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Interdependency, dynamism, and variety (IDV) network modeling to explain knowledge diffusion at the fuzzy front-end of innovation

Samir Gupta [a,*], Elliot Maltz [b,**]

[a] Monash University, Australia
[b] Willamette University, Salem, OR, United States

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ABSTRACT

Using network theory this research explains innovation as an interactional, networked, systemic phenomenon. The proposed interdependency, dynamism, variety (IDV) model attempts to detail actors' roles in intra- and interfirm knowledge diffusion during the fuzzy front-end of innovation (FFEI). Based on in-depth interviews, the results reveal that actors at the FFEI use their core competencies and knowledge diffusion in developing new products satisfying real-world requirements. Industry actors engage public research labs when the patented product demonstrates economic feasibility. The dynamic nature of FFEI prompts actors to seek external validation. Resource availability and knowledge diffusion do not necessarily lead to positive economic outcomes, but actors who demonstrate successful prototypes gain value through this collaboration. To reduce equivocality, networked actors should discuss the meaning and plausible uses of the discordant information, though equivocal information also can lead to innovation. Finally, early releases of patent information can distract actors if the patent is misused.

1. Introduction

Marketing managers generally are familiar with later innovation stages, characterized by defined activities and processes, clear procedures, and documented responsibilities that culminate in the commercialization of the innovation. Yet, Gassmann and Schweitzer (2014) note that the real benefits of new ideas emerge from the so-called fuzzy front-end of innovation. This stage occurs between opportunity recognition and the initiation of serious effort to develop the innovation (Khurana & Rosenthal, 1997; Montoya-Weiss & O'Driscoll, 2000; Reid & de Brentani, 2004; Smith & Reinertsen, 1992). In this context, innovation refers to research and development (R&D) activities, coordinated among actors who use available resources to introduce new, economically viable products.

In their pursuit of being first to market, many companies speed up innovation diffusion, which can lead to expensive failures, recalls, and changes. These companies also are responsible for system integration and can effectively outsource research activities to network partners, such as universities, internal R&D departments, a network partner's R&D lab, or public research laboratories (PRLs). The latter receive funding from government entities but also must generate funds by contracting with or selling patents to industry and government actors. They often function at the fuzzy front-end of innovation (FFEI) and tend to be staffed by skilled, knowledgeable actors. They require various internal and external resources and have capacities to develop ideas (Calia, Guerrini, & Moura, 2007; Schoonmaker, Carayannis, & Rau, 2013), such that PRLs engage actors from various disciplines and network with other research institutions as required. Anderson, Håkansson, and Johanson (1994) propose a model including actors, resources, and activities (ARA) to capture this network connectedness. Thus, a focal firm cooperates with other businesses, transfers resources if knowledge or solutions are transportable, and performs activities that strengthen the relationships of actors in the network (Anderson et al., 1994). The ARA model can investigate business networks (Hakånsson & Ingemansson, 2013; Håkansson & Johanson, 1992), but an interdependence, dynamic, and variety (IDV) model (Håkansson & Olsen, 2012) might be more appropriate for understanding how actors develop innovative projects and the processes in the FFEI. Innovation and business development are interactional, networked, systemic phenomena that must be conceptualized, investigated, and explained accordingly (Håkansson & Olsen, 2012). Actors transform resources to

* Correspondence to: S. Gupta, Department of Marketing, Monash University, Chisholm Tower, 26 Sir John Monash Drive, Caulfield East, Melbourne, Victoria 3145, Australia. Tel./fax: +61 3 9903 2492/2900.
** Correspondence to: E. Maltz, Atkinson Graduate School of Management, Willamette University, 900 State Street, Salem, Oregon 97301. Tel.: +1 503 370 6832; fax: +1 503 370 3011.
E-mail addresses: samir.gupta@monash.edu.au (S. Gupta), emaltz@willamette.edu (E. Maltz).

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maintain, grow, and perform their R&D activities (Lenney & Easton, 2009). From an FFEI/PRL perspective, this research focuses on actors in social systems that participate in knowledge diffusion innovation processes over time. The social system is a set of interrelated, interdependent units (disciplines), in which actors engage in joint problem solving to accomplish a common goal (Rogers, 1995). Actors in these social systems must discover, relate to, and interact with others to perform specialized activities.

In turn, this research describes knowledge diffusion at the fuzzy front end of innovation in hybrid labs, from idea generation (patent) to scaling up economically viable prototypes (Håkansson & Olsen, 2012; Van den Ende, Frederiksen, & Prencipe, 2014). Thus, this study extends the IDV model (Håkansson & Olsen, 2012) and looks at innovation as open, creative, and full of uncertainties, as well as a systematic process of combining, adapting, and linking to derive the creative new product in an economically efficient way.

Recent research investigations include studying influences on innovation in living laboratories (Nystrom, Leminen, Westerland, & Kortelainen, 2014), activities in biotech firms (Schoonmaker et al., 2013), and user-driven innovation in public-sector front-end innovation processes (Hennala, Parjanen, & Uotila, 2011). These studies provide a foundation for describing roles, role patterns, activities, and resource capacities however limited research describes innovation knowledge diffusion at the FFEI in applied research processes. Applied research consists of scientific investigations intended to solve practical problems, whereas basic research involves original investigations to advance scientific knowledge, without a specific objective (Rogers, 1995).

