Please cite this article as:

Brode L, Dell'Era C and Verganti R (2014).
The contributions of interpreters to the development of radical innovations of meanings: the role of "pioneering projects" in the sustainable buildings industry.
R&D Management, Vol. 44, No. 1, Pp. 1-17.
(DOI: 10.1111/radm.12035)

THE CONTRIBUTION OF INTERPRETERS TO THE DEVELOPMENT OF RADICAL INNOVATIONS OF MEANINGS: THE ROLE OF "PIONEERING PROJECTS" IN THE SUSTAINABLE BUILDINGS INDUSTRY

Lisbeth Brøde Jepsen (corresponding author)
Department of Environmental and Business Economics
University of Southern Denmark – Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark
Tel: +45 6550 4209
Fax: +45 6550 1091
lbr@sam.sdu.dk

Lisbeth Brøde Jepsen is a Research Assistant in the Department of Environmental and Business Economics at the University of Southern Denmark. Her research relates to the *management of innovation*. Specifically, her research focuses on intra- and inter-organisational information sharing and collaborations (including networks) in new product development and the management of design-driven innovation.

Claudio Dell'Era
Department of Management, Economics and Industrial Engineering,
Politecnico di Milano – Piazza L. da Vinci, 32 20133 Milano Italy
Tel: +39 02 2399 2798
Fax: +39 02 2399 2720
claudio.dellera@polimi.it

Claudio Dell'Era is an Assistant Professor in the Department of Management, Economics and Industrial Engineering at Politecnico di Milano, where he is also Co-Director of MaDe In Lab, the Laboratory of Management of Design and Innovation at MIP Politecnico di Milano, and Guest Researcher at Mälardalen University. Dell'Era's research focuses on the *Management of Innovation*. Specifically, his research interests include two main areas of focus. The first concentrates on innovation strategies developed by leading companies that operate in design-intensive industries where symbolic and emotional values represent critical success factors for generating competitive advantage (*Management of Design-Driven Innovation*). The second analyses the approaches and practices adopted during innovation processes by high-tech companies that face turbulent environments (*Management of Technological Innovations in Turbulent Environments*). He has published his research in important international journals such as the *Journal of Product Innovation Management*, *Long Range Planning*, *R&D Management*, *International Journal of Operations & Production Management*, *Industry & Innovation*, and the *International Journal of Innovation Management*.

Roberto Verganti
Department of Management, Economics and Industrial Engineering,
Politecnico di Milano – Piazza L. da Vinci, 32 20133 Milano Italy
Tel: +39 02 2399 2770

Fax: +39 02 2399 2720
roberto.verganti@polimi.it

Roberto Verganti is a Professor of Management of Innovation at the Politecnico di Milano, where he also is the Scientific Director of MaDe In Lab, the laboratory for education in the management of design and innovation, and Guest Professor at Mälardalen University. He is also chairman of PROject Science, a consulting institute focusing on strategic innovation, a visiting professor of Design Management at the Copenhagen Business School and an Adjunct Professor of Design Innovation at the University of Vaasa, Finland. He is a member of the Editorial Board of the Journal of Product Innovation Management and of the Advisory Council of the Design Management Institute. He has published more than 100 papers, including 35 papers in leading international journals (such as the Journal of Product Innovation Management, Management Science and Harvard Business Review) and seven books. He was awarded the "Compasso d'Oro" in 2001 (the most prestigious design award in Italy) for the Italian Design System research project for which he was a member of the Scientific Organising Committee. His most recent book is Design-Driven Innovation, published in August 2009 by the Harvard Business Press.

THE CONTRIBUTIONS OF INTERPRETERS TO THE DEVELOPMENT OF RADICAL INNOVATIONS OF MEANINGS: THE ROLE OF "PIONEERING PROJECTS" IN THE SUSTAINABLE BUILDINGS INDUSTRY

Abstract

Studies of innovation management have often focused on two domains: technologies and markets. An ever-increasing standard of living is pushing companies to develop products and services that are not only profitable but also socially responsible. Sustainable housing offers an intriguing empirical setting that allows the investigation of new processes able to support innovations that must be both profitable and socially responsible. Energy-efficient houses not only require technological changes (new sustainable energy technologies) but also require behavioural changes in consumers' attitudes, decisions and practices about living in sustainable houses. Companies are not only innovative in regard to their own product, but apply the entire system of application with which their specific technologies interact. The development of Pioneering Projects requires many skills and competencies that often exceed the capacity and competencies of a single company. In other words, Pioneering Projects are testing grounds for experimentation, where unconventional, temporary partnerships of stakeholders from different industries unite in the development of real market applications.

The paper addresses the value of key interpreters in facilitating the development of radical innovations of meanings in the sustainable buildings industry. Specifically, the

paper analyses the ability to create value for the Pioneering Projects from the exploration and knowledge diversity of the interpreters and the impact that Pioneering Projects have on the companies' outcomes. Empirical data about Pioneering Projects were collected from two manufacturing companies in Denmark: DOVISTA and Saint-Gobain Isover.

1. Introduction

Studies of innovation management have often focused on two domains: technologies and markets (for an extensive review see Garcia and Calantone, 2002; Calantone et al., 2010). Technological innovation has been capturing the most attention, especially radical technological change (Abernathy and Clark, 1985; Henderson and Clark, 1990; Utterback, 1994; Christensen and Bower, 1996; Christensen, 1997). Historical, social, demographic and industrial factors are forcing companies to develop offerings that merge profitability with social and cultural values. An ever-increasing standard of living is pushing companies to develop products and services that are not only profitable but also socially responsible. As argued by the rich literature on socio-technical systems (Carlsson and Stankiewicz, 1991; Geels, 2004), companies must design and develop socially and culturally responsible products.

