchange in these provinces is lower, and they are more active as net technology importers (Wang et al., 2015).

Understanding network dynamics is important because of the potential role of conscious agency by network participants in creating network structures that benefit them. Meanwhile the benefits are dependent on the network architecture and its evolution over time (Ahuja et al., 2012). It is not easy to reveal the nature of network dynamics by only considering the causal factor or consequences. Indeed, the advantages of the network approach may enable us to overcome this artificial division between structure and performance (DeBresson and Amesse, 1991). After introducing the network approach, it is necessary to reveal the evolution of inter-regional networks and move beyond traditional studies that focus on structures which condition performance (Sun, 2016). Thus, understanding network evolution, from the perspective of both actors and relations, has a potential role in examining how benefits/outcomes are endogenously shaped into specific evolving structures, instead of assuming that benefits exist with a given structure. The present paper attempts to propose an evolutionary hypothesis of inter-regional networks based on technology transactions from the perspective of both actors and relations. That is, besides geographical proximity and preferential attachment, the technological and economic factors could be considered as factors to explain the evolutionary process of inter-regional networks in technology transactions.

This study yields two contributions to advance previous empirical studies. First is to examine the knowledge flows or technology relations across regions through the market channel of technology transfer. Extant studies have examined the inter-regional innovation network based on patent citations (Mukherji and Silberman, 2013; Scherngell and Barber, 2009). In essence, the difference between patent citation and technology transaction is the operating mechanism. The inter-regional knowledge spillover/flows by patent citations is a kind of positive externality, and the patent citations is a non-market and passive process within research activities. Technology transaction is a market-based and initiative process through patents licenses, patent assignment, know-how transfer, in which a buyer-seller transaction takes place at market prices between regions (Mowery and Ziedonis, 2001; Sun and Liu, 2016). And, a few studies examined the inter-regional network based on patent licenses (Wang et al., 2015; Zhang et al., 2016). Thus, a significant development of the present article would be to expand the content of inter-regional innovation relations through investigating technology transaction between regions.

Second, it is (to the best of the authors' knowledge) the first study to examine the evolutionary process of inter-regional networks considering the network position of actors, including direction. Sun and Liu (2016) transform the value relations between two regions to binary relations, which also neglect the direction of technology transfer. While Zhang et al. (2016) explain technology transfer through the gravity model, which reflects the direction of ties, they also do not take the network positions of regions into account. Indeed, it is necessary to distinguish a region's network position based on relations of technology buy and sell, which could be influenced by different determinants.

2. The actors- and relations-based mechanisms of network evolution

In this section, we first of all propose an approach of inter-regional network construction based on technology transactions across organizations; then we present two hypotheses to explain the evolutionary process of inter-regional networks from the perspective of actors and relations.

2.1. An approach towards building an inter-regional network model

A network is a set of individuals or groups, each of which has relations of some kind to some or all of the others. In this paper, the nature of inter-regional relations is inter-organizational relations across regional boundaries (Sun and Cao, 2015). In other words, technology transactions between organizations across regions form inter-regional relations. For example, if a firm from region *A* buys technologies from a university in region *B*, this transaction create a ties between region *A* and *B*. Repeating the same exercise for all cases of technology transaction, we could end up with a map representing the inter-regional network of technology transaction across regions.

The actor is the region and the tie is the relation of technology transaction between two regions in the inter-regional network, which is similar to the collaborative network. However, the network of technology transactions is a directed network based on the buyer-seller transactions, which means that the seller transfers technology to the buyer. Meanwhile, the inter-organizational relations spanning regional boundaries form the multilevel network- inter-organizational network and inter-regional network (Sun, 2016). The transaction behavior between organizations is still the primary cause which conditions the evolution of the inter-regional network. Further, regions as actors of the inter-regional network also have unique factors which differ at the organizational level. Thus, attention to organizational/regional behavior is useful for understanding inter-regional relations.

According to Ahuja et al. (2012)'s argument, the evolutionary trajectory of networks is at the level of ties/relations and nodes/actors is determined by mechanisms that derive from the micro-foundation of network evolution. The micro-foundation means the basic factors that drive or shape the formation, persistence, dissolution, and content of ties in the network. In other words, the network evolution consists of individual actors creating, maintaining or terminating relations to other actors. Accordingly, the point of interpretation for network evolution is to explain the behavior of actors creating ties. Thus, this article seeks to explain the evolution of inter-regional networks by actor and relation, excluding exogenous and random factors.

Methodologically, in economic geography and regional economics, network relations are frequently predicted and elucidated with an analogy to Newton's law of universal gravitation. In its most elementary form, the gravity model predicts that the relations (flow or interaction intensity) between two regions are assumed to be directly correlated with the characteristics of the regions and inversely correlated with the physical distance between the regions (Broekel et al., 2014). The gravity model is used to explain the relations between two regions through their attributes, but completely ignores the actor's embeddedness and the relationships between regional relations.

To be clear, the actors and relations are two faces of an inter-regional network. Generally, the network actor has two sets of features. One is a kind of attribute like a region's resource, while a relation like a region's ties. The technology relation is one feature of a region, for example, the centrality reflects the region's embeddedness in the network. On the other hand, the region's relations depend on its features including prior relations. A region will focus on the others' features including network relations of other regions they link to, to form or dissolve ties and change the network in this way, which is called nodal