Paper to be presented at the

35th DRUID Celebration Conference 2013, Barcelona, Spain, June 17-19

The impact of organizational knowledge integrators on innovative R&D projects

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Abstract

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Jelcodes:M19,Z00

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Keywords: Organizational knowledge integrator, innovative performance, R&D projects, and mixed method research

Introduction
Innovative R&D projects are a risky business. Under circumstances of high uncertainty, it makes sense to ask: What can be done to reduce uncertainty and increase the innovative outcome of the project? In R&D projects the aim is to develop new solutions and innovation, and the process frequently takes place across internal and external boundaries of organizations. The exchange of knowledge is one of the main incentives in R&D partnership projects, where different partners can gain knowledge from each other and generate new knowledge and innovation together. Knowledge integration in inter-organizational partnerships is of great importance for innovative projects (Berggren, 2011, Enberg et al., 2010, Kogut, 2000, Tiwana, 2008). In spite of this, the role of organizational knowledge integrators in R&D projects in terms of innovative performance is poorly understood.

The objective of this paper is to examine if a specific partner such as an organizational knowledge integrator can contribute to innovative performance. The analysis is conducted from an organizational perspective and at project level. *An organizational knowledge integrators is an actor, who have a specific interest, due to their position in the innovation value chain and the technology stage, in pulling the knowledge from earlier phases of development closer to their own domain and ultimately toward commercialization*. The knowledge integrator may be driven by using the output from the R&D project in own innovation activities.

The central assertion of this paper is that knowledge integrators will have a positive effect on innovation performance for three reasons. First, if knowledge integrators find the scope of an R&D project relevant and interesting, they have an interest in pulling the knowledge from one technological phase to the next, e.g. from basic to applied research with the aim of using the knowledge. Furthermore, by carrying the knowledge to the next phase, they have an incentive to finish the projects successfully and implement them as fast as possible. Second, prior research has shown that knowledge integrators are part of R&D projects, and involving a knowledge integrator has an impact on the funding, partner construction, and exploration (Bulathsinhala and Knudsen, 2012). Finally, a knowledge broker (Hargadon, 1998) and an organizational knowledge integrator might have similar aspects in common, but the paper aims to examine the differences of the roles they play in regard to innovative performance in collaborative R&D projects.

This leads to the research questions:

Do R&D projects embodying a knowledge integrator experience significantly higher innovative performance compared to R&D projects that do not incorporate a knowledge integrator?

Is there a significant difference between the innovative performance of R&D projects incorporating knowledge brokers and knowledge integrators, respectively?

The study examines the impact of organizational knowledge integrators on innovative performance by combining a quantitative empirical analysis with qualitative data from interviews and email correspondence. The empirical sample includes 401 projects from a public energy program that supports R&D projects developing environmentally friendly technologies like wave energy and solar energy. The R&D projects can encompass different types of partners, from universities to private companies, and together they formulate a common project and apply for funding. To supplement the econometric results, in-depth qualitative interviews, evaluation documents, and email correspondence were obtained from research coordinators, evaluating experts, and project managers. The use of the mixed method methodology provides an examination of the research question from different perspectives. It documents how knowledge integrators affect innovative performance and shows the complexity of involving a knowledge integrator in an R&D project and why they are involved. Using the mixed method approach can provide stronger evidence for the existence of knowledge integrators and produce more complete knowledge about how they contribute to innovation.

The approach of this paper builds on and extends previous literature in two ways. First, whereas Lindkvist et al. (2011) and Kraaijenbrink (2012) look at individuals in R&D projects, this paper focuses on partners on an organizational level in R&D partnership projects. R&D projects can involve different organizational partners, from public research institutes to private companies. Second, Laursen and Salter (2006) studied the breadth and depth of collaboration and found that the use of external sources is inverted u-shaped in terms of innovative performance. This paper aims to discover that innovative performance is not only about the breadth and depth of external partners, but also that the involvement of the right partners may affect innovative performance. Involving different external sources in R&D projects might benefit the project, but the goal of this paper is to uncover the partner who has the relevant knowledge and essential capabilities to propel R&D projects in regard to innovative performance.