Sustainable housing represents an intriguing empirical setting that allows the investigation of new processes able to support innovations that must be both profitable and socially responsible. Approximately 40% of the total energy consumed in Europe is used for heating and cooling buildings. This consumption must be reduced, and the EU has stated that energy consumption and carbon emissions must be reduced by 20% by 2020 (VKR Holding A/S, 2011). This intensified focus on climate issues has created

the potential for innovation and has increased the demand for sustainable housing. Energy efficiency is becoming a major impetus for firms to take more proactive and radical action. In particular, building regulations play a key role in the construction industry, and rather than focusing on markets, company strategies are focusing on new policy trends (Ornetzeder and Rohracher, 2006). Thus, companies have shifted their focus towards (1) sustainable innovation technologies and (2) system innovation, which emphasises the development of radical innovations such as sustainable buildings. First, energy-efficient houses require not only technological changes (new sustainable energy technologies) but also changes in consumers' attitudes towards decisions and practices regarding living in sustainable houses in the future. For example, a sensor would signal when it is appropriate for an inhabitant to open a window; he/she would not be allowed to open a window manually because doing so would influence the energy consumption negatively. This radical redefinition of a product's (house) meaning is referred to as design-driven innovation (Verganti, 2009; Dell'Era and Verganti, 2009). Second, companies are not only innovative in regard to their own product, but apply the entire system of application with which their specific technologies interact. In other words, companies seek collaboration with other valuable stakeholders, which not only contributes to the development of sustainable housing but also influences the future way of living. In the case of sustainable housing, architects, engineers, construction companies and suppliers of building material are all stakeholders who want to understand and influence future scenarios for sustainable housing and are therefore considered *interpreters* (Verganti, 2008). The development of design-driven innovation requires many different skills and competencies that may not all be available in a single company. Therefore, interpreters vary by industry and background but share the same goal and are eager to explore future scenarios. According to Verganti (2009), by

stepping back from focusing on a user performing a specific action and taking a broader perspective on the context in which that person lives, every company can identify several interpreters from different categories, including research and educational institutions, technology suppliers, firms in other industries, designers, retail and delivery firms, cultural organisations and artists. These individuals share the same mission: conducting research on how people assign meanings to things. They also support the spread of new meanings, exploiting their seductive power.

Collaboration and experimentation among different interpreters for design-driven innovations (such as sustainable housing) normally occur outside the normal market of special projects and are referred to as *Pioneering Projects*. Pioneering Projects are the testing grounds for experimentation, where unconventional, temporary partnerships of stakeholders from different industries unite to develop real market applications. These projects offer an interesting venue for experimentation and are particularly well-suited to radical innovations because they are early versions of future innovations (e.g., sustainable houses) that will be used by real clients. Pioneering Projects enable the identification of innovative solutions, which can be transferred to more traditional projects as technological and process improvements. The ability to ignore some constraints enables the exploration of different paths and the implementation of counterintuitive solutions. They are characterised by two specific factors compared with other explorative methodologies: i) a real-life environment and ii) clients' knowledge of the project. Unlike traditional experiments or beta testing, Pioneering Projects are not experiments but rather foresee the use of new products and services in real-life settings. Clients know they are involved in the pioneering projects and accept being part of the experiments to seek new solutions. Very often, clients involved in

Pioneering Projects are so visionary that they expect not only their own payoffs, but they also pursue their own specific visions for a solution that could benefit society in the future. Therefore, these Pioneering Projects have the potential to influence the people's behaviours in the future and how they assign meaning to things (Verganti, 2009).

The aim of this paper is to explore the network of interpreters. Of particular interest are the relationships between (1) the explorative role of the interpreter (architects, engineers, and construction companies) and the value of that contribution to the Pioneering Projects; (2) the diverse knowledge of the interpreters and the value of that contribution to the Pioneering Projects and, finally (3), the value contribution and the performance of the Pioneering Projects. The structure of the article is as follows. The next section introduces the conceptual framework and research hypotheses. Section 3 describes the empirical setting, and section 4 gives an overview of the data used in the analysis. The fifth section describes and discusses the empirical results. Finally, conclusions and avenues for future research are outlined.

2. Conceptual framework and research hypotheses

This section is organised in three main parts. First, we introduce two main characteristics of the interpreters involved in Pioneering Projects (explorative attitude and knowledge diversity); then, we discuss the main outcomes of the Pioneering Projects.

Explorative attitude

Inter-organisational collaborations such as social (Argote et al., 2003) or alliance networks (Gulati, 1998) have been found to be beneficial for the development of new innovation (Hakansson and Laage-Hellman, 1984) and to have a positive influence on the innovative performance of companies (Argote and Ingram, 2000; Hargadon and Sutton, 1997; Hargadon, 1998). Recent studies have focused on issues related to alliances as ways to develop exploration or exploitation strategies (Ahuja and Lampert, 2001; Koza and Lewin, 1999; Lavie et al., 2009; Rothmaerler and Deeds, 2004). These collaborations are seen as a way of facilitating innovation, and companies engage in collaborations for the exploitation of the existing knowledge base and for the exploration of new opportunities (Koza and Lewin, 1999; March, 1991; Bidault and Cummings, 1994). As March (1991) argues, exploitation is about making the best of existing competencies and creating reliability in experience, and the outcome of this exploitation includes better efficiency, reduced time-to-market and cost reduction. This strategic behaviour has proven beneficial in the short run. Exploration, on the other hand, addresses experimentation with new alternatives and the exploration of a new (technological) field (March, 2001). Therefore, exploration alliances are generally used when the aim is to create radical new innovation (Argyris and Schon, 2007). Collaboration in design-driven innovation is an example of an exploration alliance. Verganti (2008) argues that collaborations in design-driven innovation are similar to alliance and network research, even though alliance research focuses on technological knowledge, and design-driven innovation focuses on knowledge of languages and meanings (Verganti, 2006). Design-driven innovation is, thus, the result of a networked research process, where companies and external interpreters share and collectively develop languages and meanings. In other words, when companies develop radical

design-driven innovation, where new scenarios need to be created, they explore new knowledge and new capabilities (Verganti, 2009).

In many industries, innovators use products in special settings outside the normal market stream, where they have greater freedom to explore new solutions. As previously mentioned, Pioneering Projects are characterised by two specific factors compared with other explorative methodologies: i) a real-life environment and ii) clients' knowledge of the project. Because clients of Pioneering Projects accept that they will encounter new avenues and create new landmarks, they provide more freedom to explore radical solutions. Moreover, Pioneering Projects present an opportunity to share and develop new knowledge with noncompeting interpreters who are at the forefront of research and exploration. The value of such projects is strongly influenced by the explorative attitude demonstrated by the interpreters involved. Therefore, we posit the following:

H1: The more explorative the attitude demonstrated by interpreters (exploration attitude), the higher the value of the Pioneering Project (collaboration value).

