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Network evolution and the embedding of complex technical solutions: The case of the Leaf House network

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ABSTRACT

The purpose of this paper is to investigate the connection between *network evolution* and *technology embedding*. To this end, we performed an exploratory case study of the network surrounding an eco-sustainable technology, Leaf House, Italy's first zero-carbon emission house. We apply theories on technological development within industrial networks, with a specific focus on their resource layer and on the three settings involved in embedding an innovation: "developing", "producing", and "using". Our results contribute to these theories by developing four propositions on the connections between network evolution and embedding: first, technology embedding entails both downstream network expansion and upstream restrictions. Secondly, conflicts among actors increase as technology embedding approaches the producing and using settings. Third and fourth, the more the shapes a technology can assume, and the more each of these shapes involves actors acting in different settings, the easier it is to embed it. The paper concludes with managerial implications and suggestions for further research.

1. Introduction

In the light of the centrality of the environment in political debates and managerial discourses (Hart & Milstein, 2003), firms are increasingly investing in eco-sustainable technologies. However, in order to turn these new technical solutions into usable and marketable products, being "green" is not enough: they must also be inexpensive to produce and use (Porter & van der Linde, 1995; Stone & Wakefield, 2000). Cost and green targets need to be met simultaneously (Maxwell & van der Vorst, 2002) and – like any innovation – these solutions' positive features need to be appreciated by several actors involved in their innovation process, from developers, to producers and distributors, all the way to users (Van de Ven, Polley, Garud, & Venkataraman, 1999; von Hippel, 1988). These solutions also require combining technologies from several suppliers (Håkansson & Waluszewski, 2002a,b). For these reasons, it is relevant to consider eco-sustainable solution development from an industrial network perspective (Ford, Gadde, Håkansson, & Snehota, 2003; Håkansson & Snehota, 1995).

This paper's empirical focus is on a specific eco-sustainable solution, Leaf House, an innovative building that combines several technologies to create Italy's first zero-CO_2 emission house. Promoted by the medium-sized Italian firm Loccioni Group, Leaf House was created during a project that involved a network comprising about 80 partners that contributed specific technologies and competences, and also represented the user side of eco-sustainable solutions. Leaf House emerged as a complex technical solution that integrates several subsystems, products, and components for the efficient production, monitoring, control, and use of light and energy. These pieces of technology were either developed from scratch or, where already available, they needed to be adapted and brought together into a functioning whole. For instance, all single hardware pieces needed to be connected with sensors capable of interfacing with ICT solutions that handle several software languages.

These technical tasks are challenging but are only the start of a more complex journey that a new technology needs to undertake before it can become an innovation (Van de Ven et al., 1999). In fact, one common definition of innovation is a technology that has been adopted by users who appreciate its features and are ready to pay for it (Tidd, Bessant & Pavitt, 2001: 38–39). However, before a new technology can be *adopted*, it needs to be produced in large scale and also *adapted* to the user context (Van de Ven et al., 1999: 53–4; Oudshoorn & Pinch, 2003). Or, as stated by Akrich, Callon, and Latour (2002b: 209), "To adopt an innovation is to adapt it". There is a further challenge that appears here, since technology adoption is not a smooth process of diffusion across a population of impatient or passive users (see Geroski, 2000; Mansfield, 1961; Rogers, 1976), but a demanding and onerous process (Akrich, Callon, & Latour, 2002b) whereby *interfaces* need to be created that connect the new solution to specific resources and investments in the production and using

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contexts (Waluszewski, Baraldi, Linné & Shih, 2009 87; Håkansson & Waluszewski, 2007). We define this *creation of interfaces* between the tangible and intangible resources that influence a new technology's transformation into an innovation as the *embedding* of that solution (Waluszewski, Baraldi, Linné, & Shih, 2009: 87; Baraldi & Strömsten, 2006: 58, Håkansson & Waluszewski, 2002b: 225–8).

In the case of Leaf House, the network of partners involved in its development project also used the building and its infrastructure to conduct tests for their new energy-saving solutions, in order to produce and sell them later on. In other words, these actors combined several technical and organizational resources (Håkansson & Waluszewski, 2002b) inside and around Leaf House as they tried in various ways to embed the related technical solutions. But while the technical solutions in Leaf House started to become embedded, the network evolved as new actors entered it and their relationships changed. Whereas in the period leading up to the prototype building's completion there were very few conflicts, because all actors *could gain something* in relation to Leaf House (this is an important condition for sustaining technologies' development in a business network setting; Håkansson, 1987), more challenges appeared during the period of the pilot solutions' large-scale embedding in a broader producing and using setting.

The Leaf House case is therefore particularly interesting from a theoretical perspective, because it allows the investigation of *both* the embedding of a new complex technical solution *and* the changes occurring in the network around it during such embedding. The *simultaneous* investigation of technology embedding and network evolution is advantageous, because it allows one to approach the adaptations necessary to transform a new technology into an innovation, not as a unidirectional phenomenon of *re-invention* (see Rogers, 1995) whereby the new technology is modified to fit the using or producing context, but as a bidirectional phenomenon of *co-development* of and mutual adaptation between the technology and its surrounding network. Such an approach also underlines the changes that the network context undergoes as it accompanies a new technology's embedding. Network changes also occur because, in order to become a sellable product, a new technical solution must fit in and be progressively embedded in three contexts: a development setting, a production setting, and a usage setting (Håkansson et al., 2009; Håkansson & Waluszewski, 2007). As these three settings overlap, but also conflict in terms of their logic and composition, embedding a new technology is accompanied by several changes in its surrounding network.

