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Networks as sponges: International collaboration for developing nanomedicine in China

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ABSTRACT

Previous research tended to emphasize the benefits of international collaboration. This emphasis has led to a common belief that international collaboration will necessarily enhance productivity in science, innovativeness, and even societal impact. Yet, benefits and costs are relative. Economic actors and scientists do not perceive benefits in the same way in all contexts, and there are situational barriers to overcome for materializing the benefits of collaboration. This study examines the case of Chinese science actors who develop medical applications with nanotechnology, and highlights the "barriers to networks" when scientists attempt to collaborate overseas for an emerging technology. I present my findings with the metaphors of "pipes", "prisms", and "sponges", and propose a framework for evaluating the utility of international collaborative networks.

1. Introduction

Previous research emphasized the desirable effects of network connectivity. Yet, as research evidence accumulates, the literature has shown that network benefits are conditional upon a myriad of factors. With respect to performance, networks can increase an actor's information search capacity (Granovetter, 1973), creativity (Powell et al., 1996), and productivity (Fernandez et al., 2000). But these benefits depend on mobilizing the appropriate network(s) at the right time. The distribution of network benefits is another important issue worthy of consideration. When two or more actors are connected in a network, not all of them may yield the same level of benefits, if at all. At any given time, the benefits may only be felt by some members in the same network (Smith-Doerr, 2005).

There are strong motivations to study the conditional nature of network benefits: first and foremost, as network benefits may be felt, perceived, and realized differently in different situations (Casciaro et al., 1999), it is useful to reveal how the utility of networks matches with specific contextual needs and institutional conditions (Luk et al., 2008). The findings would help practitioners better understand the range of network benefits and utilize them appropriately. Second, as Miles and Snow (1992) pointed out, network forms of organizations are subject to failures in several ways. Among other things, network partners may be unable to handle network traffics at times of "overflow" or "congestion". To capture how organizational actors may utilize networks flexibly to avoid or mediate network failures, it is essential to follow their actual work process (Latour, 1988; Fujimura, 1996).

Specifically, this paper develops the metaphor of "sponges" to complement two older metaphors of network benefits—pipes and prisms—in the literature (Podolny, 2001). Podolny's conceptions of pipe and prism are quite clear in their meanings. Pipe refers to a network structure that allows resources to flow from one party to another. Prism refers to a network structure that allows light to shine from one party on the other, making the latter glow in colors. Quite generalizable as these two metaphors may be, they do not adequately capture the flexible and voluntary nature of many network activities in action (Jones et al., 1997). To fill this gap, sponge can be construed as a flexible network structure that absorbs fluid materials from all sides and, with constructive efforts of network partners, squeeze out the useful materials at a later time. Like other metaphors, the use of sponge would not capture the full range of network benefits. Yet, it highlights several salient issues of network benefits for inter-organizational exchanges. Most importantly, I emphasize that networks provide opportunities for organizational actors to engage in learning-by-doing (Argote, 1999; Beckman and Haunschild, 2002; Irwin and Klenow, 1994). My findings are also concerned with how network partners of unequal power could benefit from the spongy nature of networks differently, and address failures of networks as pipes and prisms with different degrees of success.

The empirical case of this study focused specifically on Chinese academic institutes and their scientists who utilized international networks to develop nanomedicine (medical products enabled by nanotechnology research). Nanomedicine includes such products as gold nanoparticles inserted into human bodies to prevent

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cancer cells from multiplying (Kang et al., 2010). Although these nanomedicine products had great potential therapeutic value, the technology was still nascent among scientists—many of them continued to view nanotechnology with great uncertainty (Roco, 2007). In China, some scientists view nanotechnology and nanomedicine as opportunities to elevate the nation's science and technology status (Leung, 2012a,b). Yet, the technical infrastructure is still underdeveloped in China. Can they benefit from international networks for learning-by-doing? Can these networks be conceptualized as sponges?

To answer these questions, this research adopts a hybrid approach that combines quantitative and ethnographic research. This approach is useful in generating conceptual frameworks, and propositions for testable hypotheses (Harrigan, 1983). I analyzed quantitative data to identify high-performance Chinese institutes in nanomedicine research, and utilized ethnographic data to reveal Chinese scientists' perceived benefits of international networks. Based on my observations, Chinese science actors had mixed feelings regarding international networks. Interestingly, those who benefit from networks the most placed a great value on the ongoing relationships that they develop with international colleagues, much more so than the short-term, immediate "publication" or "prestige" gains, offered by networks. This is not because Chinese science actors neglect the impacts of publications or prestige; in fact, these achievements have become important criteria for career advancement in the Chinese high-tech sector nowadays (Leung, 2008). The more important reason, according to many of my interviewees, is that "China has to rely on its own" in the long run. They view overseas networks as capitals for learning and long-term development, rather than assets to acquire short-term gains.