Knowledge diversity

The network characteristics of exploitation strategies and exploration strategies differ in alliance composition and in partner capabilities (Duysters and De Man, 2003). Whereas exploitation networks require intense, close collaboration with the same partners over time (Li and Rowley, 2000), exploration networks are characterised by frequent partner exchange (Khanna et al., 1998). Burt (1992) suggests that a portfolio of alliances consisting of ties to companies in a variety of markets may be more valuable than an otherwise similar portfolio of alliances with firms in the same or similar

markets. Furthermore, research has found that certain characteristics of partners influence companies' innovative performance.

According to Burt (1992), building a network requires maximising the proportion of bridges (i.e., non-redundant contacts) to total contacts in the network. The diversity of direct contacts developed by a company strongly affects its innovation capability; the number of direct contacts becomes relevant only to the extent that it increases the probability of network diversity. As demonstrated by several studies, a company's portfolio of partners may be as influential as the dyadic characteristics of these alliances (Gulati, 1998; McEvily and Zaheer, 1999). The relationship between diversity and innovativeness is recognised and discussed from different perspectives (Cox and Blake, 1991; Iles and Hayers, 1997; Richard and Shelor, 2002). Collaboration with heterogeneous partners can increase the recombination possibilities and can recognise opportunities before competitors. Collaboration with heterogeneous partners may lead to constructive conflict, increasing a firm's problem-solving capabilities and allowing it to approach new opportunities through new frameworks (Haunschild and Sullivan, 2002; Dell'Era and Verganti, 2010). Exposure to heterogeneous knowledge should improve managers' innovation performance. The variety of knowledge to which a manager is exposed has a positive impact on both overall managerial performance and on innovation performance (Rodan and Galunic, 2004). In other words, very often insights are scattered among several interpreters, and the combination of all these perspectives provides the relevant value for innovation. This leads us to argue that:

H2: The more diverse the knowledge brought by interpreters (knowledge diversity), the higher the value of the Pioneering Project (collaboration value).

Performances of the Pioneering Projects

The value of the Pioneering Project generated through collaboration with several interpreters represents an internal construct because it represents the company's perception of the knowledge improvement obtained by the Pioneering Project. Its outcomes refer to the external results generated by this value, and consequently, those results can be perceived by players in the company's environment. The *collaboration value* can be interpreted as an asset that can be valorised in different ways. For this reason, it can be linked to the "value creation" literature and more specifically to the resource-based theories that underline the importance of developing unique and difficult to imitate strategic resources (e.g., Wernerfelt, 1984; Barney, 1991). By contrast, the "value appropriation" literature suggests different modalities for exploiting the asset to achieve specific outcomes. For the advocates of these strategies, the creation of strategic assets is not enough to obtain and maintain a competitive position in the market; the strategies of value appropriation are pivotal in the transformation of value into effective results and the maintenance of these results over time (Teece, 1986; Mizik and Jacobson, 2003).

To develop radical innovation, the company and its partners (interpreters) sometimes choose to perform experiments through Pioneering Projects (Verganti, 2009). They offer an interesting environment for experimentation and are particularly well-suited to radical innovations because they are early versions of future innovations (e.g., sustainable houses) that will be used by real clients. Pioneering Projects enable the identification of innovative solutions, which can be transferred to more traditional projects that involve technological and process improvements. Second, the ability to ignore some constraints enables the exploration of different paths, the implementation

of counterintuitive solutions and the exploitation of opportunities. Specifically, Pioneering Projects can be used to improve the efficiency of existing technologies or to verify their applicability in other contexts (*new applications*). Therefore, we posit the following:

H3: The higher the value of the Pioneering Project generated by the collaboration with the interpreters (collaboration value), the greater the ability to identify new applications (new applications).

Furthermore, Pioneering Projects are typically collaborations among several valuable partners (e.g., architects, engineers, construction companies) who interpret new meanings of the future scenario (e.g., the way people will live in future sustainable houses). Therefore, Pioneering Projects are a unique opportunity to create and develop new knowledge. As argued by Verganti (2009), Pioneering Projects are beacons of cultural production. They receive significant attention from other interpreters, including the media, cultural institutions, and the public, and thus often eventually influence how people give meaning to products. In other words, they can improve the *exposure* of the company. This leads us to argue that:

H4: The higher the value of the Pioneering Project generated by the collaboration with the interpreters (collaboration value), the higher the exposure of the participants (exposure).

Among all partners (interpreters) with which a firm may interact in the design discourse, some partners have a crucial network position. Some partners may act as crucial gates

(gatekeepers) that facilitate a firm's access to the design discourse (Verganti, 2008). Others are bridges between different socio-cultural worlds and industries and therefore facilitate the transfer of knowledge of meanings and languages among different contexts. This knowledge transfer might lead to exposure in the community and to potential new partners. Stuart (2000) wrote that in addition to providing access to new partners and new communities, an alliance can be a signal that conveys social status and recognition and therefore can be a good way to promote a strong reputation in an industry. In other words, Pioneering Projects have the potential to influence and make assumptions about future lifestyles and regulation. They can *influence* stakeholders belonging to the network where the company operates to the point that they attract new partners. Therefore, we posit the following:

H5: The higher the value of the Pioneering Project generated by the collaboration with the interpreters (collaboration value), the higher the ability to influence influencing current and new communities (influence).

Figure 1 synthesises the conceptual framework built around three main constructs: interpreters involved in a Pioneering Project, the value of the Pioneering Project and the outcomes of the Pioneering Project.

