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When is a network a nexus for innovation? A study of public nanotechnology R&D projects in the Netherlands

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ABSTRACT

Most empirical studies that test the influence of R&D collaboration on innovation performance either focus on the diversity of partners that enhances innovation or focus on social embeddedness of partners that enhances or inhibits innovation. We combine these two factors to explain innovation. By using the business interaction model (Håkansson et al., 2009) we test the effect of resource heterogeneity, value chain complementarity, user interaction, and structural stability of partnership portfolios on application and value creation performance of public nanotechnology R&D projects. We used an enriched database on utilization of technology research projects from the Dutch Technology Foundation STW. To test our hypotheses we selected from the database 206 nanotechnology research projects, which started in a five year period from 2000 to 2004. Project performance was measured five years after completion of the project. Support is found for an inverted U shaped effect of the interaction between stability of the relationship structure and technological heterogeneity, industry heterogeneity, value chain complementarity and user interaction in the R&D partnership portfolios on both application and value creation performance. The framework introduced in this study allows an evaluation of the effects of participant portfolios on Public R&D projects performance.

1. Innovation in networks

Several scholars have dealt with the relationship between innovation and networks of inter-organizational interactions (Callon, 1998; Håkansson & Lundgren, 1995; Powell, Koput, & Smith-Doerr, 1996). Because as Powell et al. (1996: 116) state: "when the knowledge base of an industry is both complex and expanding, and sources of expertise are widely dispersed, the locus of innovation will be found in networks of learning rather than in individual firms." Yet, innovation in networks seldom presents itself straightforward, constraints in this process are frequently explained by the concept of path dependence. The classic literature on path dependence in economics (Arthur, 1986; David, 1985) and institutional change (North, 1990) argues that self-reinforcing mechanisms, such as increasing returns, technical interrelatedness and quasi-irreversibility of technology or institutions constrain change. This view of path-dependency is criticized for giving too much weight to stability while there are many reasons for path dependence which do not occur at the same time and place (Beyer, 2010; Håkansson & Lundgren, 1997). A second critique is that too less weight is given to agency (Araujo & Harrison, 2002; Garud, Kumaraswamy, & Karnøe, 2010). The interest of the scholars who criticize the path dependence view lies in exploring the possibilities of innovation or path creation, through the interactions of actors, activities and resources that constitute inter-organizational networks. To answer the question when is a network a nexus for innovation, we continue on ideas and findings from the Business Network Approach that focuses on technological development and innovation in networks (Chou & Zolkiewski, 2010; Håkansson & Lundgren, 1995; Håkansson & Waluszewski, 2002; Raesfeld Meijer, 1998; Raesfeld, Geurts, Jansen, Boshuizen, & Luttge, 2012). In particular we will test the separate and combined influence of process and structure characteristics of relationships between participants in public–private R&D projects (Håkansson & Lundgren, 1995; Håkansson et al., 2009) on application and value creation performance of these projects. The paper is structured as follows. In the next section we develop our model based on the literature on innovation in collaborative networks. We then proceed by testing the hypotheses and presenting the findings. The final section discusses the results and provides suggestions for further study.

2. Process and structure in cooperative R&D

Assuming that continuity and change are processes driven by similar dynamics, Håkansson and Waluszewski (2002) showed how path-dependence can enable technological development, when the resources that are historically built in industrial networks are confronted with new utilization possibilities. In a similar

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way though focusing more on agency and less on substance, Garud et al. (2010) put forward a path creation perspective suggesting instead of lock-in, the provisional stabilization of networks, in which initial conditions are socially constructed, self-reinforcing mechanisms for change and stability, are strategically cultivated, and where contingencies emerge and serve as embedded contexts for ongoing action. For this study the question then is: what are these contingencies emerging and what is their influence on inter-organizational innovation? Araujo and Harrison (2002) and Garud et al. (2010) suggest that at certain points in time and space a collection of independent factors as well as stabilized network structures probably will affect the choices and outcomes that will arise. This is not the same for every actor due to differences of embeddedness in the network and not completely determined as there is room for strategic choice. Håkansson et al. (2009: 236) are explicit about what embedddedness is, they consider a network as consisting of the tangible and intangible investments that connect relationships between more than two businesses and these connections, not the relationships in themselves, provide opportunities to multiply the effect of investments. Connections are made of resource ties, activity links and actor bonds. This implies that networks evolve over time through linking new resources to existing resource combinations and relating new activities to existing activity patterns. Therefore, in order to improve this process it is important to be conscious about both the time and space aspects of the business network (Waluszewski, 2011a). Continuing on this line of reasoning we hereafter, address factors affecting the innovation outcomes of inter-organizational R&D projects.