The following discussions summarize the relevant literatures from organization theory and science studies that orient this research. My emphasis is that the utility of networks requires different parties to perform mutual adjustment to align multiple interests over time (Latour, 1988; Fujimura, 1996). I also outline a number of important changes in the Chinese high-tech sector to contextualize my research findings. Then I explain strategies of data collection and analysis, and propose a framework of evaluating costs and benefits of networks. Towards the end, I further discuss the implications of my findings.

2. Literature

2.1. Network benefits: pipes and prisms?

In the literature, Podolny generalized network benefits with the metaphors of "pipes" and "prisms" (2001). This framework assumes that two major sources of uncertainty prevail in market transactions, which may be reduced by utilizing external networks. That is, economic actors face "ego-centric" uncertainty (about themselves), and "altercentric" uncertainty (from others). Ego-centric uncertainty arises because of resource constraints, and/or other task-related difficulties. For example, an individual entrepreneur might be uncertain about the firm's resource capabilities. To remain competitive (or simply survive), s/he needs resources. Yet, s/he might use up all resources at unpredicted times, and lack the capacity to re-generate resources. External network ties provide an accessible channel where critical or supplementary resources can become available in times of need.

Alter-centric uncertainty is concerned with social acceptance or expectation from other actors. For instance, the same entrepreneur (or his firm) is facing a group of skeptical customers, who worry that the firm is unable to serve their needs well. By building networks with other reputable firms, the entrepreneur is able to restore the confidence of his customers. Moreover, other firms in the market may develop great trust with the entrepreneur or the firm. In Podolny's conception, networks as pipes (to transfer resources) enable the focal actor to reduce ego-centric uncertainty; networks as prisms (to share reputation and trust from others) enable the focal actor to reduce alter-centric uncertainty. The unit of analysis does not have to be individuals. It can be the entire organization.

The metaphors of pipes and prisms are quite appropriate for explaining why Chinese scientists seek international network partners. First, international networks are useful information and knowledge pipes for Chinese science institutes. In the literature, Granovetter (1973) showed that network ties enhance the information-seeking capability of job seekers to identify potential jobs. Networks can be regarded as information pipes in this context. In the case of Chinese science institutes, information about the latest development of nanotechnology and nanomedicine was still quite limited. International networks functioned as pipes of information and knowledge resources, which were essential to developing something as high-tech as nanomedicine.

Kostoff et al. (2006) adopted a bibliometric approach to show how Chinese science institutes obtain prism value from international networks. According to their findings, collaboration between American and Chinese scientists benefits the latter group at the expense of the former. That is, American researchers had generally achieved high impact scores in publications than their Chinese counterparts. As such, scientific teams of "American researchers only" outperformed those teams having both American and Chinese researchers. Also, since "US-China" teams outperformed the teams of "Chinese researchers only", Chinese research teams essentially enjoyed a net "prism" gain by collaborating with American teams in publishing. At the same time, the American teams had to bear a "cost of impact score" to collaborate with Chinese researchers. These research findings are intriguing by themselves. But more importantly, they suggest that collaborative parties may be "unequal" in terms of expectations, cost-benefits calculations, and even negotiation power (Spencer-Oatey, 1997). This point will be further discussed below.

2.2. Conditional network benefits

The utilization of international networks can be quite different in specific cases, even for science actors within the same national setting. The literature contains empirical evidence about possible variations. For example, in Granovetter's job search study, his specific results showed that "weak ties" (distant friends and relatives of the job seeker) were more useful than "strong ties" (close friends and relatives that share the same social circles) in providing information to job seekers. Bian and Logan (1996) pointed out that the relative utility between weak and strong ties varies across socio-economic contexts. In their research, weak ties did not provide useful information for job seekers in the transitory Chinese economy. Contrary to Granovetter's findings, Bian and Logan believed that valuable information could only transfer through strong ties of Chinese job seekers. In other business contexts in China, networks "may not work" in ways similar to those in Euro-American settings (Xiao and Tsui, 2007).

More recently, Luk et al. (2008) demonstrated that social network does not confer the same type of benefits to organizational actors in different institutional contexts. In market economies, social network provides useful informational benefits—many of them are benign. In transitional economies, however, social network may create particularized trust and other malignant effects. In other studies, researchers found that the costs of networks outweighed the benefits. For example, new immigrants without family ties might turn to local ethnic communities for material assistance and moral support in their initial years in the U.S. (Portes and Sensenbrenner, 1993). Yet, some of these immigrants might