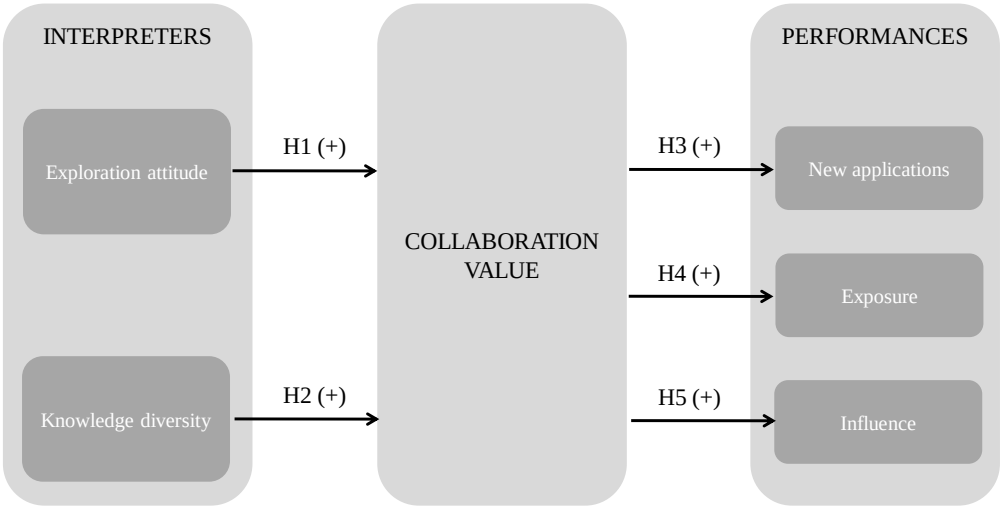


Figure 1: Conceptual framework and research hypotheses

3. Empirical setting

To examine our hypotheses, we collected data from 30 Pioneering Projects from two manufacturing companies in Denmark: DOVISTA and Saint-Gobain Isover (for further details see Appendix A).

DOVISTA is owned by the Danish VKR Holding, which employs 16,000 employees. DOVISTA is the parent company of the DOVISTA Group, which comprises 10 strategic business units (brands) and employs 4,000 people in seven European countries. The group develops and manufactures energy-efficient windows for sustainable buildings. Traditionally, product manufacturers (including the DOVISTA Group) in the construction industry have not taken much interest in being system integrators. However, with the Pioneering Projects of DOVISTA, the manufacturers' role is changing. Now, they play a more active role as integrators in the value chain, which is related to a greater interest in system innovation. In January 2009, DOVISTA

found the small business unit LivingLab, which consists of 9 employees and whose purpose is to conduct pioneering, groundbreaking, high-profile projects with a high degree of novelty. These projects are cross-disciplinary, new-building projects (such as "bolig for livet"[i]) that are characterised as Pioneering Projects in which windows are integrated in experimental houses for the future (see Figure 2). The goal of the Pioneering Projects is to develop future sustainable housing with respect for the residents and their well-being.

Figure 2: Pioneering Projects of LivingLab by DOVISTA

Saint-Gobain Isover Scandinavia manufacturers glass wool insulation in Denmark and Sweden. Saint-Gobain Isover Scandinavia is part of the global Saint-Gobain Group based in France. Saint-Gobain was founded in 1665 and has 200,000 employees in more than 50 countries. In 2007, Saint-Gobain Isover Denmark initiated a development project, Comfort Houses, consisting of ten single-family houses with no heating systems and with an optimal indoor climate. The Comfort Houses are built in collaboration with architects, engineers, construction companies and manufacturers of building materials with the goal of spreading knowledge about buildings with passive

heating. Comfort Houses are a "living" example of how energy consumption can be reduced while maintaining a high level of home comfort (see Figure 3). Saint-Gobain Isover believes that Comfort Houses have the potential to set the agenda both for future construction and for the energy policy debate.

Figure 3: Pioneering Project "Comfort Houses" of Saint-Gobain Isover

4. Data collection

Three in-depth interviews with the employees of LivingLab by DOVISTA and Saint-Gobain Isover resulted in the development of the questionnaire, which was pre-tested and modified after responses from the group of employees. In total, 38 detailed questionnaires were designed and distributed to the employees of LivingLab and Isover. The result was a sample of 30 projects. The questionnaire included 58 single items and is reported in Appendix B. As previously mentioned and represented in Figure 1, the conceptual framework focuses on three main constructs: the interpreters involved in a Pioneering Project, the value of the Pioneering Project and the outcomes of the

Pioneering Project. The *exploration attitude* of the main interpreters (engineer, architect, and construction company) involved in each Pioneering Project is investigated by *Question 6*, which explores the trade-off between exploitative and explorative behaviours shown by interpreters during the development of the Pioneering Project (see Appendix B). The *knowledge diversity* is measured by the number of Kompass codes that characterise each interpreter. Kompass is a comprehensive B2B database, with more than 3 million international and domestic companies listed, that links buyers and sellers worldwide. The Kompass classification, containing more than 57,000 Kompass Classification Codes, has been developed over the past 60 years. Recently revised, it is now standardised worldwide and provides users the opportunity to develop projects for different product categories and allows the companies to gain more experience and knowledge. As demonstrated by several studies, the exchange of technologies and languages enables innovative solutions (Hargadon and Sutton, 1997; Hargadon, 1998; Verganti, 2003). The construct *value* synthetically represents the contribution provided by interpreters involved in the Pioneering Project. *Question 7* investigates different typologies of contribution that each interpreter can provide using a Likert scale from 1 to 5 (see Appendix B). The *value* is operationalised as the average contribution provided by each interpreter. Finally, considering that the objectives of a Pioneering Project can be multi-faceted, *question 8* rates from 1 to 5 several performances along which a Pioneering Project can be evaluated: new applications (items A, B, C), exposure (items D, E, F) and influence (items G, H, I) (see Appendix B). Finally, we introduce the number of man-hours scheduled by LivingLab for the development of the entire Pioneering Project as a control variable. Table 1 reports descriptive statistics for all the variables.

Variable	N	Mean	Std Dev	Min	Max
Exploration attitude - Engineer	30	34.2 %	28.3 %	0.0 %	100.0 %
Exploration attitude - Architect	30	42.8 %	28.3 %	0.0 %	100.0 %
Exploration attitude - Construction company	30	35.2 %	30.1 %	0.0 %	100.0 %
Knowledge diversity - Engineer	30	21.0	30.5	1.0	121.0
Knowledge diversity - Architect	30	7.0	9.1	1.0	26.0
Knowledge diversity - Construction company	30	10.6	16.6	1.0	57.0
Collaboration value	30	2.8	1.0	1.0	4.7
New applications	30	3.5	1.4	1.0	5.0
Exposure	30	3.3	1.0	1.0	5.0
Influence	30	3.0	1.1	1.0	5.0
Number of man-hours	30	621.2	636.1	45.0	1,500.0

Table 1: Descriptive statistics

5. Results and discussion

This section is organised in two parts. First, we explore the effects of the interpreters' characteristics (*exploration attitude* and *knowledge diversity*) on the *collaboration value* of Pioneering Projects to verify hypotheses 1 and 2. Second, we analyse the relationships between *collaboration value* and outcomes (*new applications*, *exposure*, *and influence*) to discuss hypotheses 3, 4 and 5.