Most PRLs are hybrids that conduct both applied and basic research (Lal & Boardman, 2013), and investigating these laboratories is important for three reasons. First, as outsourcing partners for the private sector, PRL's networks with external partners might facilitate diffusion processes. Second, PRLs are important contributors to global R&D output and often participate in FFEI processes (Gassmann, Sandmeier, & Wecht, 2006). In many countries, PRLs create basic and applied knowledge, not their university counterparts (Gulbrandsen, 2011). Third, PRLs link various scientific disciplines and can develop knowledge through the knowledge diffusion process at the FFEI. Actors (scientists) build trust, appreciate and influence one another, and develop mutual commitments (Wilkinson & Young, 1994).

Anderson et al. (1994) suggest using qualitative field research to develop knowledge about business relationships within different network structures. The present study seeks to describe and understand how actors in PRLs at the FFEI use their limited resources, interact across multiple disciplines, and perform activities to create new products. In turn, this study offers several propositions within a theoretical framework, designed to explicate innovation knowledge diffusion and patent development in research laboratories. The focal research questions thus adopt an actor's perspective to answer (1) how do actors within PRLs facilitate knowledge diffusion of innovation at the FFEI across their own IDV networks; how do actors within PRLs diffuse and share knowledge with other PRLs during the FFEI processes; does the innovation diffusion process lead to noncommercial patents, even though a by-product of the same innovation might be considered a commercial success?

For the purpose of this study, disciplines within PRLs are focal nodes; discipline actors are those who use internal resources and, when required, seek knowledge from other disciplines or similar PRL institutes to develop new knowledge (basic research), new products, or services (applied research). The terms institute, laboratories, and labs are used interchangeably. This research presents five case studies of projects that vary in their engagement in the FFEI process from an actor's perspective.

2. Literature review

2.1. FFEI

Understanding the fuzzy front-end of innovation projects is critical for two reasons: First, success or failure often gets established even before a new concept enters a formal development process. Second, many firms lack proficiency in all aspects of the innovation process (Frishammar, Floren, & Wincent, 2011). The activities, resources, and actors that participate in the development process all exert impacts on process success (Cooper, 1988). In competitive environments, new concepts and idea generation help ensure the firm's future (Van den Ende et al., 2014). New concepts or ideas emerge from internal or external networks or some combination thereof. Despite some explorative studies (e.g., Khurana & Rosenthal, 1997; Koen et al., 2001; Montoya-Weiss & O'Driscoll, 2000) and theoretical papers (De Brentani & Reid, 2012; Reid & de Brentani, 2004), the need to understand the processes, from idea generation to prototyping and testing, remains unmet (Van den Ende et al., 2014).

2.2. ARA-IDV at the FFEI

The ARA model (Anderson et al., 1994; Håkansson & Johanson, 1992) consists of three layers, each of which can be classified as a network: a network of actors, a resource network, and patterns of activities. The networks comprise finite sets of actors and the network boundaries, which must be defined to clarify the networks being explored. This article investigates the diffusion process at the FFEI within PRL networked layers, where social interaction and knowledge sharing lead to innovation. A basic assumption is that PRL actors influence one another and use resources to conceptualize their ideas, using existing theories and methods to raise awareness, demonstrate their findings, and transfer innovation during the FFEI process.

Moving beyond detailed studies of the ARA model (Håkansson, Frost, Gadde, Snehota, & Waluszewski, 2009; Håkansson & Laage-Hellman, 1984; Håkansson & Waluszewski, 2002, 2007), this research considers intra-organizational networks, in which network actors not only interact within but also have the option to interact with actors outside their immediate surroundings. The IDV framework (Håkansson & Olsen, 2012) thus might inform understanding of how actors in networks interact during innovation processes at the FFEI.

Markham (2013) investigates FFEI adoption from an activity perspective, whereas Bicen and Hunt (2012) research FFEI from a resource perspective, and Miustak (2014) uses a service perspective. Few studies investigate the concept of intermediaries (Agogue & Le Masson, 2013; Howells, 2006) or outsourcing of non-essential innovation activities to other laboratories (Gupta, Woodside, Dubelaar, & Bradmore, 2009). Cooper and Kleinschmidt (1987) identify the quality of execution and predevelopment phases as critical. Beyond acknowledging the relevance of the FFEI though, most studies do not investigate in any great detail the various activities actors perform (Herstatt & Stockstrom, 2006) and instead present them collectively as predevelopment activities, which suggest the need for more in-depth research. Herstatt and Stockstrom (2006) conclude, in accordance with prior research (Herstatt, Verworn, & Nagahira, 2004), that firms employ creative techniques involving interdisciplinary actors who interact in creation processes. Because PRLs consist of interdisciplinary teams, they are ideal for explaining this complex phase of innovation. The FFEI has three activity stages: awareness, demonstration, and transfer (Khurana & Rosenthal, 1997; Koen et al., 2001). Awareness comes from knowledge of the area, demonstration implies that a prototype based on the patent is ready for clients, and the transfer of the patent rights then follows. Schoonmaker et al. (2013) claim that understanding these three stages is important, to recognize the upfront work that actors must do. Markham (2013) calls for research that explains and describes the