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Digital innovation in the energy industry: The impact of controversies on the evolution of innovation ecosystems

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ABSTRACT

The concept of innovation ecosystems gained significant importance in academic research on strategy and practice over the last years. The emergence of the Internet of Things is disrupting industries and setting the ecosystem in the focus of innovation. Even traditional analog industries, like the energy industry, are under pressure to foster and manage ecosystems during their innovation efforts. Thus, the energy industry represents an appropriate setting for examining the evolution of an innovation ecosystem under the empirical lens of controversies, which describe the challenges of the status quo and is congruent with previous research on dialectical inquiries as source of innovation dynamics. For the purpose of this paper, the Actor-network theory (ANT) is regarded as an appropriate tool since it allows researchers to analyze how actors interact due to their specific interests with each other and thus configure the ecosystem in its base. ANT further enlarges the perspective of handling actors, while it involves not only human but also non-human actors (i.e. technologies). This is a valuable and necessary feature while dealing with digital innovations such as virtual power plants (VPP). By analyzing three how distinctive typologies, their mechanisms as well as their pathways of controversies affect the innovation ecosystem of VPPs and the evolution of the technological components of the innovation, this interaction between human and non-human actors is highlighted. In consequence, our research emphasizes the significance of involving non-human actors into managerial strategies and the role they inherit for the evolution of ecosystems. Furthermore, the present research reveals that controversies are not only a moderating factor but also a constitutional one for the coevolution of the ecosystem as well as the innovation itself especially during the forming phases. With respect to recent research of the management of digital innovation, this paper contributes to a better understanding of managerial challenges associated with digital innovation and their respective ecosystems.

1. Introduction

The emergence of the Internet-of-Things (IoT), creates a technological network of connectivity with self-configuring capabilities that are enabled by standardized and interoperable formats and connecting heterogeneous digitized objects via the internet (Atzori et al., 2010). Digital technology therefore is combining digital and physical components into novel value propositions. Furthermore, ubiquitous computing enables the interconnection of multiple devices (Yoo et al., 2010).

Along with this digitization of technology, the organizing logic of innovation is changing (Yoo et al., 2010). Schumpeter (1942) model of the lone entrepreneur that brings a certain value proposition to the market has to be rethought, as innovation are increasingly created in networks (i.e. ecosystems) of produces, users, complementors and several other institutions that create a social system consisting of multiple and heterogeneous actors (Adner, 2006; Moore, 1993). The high level of openness in innovation makes firms more dependent on each other as well as dynamics within the firm's environment (Adner and Kapoor, 2010; Battistella et al., 2013; Chesbrough, 2006). Therefore, innovation ecosystems are an ensemble of interdependent and heterogeneous actors (e.g. suppliers, distributors, competitors, customers, government, and other institutions) (Moore, 1993; Teece, 2007) that emerge around an innovation (i.e. a technological network) and are dynamic and steadily evolving (Iansiti and Levien, 2004).

Understanding how such ecosystems evolve over time is becoming critically important for many firms. Hence, research on ecosystem evolution gains increasing attention (e.g. Henfridsson and Bygstad, 2013). Drawing on the metaphor of a biological ecosystem, one suitable way to explain the path-dependent and frequently chaotic dynamics within such a system is Darwin's (1859) notion of evolution and co-evolution. While evolution describes the change of a system over time on a more

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holistic level, co-evolution explicitly focuses on the interaction between entities within a system that creates conflict or cooperation and therefore creates dynamics.

One aspect that has not been considered by research on ecosystem dynamics is an integrated view on how such interaction between both, technological and human entities in an ecosystem affect the relationships among them and influence the dynamics of an innovation ecosystem. However, integrating the technological as well as the social perspective is required to gain a deeper understanding of the dynamics of innovation ecosystems.

We therefore argue that Actor Network Theory (ANT) is a suitable theoretical lens (Callon, 1986; Latour, 1990) for analyzing an innovation ecosystem as network of human (e.g. organizations) and non-human (e.g. technological) actors. In particular, the dynamics of an ecosystem are defined as a socio-technological process in which various organizations translate and inscribe their interests into a technology, creating an evolving network of human and non-human actors (Henfridsson and Bygstad, 2013). Controversies are situations in which formerly fixed ideas are challenged and contradict the status quo (Latour, 2005; Venturini, 2010). Such changes in the status quo of a socio-technological system frequently lead to ripple effects, which result in an overall system's evolution. In the sense of ANT this can be positive controversies such as the emergence of novel ideas or technologies or negative like in the sense of conflicts. This argumentation is in line with previous research that highlighted the role of dialectic objectives and conflicts in organization or groups as source of innovative outcomes (Harvey, 2014). However, this research was neither focusing on the interorganizational level of ecosystems nor did it examine the crucial role of technology in such settings. Therefore, the concept of controversies in socio-technological actor networks are a suitable mechanism to explain ecosystem dynamics

In order to analyze the impact of such controversies on ecosystem evolution, we addressed several key questions: What are typologies of controversies within the innovation ecosystem? How do they affect the dynamics of ecosystem? Moreover, what is the underlying logic of the evolution process shaped by controversies?