The impacts of exploration attitude (H1) and knowledge diversity (H2)

First, a factor analysis was conducted to reduce the variables. The extraction method used is the principal components analysis (Norusis, 1993), and the rotation method used is varimax with Kaiser normalisation. Table 2 shows the factor loadings, eigenvalues, variance explained, and Cronbach's alpha (Fullerton and McWatters, 2001) of *exploration attitude,* while Table 3 shows similar results to *knowledge diversity*. In the first case, the principal components split the *exploration attitude* according to two main knowledge domains: technologies and social aspects.

	Technical Exploration attitude	Social Exploration attitude

Exploration attitude - Engineer	0.885	
Exploration attitude - Architect		0.991
Exploration attitude - Construction company	0.872	
Eigenvalue	1.551	1.017
Variance explained	51.7%	33.9%
Cronbach's Alpha	0.705	-

(*) Extraction method: principal component analysis; rotation method: varimax with Kaiser normalisation; total variance explained: 85. 6%; n=30; coefficients below 0.5 were omitted to increase readability.

Table 2: Factory analysis about *Exploration attitude

In the second case, the principal components underline the capabilities demonstrated in the interaction with the client (front end) and characterise back-office activities (back end).

	Front end Knowledge diversity	Back end Knowledge diversity
Knowledge diversity - Engineer		0.997
Knowledge diversity - Architect	0.873	
Knowledge diversity - Construction company	0.876	
Eigenvalue	1.608	0.933
Variance explained	53.6%	31.1%
Cronbach's Alpha	0.702	-

(*) Extraction method: principal component analysis; rotation method: varimax with Kaiser normalisation; total variance explained: 84.7%; n=30; coefficients below 0.5 were omitted to increase readability.

Table 3: Factory analysis about *Knowledge diversity

We explored the relationships among the *exploration attitude*, *knowledge diversity* and *collaboration value* of the Pioneering Projects using a linear regression analysis (see Table 4). The empirical results completely support hypothesis 1: both *technical* and *social exploration attitude* positively influence the *collaboration value* of Pioneering Projects. Hypothesis 2 is partially supported by the empirical results; specifically, only *front-end knowledge diversity* affects *collaboration value*, while *back-end knowledge diversity* is not statistically significant.

In other words, while the exploration attitudes demonstrated by all interpreters significantly affect the knowledge asset developed through the Pioneering Projects,

only the knowledge diversity provided by architects and construction companies significantly influence the collaboration value. According to Geels (2004), dynamics in socio-technical systems involve a dynamic process of mutual adaptations and feedback between technology and the user (social) environment. Several studies underline the synergies and interactions between the evolution of technologies and the user (social) environment (sociology of technology (see Latour, 1987, 1991, 1992; Callon, 1991)), the social construction of technology (see e.g., Pinch and Bijker, 1987; Kline and Pinch, 1996; Bijker, 1995), and large-technical systems theory (see Hughes, 1983, 1987; Mayntz and Hughes, 1988; La Porte, 1991; Summerton, 1994). The empirical results show that collaboration with interpreters generates value by exploring both knowledge domains: technologies and the user (social) environment.

The empirical results indicate the appropriate mix that is able to generate *collaboration value* during the development of Pioneering Projects: the *exploration attitude* demonstrated by interpreters can be valorised by the *knowledge diversity* of the key interpreters that interact with the client (Architect and Construction Company). In other words, the explorative attitude of the interpreters increases the potential value of Pioneering Projects. However, these potentialities can be valorised and concretised only if the architect and the construction company enable new scenarios in selecting the appropriate implementation from a broad range of solutions from several knowledge and experience domains.

Front-end interpreters (architects and construction companies) that significantly contribute to the Pioneering Projects are those operating in different industries. Only by operating in different industries are they able to move technical solutions from one

industry to another, enabling innovations and providing a fundamental boost to the creativity of other interpreters. This specific empirical result is particularly aligned with a broad stream of literature that interprets architects as brokers of technologies and languages (Hargadon and Sutton, 1997; Hargadon, 1998; Verganti, 2008; Dell'Era and Verganti, 2010) and that provides additional insights about the role played by technology providers such as construction companies. As argued by Dell'Era et al. (2010), research on technologies allows products to embed the appropriate languages and consequently to design new scenarios. By providing several concrete solutions, construction companies free the creativity of architects and engineers from as many constraints as possible. Concept freedom is a critical factor in attracting the most talented architects and engineers. Just as an author does not worry about the typing and distribution technologies that record his/her thoughts and words, an architect or engineer should not have to worry about the production and distribution technologies through which he/she develops his/her ideas. To attract the most valuable architects, engineers and new talents, construction companies cannot focus only on a few technologies. They must enlarge their portfolios by rotating several technologies. Because the construction company recognises the strategic value of the new scenario proposed by the architect or the engineer, the company works to remove any technological constraints that might limit them.

	Dependent variable Collaboration value
Independent variables	
H1: Technical Exploration attitude	+ 0.254* (0.081)
H1: Social Exploration attitude	+ 0.494*** (0.135)
H2: Front-End Knowledge diversity	+ 0.266* (0.088)
H2: Back-End Knowledge diversity	+ 0.043 (0.127)
Control variable	

Number of man-hours	+ 0.729*** (0.133)
Adjusted R^2	0.592
F	9.400***
Number of observations	30

Standard errors in parentheses * p<0.1; **p<0.05; ***p<0.01

Table 4: Results of the Linear Regression Analysis for *Collaboration value*

Outcomes (H3, H4, H5) of Pioneering Projects

To explore hypotheses 3, 4 and 5, we focus on the relationships between *collaboration value* and three performances of Pioneering Projects: *new applications*, *exposure* and *influence*. Empirical results about the linear regression analyses reported in Table 5 support three hypotheses; specifically, the higher the value of the Pioneering Project, the higher the ability to identify new applications, expose the participants and influence current and new communities.