The theoretical contribution of the paper is twofold. The results show that knowledge integrators have a significant impact on innovation performance in regard to new technology, scientific publications, innovative technology, and new research. As argued in the existing literature on inter-organizational partnerships, partnerships with external partners can have a positive impact on innovative performance (Cook and Brown, 1999), but this paper clarifies that it is important for innovation to incorporate the right kind of partner, such as the knowledge integrator. In an R&D partnership project the different partners can hold different roles, such as central connector, boundary spanner, expert, etc. (Cross and Prusak, 2002). This paper argues that the knowledge integrator is an important role for a partner to acquire in regard to innovation. The second theoretical contribution is to the knowledge integration literature. There is not much attention on knowledge integrators on an organizational level, and the existing literature advocates knowledge integrators on an individual level (Andersson and Berggren, 2011). Exploring knowledge integrators on an organizational level enhances the understanding of how knowledge is transferred from one stage to another and how knowledge integrators in R&D partnership projects affect innovative performance. The following section outlines prior research on R&D partnerships and knowledge integration and sets up hypotheses that will be examined empirically, first quantitatively and then qualitatively.

Conceptual background

The process of developing a technology towards an innovation is a recursive process through which firms source the knowledge they need to undertake innovation, this process comprises the innovation value chain (Roper et al., 2008). The cornerstones of such processes is therefore not only the development of the actual parts and components in technological solutions, but also the sharing of insights, experiences and non-viable paths across involved actors and not least across projects in the innovation value chain.

Innovative partnerships have been broadly researched (Ahuja, 2000, Gulati, 1998, Child and Faulkner, 1998, Hagedoorn, 2002), and the research has provided useful insights into the complexity and tendencies in R&D collaborations. This paper refers to R&D partnerships as a specific form of inter-organizational partnership, where two or more organizations collaborate on an R&D project and the independent economic organizations share and exchange some of their R&D activities, knowledge, and expertise. The R&D partnerships in this paper are related to contractual partnerships and joint development agreements, primarily because they apply for public funding to carry out the project. In this paper an R&D project is referred to as "the standard research and development activity devoted to increasing scientific or technical knowledge and the application of that knowledge to the creation of new and improved products and processes" (Hagedoorn, 2002:477).

The focus on the integration of knowledge from different partners in R&D partnership projects reflects a wider trend in studies of innovation, suggesting that partnerships between different actors can play an important role in shaping innovation. A recent example of research on collaborative partnerships concerning innovation is knowledge integration (Berggren, 2011). However, knowledge integration as a concept is very broad, from an internal firm perspective to an inter-organizational perspective. Grant's focus (1996b, 1996a) on the knowledge integration concept is the core function of knowledge application and coordination within the firm. He stresses that the capabilities of a firm are related to how the firm effectively integrates specialist knowledge. Okhuysen and Eisenhardt (2002) distinguish between the knowledge integration process and knowledge integration. The knowledge integration process is the group members' actions with regard to sharing knowledge and generating new knowledge. Knowledge integration is the outcome of the group members' actions. The definitions of knowledge integration by Grant (1996b) and Okhuysen and Eisenhardt (2002) have in common that they relate to the firm level, whereas Tiwana (2008) provides a broader definition. He goes beyond the firm level and defines knowledge integration as a process of specialized knowledge held by various alliance partners at project level. Knowledge integration creates value through the knowledge of the alliance partners concerning specific project activities. The core of this definition is that knowledge from different partners creates innovation and creative accumulation. Creative accumulation is new knowledge based on existing knowledge (Granstrand, 1998, Bergek et al., 2011, Breschi et al., 2000), which is often seen in R&D projects, because the basis of R&D projects is to develop new knowledge/inventions based on existing knowledge (March, 1991). An example of knowledge integration with an innovation perspective are R&D projects in high-technology areas such as information and communication technologies (ICT) or energy technologies, where different partners can get together and apply for funding for a research program. E.g. the European Union's *Seventh Framework Programme* for research and technological development (FP7) is a seven-year program with a total budget of 53.2 billion Euros (2007-2013)[1]. Joint R&D partnership projects can apply for funding, and this encourages public and private organizations to do more external collaboration on a national and an international level.

