Technological Forecasting & Social Change xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Activity sets in multi-organizational ecologies: a project-level perspective on sustainable energy innovations

Kristina Manser [a], Bas Hillebrand [b], Paul H. Driessen [b,*], Gerrit Willem Ziggers [b], Josée M.M. Bloemer [b]

[a] HAN University of Applied Sciences, PO Box 5171, 6802 ED Arnhem, The Netherlands
[b] Institute for Management Research, Radboud University Nijmegen, PO Box 9108, 6500 HK Nijmegen, The Netherlands

ARTICLE INFO

Article history:
Received 22 February 2013
Received in revised form 17 March 2014
Accepted 21 April 2014
Available online xxxx

Keywords:
Complex innovations
Multi-organizational ecologies
Innovation activities
Innovation systems
Sustainable energy innovations

ABSTRACT

Complex innovations involve multi-organizational ecologies consisting of a myriad of different actors. This study investigates how innovation activities can be interpreted in the context of multi-organizational ecologies. Taking a project-level perspective, this study proposes a typology of four activity sets that are relevant in this context: strategic predevelopment, engineering, commercialization, and project management. The authors use archival and survey data on government-funded sustainable energy projects in the Netherlands to study the validity and relevance of the typology and show that the typology has discriminant and convergent validity. Results on the prevalence of the activity sets show that all four activity sets occur in sustainable energy projects, but to differing degrees. Furthermore, the typology is relevant because it helps to explain differences in innovation performance for complex innovations. Two activity sets – strategic predevelopment activities and commercialization activities – have significant and positive effects on innovation performance, whereas the two other activity sets – engineering and project management – do not. The data show that for sustainable energy projects, commercialization activities are often insufficient, but important to reach high innovation performance.

1. Introduction

Complex innovations are new products (innovations) that consist of multiple components with unknown and unpredictable interactions [1]. Although complex innovations come in various forms, in this paper we focus on complex innovations in which the components are of a technological nature. Such complex innovations can be found in many sectors, including the transport sector (e.g., public transit smart cards), the health care sector (e.g., e-health systems) and the manufacturing sector (e.g., aircraft). In particular, sustainable energy innovations, such as closed-loop greenhouses and sustainable electricity production systems, are often complex. The complexity of an innovation increases with the number of components involved, the degree of customization, the number of design choices, the elaborateness of the system architecture, the range and/or depth of knowledge and required skills, and the variety of information inputs [2]. Developing complex innovations requires the mobilization and management of a wide set of resources, which are rarely found within a single organization [3]. Instead, their development requires active participation by multiple organizations [3,4], often combining private and public actors [1], that complement each other [5], such as buyers, suppliers, nongovernmental organizations, knowledge institutes, and governments. For example, sustainable housing combines the inputs of architects, builders, suppliers, and local and national governments. Following Dougherty and Dunne [1], we refer to the heterogeneous set of actors involved in the development of a complex innovation as a multi-organizational

* Corresponding author. Tel.: +31 24 361 5460.
E-mail addresses: kristina.manser@googlemail.com (K. Manser), b.hillebrand@fm.ru.nl (B. Hillebrand), p.driessen@fm.ru.nl (P.H. Driessen), g.ziggers@fm.ru.nl (G.W. Ziggers), j.bloemer@fm.ru.nl (J.M.M. Bloemer).

http://dx.doi.org/10.1016/j.techfore.2014.04.010
0040-1625/

ecology. In this paper, we focus on the activities undertaken in projects aimed at developing such innovations in multi-organizational ecologies.

Complex innovations have been studied in various literature streams. The first literature stream takes an innovation systems perspective [6–12]. An innovation system is defined as a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies" [13]. The innovation systems perspective focuses on innovation at an aggregate level, more specifically, the level of a technology or innovation category (e.g., electric vehicles in general) rather than the level of an individual innovation (e.g., the Tesla Roadster, the Nissan Leaf, or the Opel Ampera, in the context of electric vehicles). In contrast, this paper uses a disaggregated level of analysis by focusing on the development of individual innovation projects. Understanding individual innovation projects is important for understanding innovation systems [8]. Although innovation systems also consist of other elements (e.g., rules, regulations, and unwritten norms), innovation projects are arguably the most important building block of successful innovation systems: innovations systems without successful projects are unlikely to flourish, whereas even a limited number of successful projects may spur an entire innovation system. The project-level perspective complements the innovation systems literature, in particular, the study of activities within innovation systems (e.g., [8,11]). Therefore, this study takes a project-level perspective on innovation activities in multi-organizational ecologies.