As previously mentioned and argued by Verganti (2009), Pioneering Projects offer an interesting setting for experimentation and are particularly well-suited to radical innovations because they are early versions of future innovations (e.g., sustainable houses) that will be used by real clients. As demonstrated by the empirical results, Pioneering Projects allow interpreters to develop new meanings of the future scenario (e.g., the way people will live in future sustainable houses). Pioneering Projects represent a unique opportunity to create and develop new knowledge in several directions. The projects support companies in the comprehension of existing technologies and in the identification of new potential applications. Furthermore, considering that Pioneering Projects are not only innovative in terms of specific technologies but also in relation to an entire system of applications with which specific technologies would interact, they also provide a real market context for the application.

Consequently they support the development of new possible markets. Pioneering Projects can influence future lifestyles and regulations. They (at least partially) anticipate the evolution of the larger market by proposing new visions. As argued by Stuart (2000), Pioneering Projects can be interpreted as signals conveying social status and recognition; interpreters use them to improve their reputation and brand perception. Moreover, Pioneering Projects are able to influence the diffusion of innovations, providing real applications that embody future scenarios. Interpreters can act as crucial gates (gatekeepers) that facilitate a firm's access to the design discourse or as bridges between different socio-cultural worlds and industries, facilitating the transfer of knowledge of meanings and languages among different contexts. In this sense, Pioneering Projects lead to exposure in the community and to potential new partners. They legitimise involved interpreters, allowing them to enter new elite circles and to become key nodes in their networks.

	Dependent variables		
	H3: New applications	H4: Exposure	H5: Influence
Independent variable			
Value	+ 0.336**	+ 0.487**	+ 0.596***
	(0.140)	(0.199)	(0.174)
Control variable			
Number of man-hours	+ 0.552***	- 0.383	+ 0.054
	(0.140)	(0.199)	(0.174)
Adjusted R^2	0.576	0.137*	0.345
F	20.675***	3.301	8.650***
Number of observations	30	30	30

Standard errors in parentheses * p<0.1; **p<0.05; ***p<0.01

Table 5: Results of the Linear Regression Analysis for performances (*New applications, Exposure, Influence*)

6. Conclusions

An ever-increasing standard of living is pushing companies to develop products and services that are not only profitable but also socially responsible. As argued in the rich literature stream about socio-technical systems (Carlsson and Stankiewicz, 1991; Geels, 2004), companies must design and develop socially and culturally responsible products. Sustainable housing represents an intriguing empirical setting that allows the investigation of processes that are able to support innovations that must be both profitable and socially responsible. Climate change provides a strong motivation for the development of sustainable houses, which radically redefines the meaning of houses and will change the future behaviour of households. Companies have shifted their focus towards sustainable innovation strategies and system innovation, which emphasise the development of radical innovations such as sustainable buildings. This change in strategic behaviour has resulted in the affiliation of special projects, referred to as Pioneering Projects, interpreted as a testing ground for experimentation, where unconventional, temporary partnerships of stakeholders from different industries unite in the development of real market applications.

The exploration attitude demonstrated by interpreters involved in the Pioneering Projects and the knowledge diversity provided by the architects and the construction companies positively affect the collaboration value of Pioneering Projects. This paper indicates the mix that is able to generate value during the development of Pioneering Projects. The exploration attitude demonstrated by those interpreters that care about both technological (engineers and construction companies) and social (architects) evolutions allows an increase in the potential value of Pioneering Projects; these potentialities can be valorised and concretised only if front-end interpreters who interact

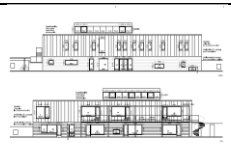
with the client (architects and construction companies) enable new scenarios by selecting the appropriate implementation from a broad range of solutions from several knowledge and experience domains. The higher the value of the Pioneering Project, the greater the ability to identify new applications and to influence current and new communities. Pioneering Projects offer an interesting setting for experimentation and are particularly well-suited to radical innovations for several reasons because they are early versions of future innovations that will be used by real clients. Pioneering Projects allow interpreters to interpret new meanings of future scenarios. Pioneering Projects can influence future lifestyles and regulations. They (at least partially) anticipate the evolution of the larger market by proposing new visions. Pioneering Projects send signals that convey social status and recognition, and interpreters use them to improve their reputations and brand perceptions. Moreover, they are able to influence the diffusion of innovations by providing real applications that embody future scenarios. Pioneering Projects lead to exposure in the community and to potential new partners. They legitimise involved interpreters by allowing them to enter new elite circles and become key nodes in their networks.

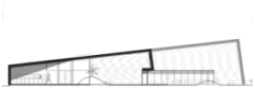
The investigation leaves several gaps that will require further research. First, it focuses on Pioneering Projects developed in the sustainable housing industry; it could be of particular interest to verify the validity of our results in industries where end-users can proactively contribute to the innovation. The concept of Living Labs[ii] is an emerging and rapidly diffusing phenomenon, as demonstrated by the growth of one of its main associations, the European Network of Living Labs (ENoLL, www.openlivinglabs.eu). Living Labs share the following two primary elements and consequently they represent an interesting empirical setting in order to extend our results: i) a real-life test and

experimentation environment and ii) users who are aware that they are co-involved in the innovation process. Also the operationalization of some constructs can be further improved: for example the exposure performance can be approximated by taking into consideration the presence on specialized magazines. Finally it could be intriguing to enrich the conceptual framework by also evaluating the impacts of pioneering projects on competitive performance such as market share and revenues.