Empirical context

The energy sector is characterized by research horizons of considerable length, size, and uncertainty. Hence, such projects require relatively large and financially demanding R&D projects, encompassing a number of different actors, often organized in large contract-based consortia. These actors are organizational project partners, and together most of them finance half of the amount of the project and then seek to supplement the funding with support from public (national or supernational level) energy programs. An example of this could be a project that seeks to develop a new technology for the production of sustainable energy. When an R&D project with such a mission has been formed, relevant partners often

1 http://cordis.europa.eu/fp7/understand_en.html

include universities with the most recent and front-end knowledge of the technology, different suppliers of equipment, and electricity companies, which in the end will use the technology and implement the innovation in the energy system. Especially in the energy field, public research programs have a substantial impact, since they help support research and development throughout the value chain, from basic research to demonstration (Borup et al., 2009).

The data employed in this paper is from Energinet.dk, who administers a number of environmentally friendly research programs for the purpose of supporting clean and environmentally friendly energy. The program called ForskEL is funded by public service obligation tariff. Energinet.dk is a transmission company owned by the Danish Ministry of Climate, Energy and Building.

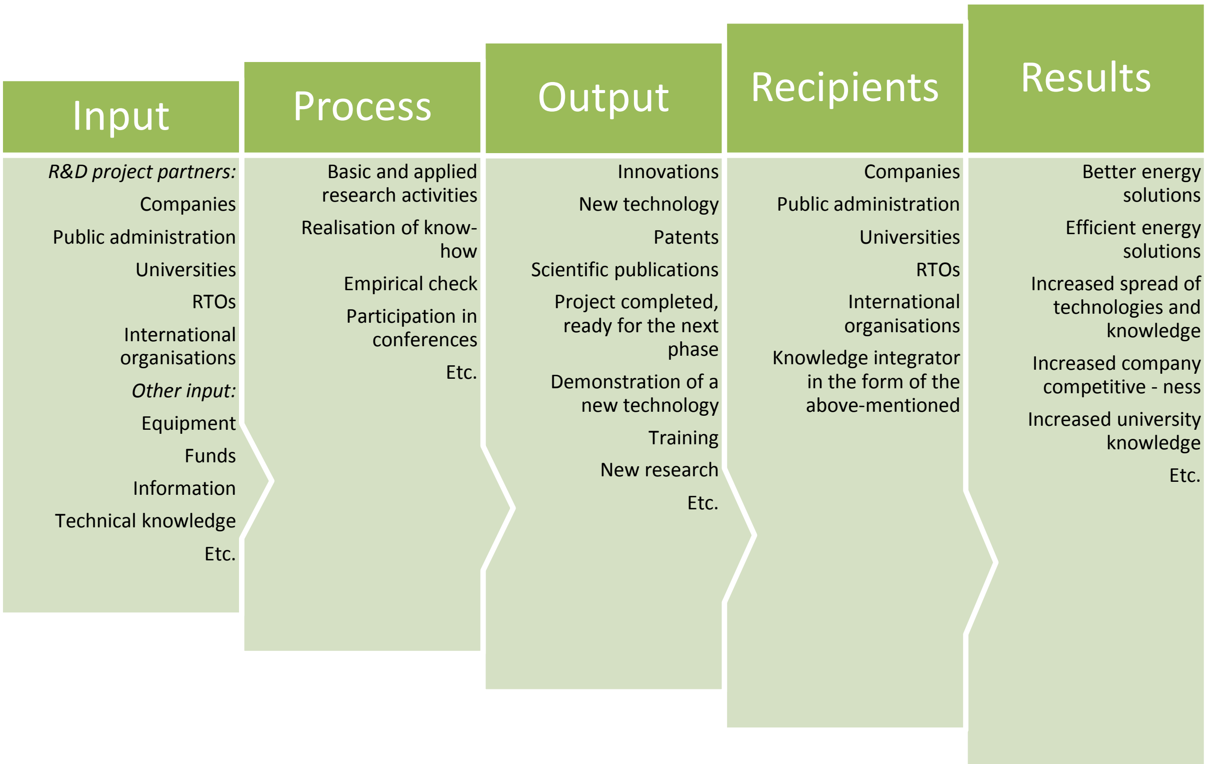

Figure 1: The development process of R&D projects. Adaptation from Coccia (2001)