A second literature stream that has studied complex innovations is what we loosely refer to as the interorganizational network literature (e.g., [14–16]). The literature on interorganizational networks has mainly focused on the relationships among actors when developing (complex) innovations. However, this stream of literature has paid only scant attention to the activities that take place in such endeavors. We argue that a focus on activities is useful for understanding innovation management in multi-organizational ecologies because ultimately actors' behavior is a major driver of an innovation's success. Therefore, this paper focuses on the innovation activities that take place in multi-organizational ecologies. In doing so, it responds to repeated claims in the literature that management should be seen as a set of activities aimed at shaping relationships, understandings, and processes and that thus bring about task completion [8,17–19].

A third stream of literature that is relevant to the study of complex innovations is the new product development (NPD) literature (e.g., [20–22]). Traditionally, this stream of literature has paid more attention to innovation activities than has the interorganizational network literature, but has predominantly done so within the boundaries of individual organizations, thereby ignoring the multi-organizational ecology context that characterizes complex innovations.

Thus, despite these rich literature streams, we still lack an understanding of the innovation activities undertaken in multi-organizational ecologies. This paper aims to fill that gap in the literature. With its focus on innovation activities, the NPD literature appears to be a good starting point for addressing the gap in the literature. However, findings from the NPD literature might not translate directly to complex innovations because the activities studied in the NPD literature do not take place in a context of multi-organizational ecologies. Therefore, we set out to investigate the following research question: how can innovation activities be interpreted in the context of multi-organizational ecologies? We address this research question in two ways. First, we acknowledge that some activities may need to be adapted to a context of multi-organizational ecologies. Second, we study which underlying generic types of activities exist in the context of multi-organizational ecologies, acknowledging that activities may be categorized into activity sets. Thus, the goal of this paper is to develop a typology of innovation activities that are relevant to the context of multi-organizational ecologies. Typologies are an effective means "to bring order out of chaos", because they can transform complexity into well-ordered sets [23]. By constructing a typology, we can identify innovation activities and structure them by categorizing them into activity sets. To study the relevance of our typology, we develop and test hypotheses about the effects of the identified activity sets on innovation performance (i.e., the degree to which an innovation is perceived to be a success in terms of business objectives [24–26]).

This paper not only has theoretical relevance, but also offers insights to managers and public policy officers. A better understanding of innovation activities in multi-organizational ecologies constitutes a substantial benefit because coordinating and developing complex innovations, undertaken by multiple parties, remains a constant challenge for managers [27,28]. Furthermore, this paper may help public policy officers in evaluating innovation projects for funding decisions. Furthermore, insight into specific activities enables actors to manage innovation projects in multi-organizational ecologies.

2. Conceptual background

2.1. Innovation activities in multi-organizational ecologies

As noted before, the NPD literature provides a good starting point for an investigation of innovation characteristics in multi-organizational ecologies. The NPD literature has a long and rich tradition in detailing the activities undertaken in innovation projects [20–22]. It tends to take a process approach. That is, many studies from this tradition have classified the activities in stages or phases that organizations go through over time when developing new products. For example, Urban and Hauser [29], Cooper [30], Song and Montoya-Weiss [20], Veryzer [31], and Schilling and Hill [32] all have identified innovation activities following this underlying idea of a sequential product development process (see Ref. [33] for an overview). Although it is widely admitted that in reality, innovation processes are not completely sequential (i.e., product development processes may include feedback loops and phases may overlap), such NPD studies do provide a good overview of the innovation activities that are part of an NPD process.

Although they differ in the terminology that they use and the specific aspects that they emphasize, in general these NPD studies are relatively consistent in distinguishing among three broad categories of innovation activities: (1) *strategic predevelopment*, the activities aimed at finding the strategic direction for an innovation project prior to actually developing the new product, (2) the actual *engineering* of the new product, and (3) *commercialization*, the commercial activities aimed at marketing the newly developed product. Therefore,

Please cite this article as: K. Manser, et al., Activity sets in multi-organizational ecologies: a project-level perspective on sustainable energy innovations, Technol. Forecast. Soc. Change (2014), http://dx.doi.org/10.1016/j.techfore.2014.04.010