Appendix A: Description of the Pioneering Projects

LIVING by DOVISTA Lab

Picture	Project name & code	Short description of the project	Finished	Picture	Project name & code	Short description of the project	Finished
	**Hyldespjældet Project 1**	Low-energy (class 1) refurbishment of a single-family house with the objective to test a new product.	December 2009		**Green Lighthouse Project 6**	The construction of a low-energy (class 1) business building with the objective to test a new product.	October 2009
	**Energy Flexhouse Project 2**	The construction of an active single-family house with the objective to test a new product.	September 2009		**Sun lighthouse Project 9**	The construction of an active single-family house with the objective to test an existing product.	October 2010
	**Solar Aktivhouse Project 3**	The construction of an active single-family house with the objective to test a new product.	September 2009		**Lind & Risør 1 Project 10**	The construction of a passive single-family house with the objective to test a new product.	November 2009
	**Energi Bo Project 4**	The construction of a low-energy (class 1) business building with the objective to test a new product.	December 2009		**Nursery Albertslund Project 11**	The construction of an institution under passive house standards with the objective to test an existing product.	February 2010

	**Home for Life Project 5**	The construction of an active single-family house with the objective to test a new product.	April 2009		**Kirsebærhaven Project 12**	Refurbishment of a single-family house under passive house standards with the objective to test an existing product.	January 2010
	**Brorsonvej Project 13**	Refurbishment of a single-family house under passive house standards with the objective to test an existing product.	January 2010		**Kildebjerg Project 25**	The construction of an active single-family house with the objective to test a new product.	Maj 2010
	**Nursery Active House Project 14**	The construction of an institution under active house standards with the objective to test an existing product.	March 2011		**Inbyg Project 26**	The construction of an active single-family house with the objective to test a new product.	June 2010
	**EUC Nord Passive-School Project 16**	The construction and refurbishment of an institution under passive house standards with the objective to test an existing product.	August 2010		**Passiv School Project 27**	The construction and refurbishment of an institution under passive house standards with the objective to test an existing product.	May 2010
	**Rind & Risør 2 Project 22**	The construction of a passive single-family house with the objective to test a new product.	May 2011		**Vordingborg Low-Energy Project 28**	The construction of a low-energy (class 0) single-family house with the objective to test a new product.	July 2010

	**JJW Wissenberg Huset Project 23**	The construction of a passive single-family house with the objective to test a new product.	September 2010		**KAB House Project 29**	The construction of a low-energy (class 0) single-family house with the objective to test a new product.	April 2010
	**Interbyg Project 24**	The construction of a low-energy (class 1) single-family house with the objective to test a new product.	February 2010				

Picture	Project name & code	Short description of the project	Finished	Picture	Project name & code	Short description of the project	Finished
	**Stenagervænget 12 Project 1**	The construction of a passive single-family house with the objective to test an existing product.	Finished August 2008		**Stenagervænget 45 Project 7**	The construction of a passive single-family house with the objective to test an existing product.	Finished November 2008
	**Stenagervænget 28 Project 2**	The construction of a passive single-family house with the objective to test an existing product.	Finished September 2008		**Stenagervænget 47 Project 8**	The construction of a passive single-family house with the objective to test an existing product.	Finished August 2008

	**Stenagervænget 37 Project 3**	The construction of a passive single-family house with the objective to test an existing product.	Finished August 2008		**Stenagervænget 49 Project 9**	The construction of a passive single-family house with the objective to test an existing product.	Finished October 2008
	**Stenagervænget 39 Project 4**	The construction of a passive single-family house with the objective to test an existing product.	Finished August 2008		**Stenagervænget 51 Project 10**	The construction of a passive single-family house with the objective to test an existing product.	Finished October 2010
	**Stenagervænget 43 Project 6**	The construction of a passive single-family house with the objective to test an existing product.	Finished October 2008				

Appendix B: Questionnaire

Pioneering project (name and code):

1. What is the status of the pioneering project?

- ☐ **On-Going**
- ☐ **Finished**
- ☐ **Stand-by**

2. Current phase of the pioneering project:

- ☐ **Concept Generation**
- ☐ **Development (production)**
- ☐ **Execution (Test & evaluation – end of project)**
- ☐ **Ramp-Up (Test & User feedback – end of feedback)**

3. Relevant milestones

Milestone	**Date**
Startup	
Expected deadline	
Actual deadline	

4. Costs

Budget number of hours planned by LivingLab for the entire pioneering project	
Actual number of hours spent by LivingLab on the pioneering project	

5. State the names of engineer, architect, construction company, owner involved in the pioneering project. Please state also the name of other participants, who have provided valuable insights for the pioneering project.

Participant	**Name**
Engineer	
Architect	
Construction company	
Other 1:	
Other 2:	

6. Evaluate the attitude demonstrated by each participant.

	Proposed solution was incremental in comparison to previous projects	**Proposed solution was unexpected and particularly radical**	**Total**
Engineer			100 %
Architect			100 %
Construction company			100 %
Other 1:			100 %
Other 2:			100 %

7. Evaluate the contribution provided by each participant in relation to the following aspects.
(1-very low, 2-low, 3-moderate, 4-high, 5-very high)

Engineer provided		**1**	**2**	**3**	**4**	**5**
A	New knowledge about our technologies					
B	New knowledge about market evolutions					
C	Innovative approaches towards sustainable housing					
D	Access to new knowledge domains					
E	Access to new communication channels					

Architect provided		**1**	**2**	**3**	**4**	**5**
A	New knowledge about our technologies					
B	New knowledge about market evolutions					
C	Innovative approaches towards sustainable housing					
D	Access to new knowledge domains					
E	Access to new communication channels					
Construction company provided		**1**	**2**	**3**	**4**	**5**
A	New knowledge about our technologies					
B	New knowledge about market evolutions					
C	Innovative approaches towards sustainable housing					
D	Access to new knowledge domains					
E	Access to new communication channels					
Other participant 1 provided		**1**	**2**	**3**	**4**	**5**
A	New knowledge about our technologies					
B	New knowledge about market evolutions					
C	Innovative approaches towards sustainable housing					
D	Access to new knowledge domains					
E	Access to new communication channels					
Other participant 2 provided		**1**	**2**	**3**	**4**	**5**
A	New knowledge about our technologies					
B	New knowledge about market evolutions					
C	Innovative approaches towards sustainable housing					
D	Access to new knowledge domains					
E	Access to new communication channels					

8. Rate your agreement with the following statements about the performance of the project.
(1-completely disagree, 2-disagree, 3-neither disagree or agree, 4-agree, 5-completely agree)

		1	**2**	**3**	**4**	**5**
A	The pioneering project increased our understanding about existing technologies					
B	The pioneering project allowed us to identify new applications of existing technologies					
C	The pioneering project allowed us to identify new possible applications based on new technologies					
D	The pioneering project attracted a lot of attention from media					
E	The pioneering project allowed us to increase our exposure in the community					
F	The pioneering project increased our brand perception					
G	The pioneering project influenced local governments and emerging legislations					
H	The pioneering project allowed us to enlarge our network attracting new partners					
I	The pioneering project allowed us to enter into "new communities"					

Acknowledgements

The authors would like to acknowledge all the practitioners who collaborated with us during the in-field data-gathering process. Any mistakes or omissions are the sole responsibility of the authors. Financial support from the Lombardy Region fund “Dote Ricercatori e della Dote Ricerca Applicata per lo sviluppo del capitale umano nel sistema universitario lombardo” is also gratefully acknowledged.