Figure 1 illustrates the development process of an R&D project from start to end. It shows the different inputs that may establish an R&D project, from different partner combinations to funds and technical knowledge. After an R&D project has been constructed, the next step is the process of research and development. In this step, the knowledge is created, tested, and demonstrated. The third step is the output, which illustrates the different outputs of R&D projects. It could include R&D from radical to incremental innovation, or scientific publications etc. Step four illustrates the different recipients of the created output. A recipient could be a knowledge integrator in the form of a company, a university, etc. or simply a company that will use the created output. Step five illustrates a possible reason why R&D projects are created and funded by public research programs.

Who is the knowledge integrator?

An organizational knowledge integrators is an *actor, who have a specific interest, due to their position in the innovation value chain and the technology stage, in pulling the knowledge from earlier phases of development closer to their own domain and ultimately toward commercialization*. Knowledge integrators are driven by the goal of using the output from the R&D project in their own innovation activities. It is important to emphasize that the organizational knowledge integrator is the partner who will use the created knowledge. Knowledge integrators in R&D projects can be private companies and may differ across projects according to the project description and the project aim. Hence, a knowledge integrator may be of different partner types (suppliers or university, etc.), which of course makes it difficult to identify them in an empirical context.

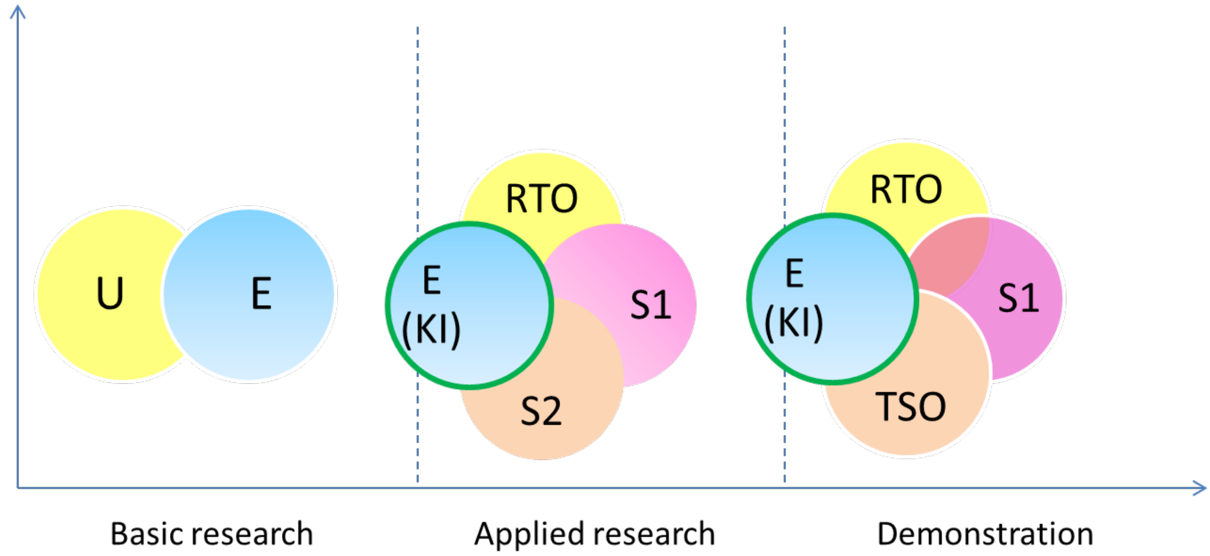

Figure 2: Technology development phase and knowledge integrators

From a process perspective, a technology can be developed from scratch, but most often a technology builds on previous knowledge from earlier R&D projects. As such a project often starts with basic research and over time, as the technology matures, it evolves to other technological phases, such as applied research and demonstration. A single project may therefore deal only with basic research or may span several phases. Importantly, a partner constellation and the specific project are considered completed once the project achieves its original aim, which is not necessarily equivalent to a technology.