In the business network approach organizations are portrayed as closely interacting with each other, which leads to multifaceted interdependencies over time and space. In the descriptive model of business interaction (Ford, Hakansson, Snehota, & Waluszewski, 2010; Håkansson et al., 2009), inter-organizational relationships are specified over time and space. This business interaction model indicates three structural or space related mechanisms (resource heterogeneity, actor jointness and activity interdependency) and in parallel three processes or time related mechanisms (paths of resources, co-evolution of actors and specialization of activities) that influence outcomes of interaction between organizations. Particularly in the case of technological development and innovation where often public and private organizations cooperate, Håkansson and Waluszewski (2007) stress to be conscious about the different coexisting economic logics of development, use and supply. Therefore, Håkansson et al. (2009) distinguish three settings of innovation development: 1) idea development, 2) production infrastructure development, and 3) user environment development. Each setting is involved in the embedding of different types of resources and activities. Hereafter, to explain technological development in public–private R&D projects, we derive hypotheses from the business interaction model in different settings of the business landscape. We investigate two particular outcomes of cooperative R&D: 1) application development which is closely related to the idea development setting and 2) value creation which is more related to the using and producing settings.

The domain of idea development involves the combination of resources to build up functionality; it is about creating new solutions. The search for functionality is often found into combining and recombining a large number of tangible and intangible resources (Håkansson et al., 2009). When a research project provides linkages between universities, research institutes and the private sector, the resources of collaborative partners can be assessed through these linkages (Gnyawali & Madhavan, 2001). Baum, Calabrese, and Silverman (2000) argue that it is not so much the number of linkages, but rather the diversity of the partner portfolio that influences performance, as combinations of partner resources create value and application opportunities. Therefore our first hypothesis is:

Hypothesis 1. Heterogeneity of resources in inter-organizational R&D projects has a positive influence on application and value creation performance of these projects.

The domain of the production infrastructure is important in innovation as new solutions have to be embedded in an efficient production system. From an innovation point of view the production system has to be co-developed with the new solution, it is concerned with searching for complementarity in the value chain (Håkansson et al., 2009). Collaboration provides access to complementary assets that support both application development and value creation (Arora & Gambardella, 1990; Bonaccorsi & Thoma 2007; Hagendoorn, 1993; Teece, 1986). Consequently, the following hypothesis is proposed:

Hypothesis 2. Value chain complementarity between partners in inter-organizational R&D projects has a positive influence on application and value creation performance of these projects.

In innovation studies there is abundant attention for user/technology alignment, as indicated by Abernathy and Utterback's (1978) life cycle theory, Burgelman's (1983) market technology linking and von Hippel (1986) lead-user approach. Use of a new solution is a central aspect that has to be developed together with the new idea and its production structure (Håkansson et al., 2009). Requirements for use of a new solution will develop in the interaction between developers and users. This leads to the following hypothesis.

Hypothesis 3. User participation in inter-organizational R&D projects has a positive influence on application and value creation performance of these projects.

Still, interdependencies in existing relationships can enable as well as constrain innovation (Ford et al., 2010; Håkansson & Ford, 2002). In earlier work Håkansson and Lundgren (1997) already discussed the embedding of resource ties, activity links and actor bonds to explain change in industrial networks. In this same writing, in addition to the issue of embedding, they used structural strengths as a force that has a decreasing effect on innovation and change. This process or time dimension indicates the degree of stability of activity patterns, actor webs and resource constellations. Therefore, we propose.

Hypothesis 4. Stability in relationship structures of the inter-organizational R&D projects has a negative influence on application and value creation of these projects.

So far, we discussed the linear influence of the heterogeneity, interdependency and connectivity between collaboration partners and of the stability of relationship structure on innovation performance. However, structural characteristics of relationships in combination with stability of the network are expected to have a nonlinear effect on innovation. Håkansson and Waluszewski (2002) showed, in their study of the development of the new 'green' catalogue paper, that path dependence can in fact stimulate innovation. Thus, varying combinations of stability and structural aspects such as heterogeneity, connectivity and interdependence can lead to varying possibilities for application and value creation of new technologies. The work of Håkansson and Lundgren (1997) suggests that a balance between heterogeneity and stability is optimal for innovation performance. This implies that the interaction effect of network stability and respectively resource heterogeneity, value chain complementarity and user participation is a inverted U shaped function for application and value creation (see Fig. 1). A comparable line of reasoning is given by Nooteboom et al. (2007). This argumentation leads to the following hypotheses:

Hypothesis 5. The simultaneous increase of network stability and respectively partner heterogeneity, value chain complementarity and user participation in the project has an inverted U shaped effect on application and value creation of these projects.