References

Ahuja, G. and Lampert, C.M. (2001). Entrepreneurship in the large corporation: A longitudianl study of how established firms create breakthrough inventions. *Strategic Management Journal*, **22**, 521-543.

Argote, L. and Ingram, P. (2000). Knowledge Transfer: A Basis for Competitive Advantage in Firms. *Organizational Behavior and Human Decision Processes*, **82**, 150-169.

Argote, L., McEvily, B. and Reagans, R. (2003). Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes. *Management Science*, **49**, 571-582.

Argyris, C. and Schon, D. (2007). Organizational Learning. *Bloomsbury Business Library - Management Library*, **78**.

Baum, J.A.C., Calabrese, T. and Silverman, B.S. (2000). Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal*, **21,** 267.

Bidault, F. and Cummings, T. (1994). Innovtion through alliances: Expectations and limitations. *R&D Management*, **24**, 33-45.

Burt, R. (1992). *Structural Holes: The Social Structure of Competition*. Cambridges, MA: Harvard University Press.

Cox, J. and Blake, S. (1991). Managing cultural diversity: implications for organizational competitiveness. *Executive (19389779)*, **5**, 45-56.

Dell'Era, C and Verganti, R (2009). Design-driven laboratories: organization and strategy of laboratories specialized in the deveopment of radical design-driven innovations. *R&D Management*, **39**, No. 1.

Dell'Era, C and Verganti, R (2010). Collaborative Strategies in Design-Intensive Industries: Knowledge Diversity and Innovation. *Long Range Planning*, **43**, Pp. 123-141.

Dell'Era, C, Marchesi, A and Verganti, R (2010). Mastering technologies in design-driven innovation. *Research-Technology Management*, March-April 2010.

Duysters, G. and De Man, A. (2003). Transitory alliances: an instrument for surviving turbulent industries? *R&D Management*, **33**, 49-58.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal*, 19**,** 293.

Hakansson, H. and Laage-Hellman, J. (1984). Developing a Network R&D Strategy. *Journal of Product Innovation Management*, **1**, 224-237.

Hargadon, A. and Sutton, R.I. (1997). Technology Brokering and Innovation in a Product Development Firm. *Administrative Science Quarterly*, **42**, 716-749.

Hargadon, A.B. (1998). Firms As Knowledge Brokers: LESSONS IN PURSUING CONTINUOUS INNOVATION. *California Management Review*, **40**, 209-227.

Haunschild, P.R. and Sullivan, B.N. (2002). Learning from Complexity: Effects of Prior Accidents and Incidents on Airlines' Learning. *Administrative Science Quarterly*, **47**, 609-643.

Iles, P. and Hayers, P.K. (1997). Managing diversity in transnational project teams. *Journal of Managerial Psychology*, **12**, 95.

Khanna, T., Gulati, R. and Nohria, N. (1998). The dynamics of learning alliances: Competition, Cooperation, and Relative Scope. *Strategic Management Journal*, **19**, 193-210.

Koza, M.P. and Lewin, A.Y. (1999). The Coevolution of Network Alliances: A Longitudinal Analysis of an International Professional Service Network. *Organization Science*, **10**, 638-653.

Lavie, D., Kang, J., and Rosenkopf, L. (2009). The performance effects of balancing exploration and exploitation within and across alliance domains. *Academy of Management Annual Meeting Proceedings*, 1-6.

Li, S.X. and Rowley, T.J. (2000). Is it better to be talented, popular or nice? The role of experiential and non-experiential information in interorganizational partner selection. pp. O1-O6. *Academy of Management*

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, **2**, 71-87.

McEvily, B. and Zaheer, A. (1999). Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, **20**, 1133-1156.

Ornetzeder, M. and Rohracher, H. (2006). User-led innovation and participation processes: lessons from sustainable energy technologies. *Energy Policy*, **34**, 138-150.

Richard, O.C. and Shelor, R.M. (2002). Linking top management team age heterogeneity to firm performance: juxtaposing two mid-range theories. *International Journal of Human Resource Management*, **13**, 958-974.

Rodan, S. and Galunic, C. (2004). More than network structure: How knowledge heterogeneity influence managerial performance and innovativeness. *Strategic Management Journal*, **25**, 541-562.

Rothmaerler, F.T. and Deeds, D.L. (2004). Exploration and exploitation alliances in biotechnology: a system of new product development. *Strategic Management Journal*, **25**, 201-221.

Stuart, T.E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation. *Strategic Management Journal*, **21**, 791.

Verganti, R. (2003). Design as brokering of languages: Innovation strategies in Italian firms. *Design Management Journal (10457194)*, **14**, 34-42.

Verganti, R. (2006). Innovating Through DESIGN. *Harvard Business Review*, **84**, 114-122.

Verganti, R. (2008). Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda. *Journal of Product Innovation Management*, **25**, 436-456.

Verganti, R. (2009). Design-Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean. *Harvard Business School Press Books*

VKR Holding A/S (2011). VKR Holding Homepage.

[i] "Home for life" is one of the 20 Pioneering Projects of DOVISTA. The building looks similar to a traditional single-family house. The idea behind Home for Life is to combine the parameters of energy, comfort and visual appeal into a holistic entity. The look and feel of Home for Life is an interpretation of the archetypical residence as a futuristic 'energy machine' that interacts with nature and the life lived inside it. The total energy consumption of Home for Life is minimized and covered by renewable and CO2-neutral energy generated in the building itself. After approximately 30 years, the surplus energy is equivalent to the amount of energy represented by the materials from which the house is built. A primary parameter in the energy design is the fenestration, positioned to cater to energy technology and visual appeal, which optimizes light, air and heat intake.

[ii] Please notice that DOVISTA's business unit LivingLab is not identical or a part of the European Network of Living Labs (ENoLL).