For this purpose, we organized the paper as follows. The upcoming sections review present work on the emergence and characteristics of digital ecosystems and our conceptual framework based on ANT. We then argue for virtual power plants (VPPs) as suitable objects for examining digital ecosystems. In order to investigate the impact of controversies on digital innovation ecosystems, we apply a case study approach examining a project of setting up a VPP within the German energy industry. A discussion of the results derived from the case analysis draws the contribution to the mechanisms of controversies on the evolution of the ecosystem. The contribution and the limitations of the paper are highlighted in the concluding section.

2. The emergence of digital ecosystems as new organizing logic for innovation

As digital technology is combining digital and physical components into new value propositions, firms can no longer rely on enhancing features and the quality of their products by solely focusing on their individual innovation efforts. Digital disruption in various traditional industries requires the blurring of industry boundaries and converging knowledge bases. Such convergence brings together previously separated user experiences (e.g. adding mobile internet), physical and digital components (e.g. smart products) and previously separated industries (e.g. software and hardware industry) (Yoo et al., 2010).

In general, the properties of digital technology implicate a layered architecture (Adomavicius et al., 2008), which is a specific functional design hierarchy that initiates the modular design of digital innovation (Baldwin and Clark, 2000). This allows an effective division of labor among different actors during the design and production of complex systems (Sosa et al., 2004; Staudenmayer et al., 2005). Thus, pervasive digital technology can be seen as an enabler of new market dynamics as well as increased exchange of specialized competences (e.g. knowledge and skills) between heterogeneous actors in complex network structures (Yoo et al., 2010). The modularity of digital innovation is therefore changing the traditional value chain into value networks and fundamentally reshaping the traditional innovation logic (Garud and Kumaraswamy, 1993; Sosa et al., 2004). In particular, the combinable developmental process of novel digital technology explains how components interact with other components and reshape an ecosystem of human and non-human actors.

The concept of such ecosystem helps to analyze interdependencies more explicitly (Adner and Kapoor, 2010; Iansiti and Levien, 2004; Moore, 1993). Innovation ecosystems are defined as a "[…] *loosely interconnected network of companies and other entities that coevolve capabilities around a shared set of technologies, knowledge, or skills, and work cooperatively and competitively to develop new products and services* […]." (Nambisan and Baron, 2013:1071).

Organizations increasingly participate in ecosystems to capitalize on knowledge outside the boundaries of the single firm (Chesbrough, 2006; Simard and West, 2006). The companies' single innovation efforts therefore reciprocally influence each other making the relationships among the actors of the ecosystem central to its success (Iansiti and Levien, 2004). Digital ecosystems are not homogenous constructs but include different actors with different kinds of relations and variable strength of ties among them (Teece, 2007). Vice versa, an ecosystem is not a stable construct but a dynamic and steadily evolving entity, which is changed by the relationships between the individual actors and their interdependencies (Ghazawneh and Henfridsson, 2013; Selander et al., 2013), changing the direction and strength of ties among them (Basole, 2009).

3. Conceptual framework: an actor network approach

3.1. Actor-network theory

We argue that the interaction within the innovation ecosystem of a VPP, is strongly affected by human (i.e. organizational) and non-human (i.e. technological) actors. Thus, ANT is an appropriate starting point for the intercourse to our research design as it explicitly highlights this interplay (e.g. Callon, 1986; Latour, 1990, 2005). Despite being criticized, it is lately used to study innovation especially in the field of information systems (IS), which fits our perspective on the context of digital innovations (e.g. Dery et al., 2013; Hanseth and Lyytinen, 2004). In fact, several authors emphasized the importance of ANT in analyzing the interaction between stakeholders, particularly to address the crucial role of technology (e.g. Luoma-aho and Paloviita, 2010; Pouloudi et al., 2004; Vidgen and McMaster, 1996).

The origin of ANT, which lies within the field of socio-technological systems, implies that "[…] *the study of any desired technology itself can be developed into a sociological tool of analysis* […]" (Callon 1987:83). Thus, the view of technology as a socially constructed system caused by several interactions perfectly fits our understanding (Hughes, 1987). Following this logic, the underlying concepts of ANT are inscription and translation (e.g. Callon, 1987; Lee et al., 2015). Engineers inscribe their intentions or imaginations of how it fits best to the desired scope into a developed or designed technical artefact (e.g. software, application). Callon (1987) titles such engineers as "*engineer-sociologists*" since they become sociologists in the way of inscribing their technical vision in the real world (organizational) context. In order to illustrate this, we give an evident example: Why do drivers trust their navigation systems at least as much as tourist information centers when searching a street? This is due to engineers inscribing navigation systems with specific respect to how drivers reach their way best as by those who once decided to develop a city guide (map). This plausible illustration highlights the central aspect of ANT of treating human and non-human actors equally. Throughout an innovation process, especially a

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