Against this background, the purpose of this paper is to investigate the *connections* between network evolution and changes, on the one hand, and new technical solutions' embedding, on the other hand. We conduct an exploratory case study grounded on a focal technology – Leaf House – and its surrounding network in order to generate a set of propositions that can contribute to research on innovations and industrial networks (e.g., Baraldi & Strömsten, 2006; Gressetvold, 2004; Håkansson, 1987; Håkansson & Waluszewski, 2002 2007; Lundgren, 1995) by pointing out salient network changes and other conditions that support embedding. To this end, we address two practical questions: (1) How did the Leaf House network evolve, in terms of changes in the composition, types of actors, and their goals and relationships? (2) Which interfaces were created between Leaf House and other social and technical resources that can influence its embedding? In addressing these questions, we enter the focal network's resource layer and apply the four-resources (4R) model (Baraldi, 2003; Håkansson & Waluszewski, 2002a,b; Wedin, 2001). Furthermore, we relate this network evolution to the three settings of development, production, and usage (Håkansson & Waluszewski, 2007). The remainder of the paper is organized as follows: the next section provides our theoretical framework. We then review our method before presenting the empirical case. The following section analyzes the case and formulates four propositions concerning the connections between network evolution and technology embedding. We conclude with suggestions for further research and managerial implications.

2. Theoretical framework: resource interaction and network evolution

This section first discusses technology embedding, from the perspective of resource interaction (Baraldi, 2003; Håkansson & Waluszewski, 2002a), and then the topic of network evolution. From an Industrial Marketing & Purchasing (IMP) view, technical development and innovations are generally investigated by focusing on business networks' resource layer (see e.g., Håkansson & Snehota, 1995: 132–91; Wedin, 2001; Håkansson & Waluszewski, 2002b; Gressetvold, 2004). Specifically, it is useful to analyze a new technology's embedding by applying a "resource interaction" perspective (Baraldi, 2003; Håkansson & Waluszewski, 2002a), which penetrates how different resources are combined and interfaced within a network to develop or modify technical solutions. One key theoretical assumption of this perspective is that the value of each of these resources, including the new technology, is not intrinsic but depends on the specific ways in which one resource is combined with the other resources (Penrose, 1959).

This relativistic view on value creation is also embraced in current research on marketing (Lusch & Vargo, 2006; Tuli, Kohli, & Bharadwaj, 2007; Vargo & Lusch, 2004, 2008). Furthermore, a relativistic and relational view on value is very important at the network level, where it is both new combinations of resources and specific inter-firm interactions that contribute to innovations (Håkansson, Henjesand, & Waluszewski, 2004; Lusch & Vargo, 2006: 285, Tuli et al., 2007). Therefore, the basic way to achieve innovation is to combine resources in new ways that create (new) values for key actors in a network. These new resource combinations entail adapting single resources to each other by modifying their "interfaces", that is, the contact points and interconnections between two or more resources (Dubois & Araujo, 2006: 22; Baraldi, 2003: 17–23; Håkansson & Waluszewski, 2002b: 214–5). These re-combinations of resources and modifications of their interfaces are necessary both at the level of *developing* new technologies and at the level of *using* them, where adaptations are pivotal to allow for adoption (Akrich et al., 2002b; Van de Ven et al., 1999: 53–4; Oudshoorn & Pinch, 2003).

Furthermore, re-combinations of resources and modifying their interfaces concern both technical and social resources. As the 4R model is useful for categorizing resources and analyzing their interactions and interfaces, we chose to apply it in data collection and analysis. The model distinguishes between physical/technical resources (*products* and *facilities*) and social/organizational ones (*organizational units* and *business relationships*) (Baraldi, 2003; Baraldi & Bocconcelli, 2001; Håkansson & Waluszewski, 2002a,b; Wedin, 2001). This model is particularly useful for investigating new technologies' embedding, which we define as *the creation of interfaces between the above-mentioned four resource types that enable a focal technology to be developed, produced, and used*. In fact, the 4R model penetrates the interactions and the interfaces between single-resource items or groups of resources (see Baraldi & Strömsten, 2006; Gressetvold, 2004; Harrison & Håkansson, 2006).

By interacting along specific interfaces, resources affect each other's values, features, and usage (Baraldi, 2003: 17–8). For instance, eco-sustainability can be seen as a key *feature* of the physical resources *facilities* and *products*, that is, as the degree to which these resources save or allow for the conservation and renewal of natural resources such as water, air, and forests. However, embedding a value in relation to a specific resource (e.g., a piece of furniture, a car, or a house) requires that several other resources be combined (Baraldi & Strömsten, 2006) in ways that are not only technically functional and ecologically friendly, but also respect cost targets and thereby provide multiple values to several actors involved in development, production, and use. For instance, IKEA's table Lack presents positive ecological features because