Figure 2 illustrates a project that involves a university (U) and an energy company (E), which collaborate in the basic research phase; the energy company may eventually implement the innovation in a product or market-like situation. In other words, the energy company will use the created knowledge and has an interest in pushing the R&D project to meet their objectives. As the R&D project moves into the subsequent phase (e.g. applied research), other partners might be involved in the project, such as suppliers of components (S1 and S2) and an RTO[2]. Furthermore, as a partner that has an interest in bringing knowledge

[2] The literature often refers to Research and Technology Organizations (RTOs). The European organization for RTOs, EARTO, characterizes the role of an RTO as follows: "RTOs occupy nodal positions within innovation eco-systems, bringing together key players across the whole innovation chain, from fundamental to technological research, from

from basic research into the next phase, the energy company is also involved in the new R&D project. For that reason, the energy company becomes the knowledge integrator (E [KI]), which is symbolized by the green circle. Going from applied research to demonstration, new partners might join the project, such as a transmission company (TSO), and the knowledge integrator will take the knowledge from applied research to demonstration.

In this example the knowledge integrator is the same throughout the development process, but the knowledge integrator can change over time depending on the project goal and aim.

Development of hypotheses

The processes of integrating knowledge are driven by key actors in each project, and the complexity of these projects can be high due to the number of actors and their dependence on each other (Carlile and Rebentisch, 2003). In this paper these key actors are identified as organizational knowledge integrators. Bulathsinhala and Knudsen (2012) find that in R&D projects involving a knowledge integrator the likelihood of incorporating other external sources is high. This also supports the findings of Arora and Gambardella (1990), who show that innovation should be perceived as a network of organizational relations. Additionally, R&D projects involving a knowledge integrator have a tendency to receive more funding than projects that do not involve a knowledge integrator (Bulathsinhala and Knudsen, 2012). Research has shown that R&D financial intensity and innovative performance are positively linked (Deeds, 2001, Morbey, 1988). Therefore, one may argue that projects with a large amount of funding and which incorporate a knowledge integrator might have a positive innovative performance. R&D projects incorporating a knowledge integrator might also contribute to new technology; because projects which have a large budget and incorporate a knowledge integrator might afford to test new combinations. At the same time, new technology leads to new research, and it can be argued that R&D projects with a knowledge integrator produce knowledge that is new to the scientific world. Therefore, the following is hypothesized:

H1a: R&D projects incorporating an organizational knowledge integrator are more likely to develop new technology compared to projects that do not incorporate an organizational knowledge integrator.

H1b: R&D projects incorporating an organizational knowledge integrator are more likely to publish scientific publications compared to projects that do not incorporate an organizational knowledge integrator.

Research has shown that strong project leaders have a positive effect on the performance of an R&D project (Keller, 1992, Waldman and Atwater, 1994). They have a central role in ensuring the development process, and they drive the project from one stage to another (Cooper, 1990). The definition of an organizational project leader is an organization that has direct access to and responsibility for the work of all those involved. Knowledge integrators can be a part of a project with many partners. But being a partner in a project and being a project leader are two different things. When a partner is included in a project, the role of the partner can differ depending on the purpose of the project. Partners can have different roles (Cross and Prusak, 2002). The organizational project leader can gain and lose a lot by being responsible for the project. Often, the project leader invests more than the other partners in the project and their drive for success can be different due to commitment. When knowledge integrators with monetary interests act as

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product and process development to prototyping and demonstration, and on to full-scale implementation in the public and private sectors" (www.earto.eu). In Denmark, RTOs are labeled GTS (**G**odkendt **T**eknologisk **S**ervice) for Approved Technological Service.

project leaders, they might be strongly motivated to produce output that is financial worthwhile and, thus, to bring the project into the next stage of development. The drive for creating the next new technology that can become a commercial success might result in R&D projects that develop innovative technologies, and these results might also affect future energy research. For that reason, one can argue that when a knowledge integrator acts as project leader the drive for success is larger than when the project leader is not a knowledge integrator.

H2a: When an organizational knowledge integrator acts as project leader, it is more likely that the project results in the development of an innovative technology compared to R&D projects where the project leader is not an organizational knowledge integrator.

H2b: *When an organizational knowledge integrator acts as project leader, it is more likely that the project results in the development of future research compared to R&D projects where the project leader is not an organizational knowledge integrator.*

A knowledge broker has the ability to mediate knowledge between entities (Hargadon, 1998, Gassmann et al., 2011). Therefore, one might argue that a *knowledge broker* is the same as an organizational knowledge integrator. But the difference between a knowledge integrator and a knowledge broker is that the knowledge broker facilitates the process, while the knowledge integrator is motivated by the process. Knowledge integrators will use the output from the R&D project in their own innovation activities. In the literature, Research and Technology Organizations (RTO) are often described as knowledge brokers. An RTO is an advanced technology group with a predefined role to bridge the knowledge gap between a research environment, e.g. a university, and industry. In a university and industry partnership, the knowledge broker could be an RTO that mediates between the two parties, the main task being to connect knowledge seekers to sources of knowledge in a given area (Dougherty, 1992). An RTO has the ability to understand both the academic perspective and the industrial view (Hoegl and Schulze, 2005, McEvily and Zaheer, 1999). The ability to mediate is also an important competence for a knowledge integrator. Knowledge integrators may also be able to communicate with the different partners in the R&D project, because they are the ones who will bring the knowledge into the next phase. Furthermore, knowledge brokers possess a function that might imply that they are neutral partners in R&D projects (Hoegl and Schulze, 2005), constructing a platform of knowledge exchange which might lead to positive innovative performance. Therefore, it is hypothesized that knowledge brokers have a positive effect on innovative technology and new research.

H3a: R&D projects incorporating a knowledge broker are more likely to result in an innovative technology compared to projects that do not incorporate a knowledge broker.

H3b: R&D projects incorporating a knowledge broker are more likely to result in energy research compared to projects that do not incorporate a knowledge broker.

Methodology

The methodology used in the study is both qualitative and quantitative, using the full applications submitted to the ForskEL program in Denmark and interviews with research coordinators, project managers and expert evaluators of the ForskEL program, respectively. The reason for using mixed method is triangulation: a process with the goal of assessing the same phenomenon using different methods (Jick, 1979) and methodological eclecticism (Tashakkori and Teddkie, 2010). By combining different methods it might contribute to a better corroboration of the results (Bryman, 2006). The quantitative data are used to identify the relationship between the knowledge integrator and performance, and the qualitative data provide deeper clarification of the quantitative results. By using a combination of survey data, in-depth qualitative interviews, written evaluation documents, and email correspondence, the analyses revealed different aspects of the knowledge integrator in the projects. This provides a better explanation of the statistical relationship between the variables and the underlying reasons of concepts, ensuring a valid analysis (Yauch and Steudel, 2003).

Empirical analysis of the quantitative study

Data collection

The highly reliable quantitative, longitudinal data used in this study consist of 401 funded R&D projects from 1988 to 2008. The data, therefore, consist of all the applications that were submitted under the Public Service Obligation program in its 10-year lifetime. The data set was compiled in 2008 by the energy program with the purpose of evaluating the program and the funded projects. The aim of the data set was to provide a comprehensive overview of all the projects. The list of projects has not been updated subsequently. The projects funded by Energinet.dk from 1988 to 2008 can be divided into energy areas such as biomass, wind energy, fuel cells, solar cells, wave energy, fossil fuel, smart grid, etc.

There is a possibility that the data used in the analysis suffer from selection bias. The sample selection model in this paper only includes funded projects and not non-funded projects. The selection of R&D projects has first of all gone through a detailed process, where the projects had to meet a great amount of criteria provided by the program. Second, the evaluation part of the project application process was conducted by experts, and projects with a high evaluation score received funding. It was not possible to compare the group of funded projects with the group of non-funded projects, but it was possible to test if there was a difference between the funded R&D projects with performance measures compared to R&D projects with non-performance measures. It was tested whether there was a significant difference between the two samples and their distribution of main characteristics, such as knowledge integrator, project duration, size, and energy areas such as solar energy, wind energy, and fuel cell energy. There was no statistically significant difference between these groups, except for wind energy. However, the correlation between projects in the area of wind energy and the independent variables is very low, suggesting that even though the two samples differ on projects in the area of wind, they do not differ in terms of the independent variables used in the study.

Dependent variable: Innovative performance

Success in R&D projects is difficult to define, as it involves a number of measures (Balachandra and Friar, 1997). But when examining R&D projects that are not yet on the market and thereby commercial, it can be more complex to measure the performance of R&D projects. Innovative performance can be to distinguish between project success (measured against the overall objectives of the project) and project management success (measured against the widespread and traditional measures of performance, such as cost, time, and quality) (de Wit, 1988, Cooke-Davies, 2002). R&D projects can go through a process where the project management was successful, but where the output of the projects was a failure, and vice versa. Therefore, we have chosen to examine innovative performance from a project management perspective and a technology perspective. When an R&D project at ForskEL is completed, the energy program demands a report that illustrates the result of the project. If the project does not send an end report to the energy program, a relatively large amount of the funding is withheld. The energy program also demands that the results are made public. The end reports are evaluated by an expert evaluator, who writes a document explaining his or her professional opinion about the project. These expert statements do not follow a particular format or look for particular issues. Rather, the content is decided by the evaluator alone. This document is returned to the energy program. It is important to emphasize that not all projects in the data collection have an end report. E.g. for relatively small projects with good contact/communication with the energy program during the project process no end report was required to validate the project.

The dependent variable was created in corporation with an evaluator and a research coordinator from the energy program. To evaluate if a project is a success or not can be rather complicated for projects that are in the early technology development phases, like e.g. the research phase. The energy program that supports the R&D projects is aware of the high risk of project failure due to the technological complexity in the projects. The goal for the energy program is therefore not that all projects should be successful, resulting in specific technologies. Some projects are initiated e.g. for the sake of testing particular ideas; hence, the aim of the program is also to support high-risk projects. The research therefore discussed the success of such projects with the actors involved in the program. As a result, a small survey was conducted, questioning the project management and technological complexity. Examples of questions in the survey are: *To what degree did the project live up to the application goals? Do you think that the overall project management in this project is a success? To what degree does the project meet its technical goal?* Other questions were included; e.g. whether any PhD projects were connected to the projects, and whether the project resulted in academic publications. In this way, it was possible to generate a set of measures for assessing the innovative performance of the individual project. The survey was subsequently sent to experts evaluating the technological performance of energy projects.

The data set consists of 135 end reports, carried out by 27 different evaluators. 20 evaluators agreed to participate in the survey, which resulted in a response rate of 74.0 %. In the process, the end report of the expert evaluator and a copy of the survey for each report were sent to the expert evaluators by email. The evaluator was requested to evaluate the end reports again and then fill in a questionnaire for each project they had previously evaluated. 105 surveys were returned, resulting in a response rate of 77.7 %. Four questions were tested as dependent variables.

New technology

The question in the survey was the following: *Did the project develop a new technology?* A new technology means a technology that is new, e.g. a new filter solution for cleansing the pollution from coal power. The variable used in the analysis is a dichotomous variable, yes (1)/no (0). This variable detects whether the main purpose of an R&D project has been fulfilled by developing a new technology.

Publications

The question in the survey was the following: *Did the projects produce any publications?* The successful publication of scientific papers illustrates that the project produced scientific novelty and, hence, measures one dimension of innovative performance. The present variable is constructed by combining the results of the survey with publication information from the program. The study has registered 236 projects. The energy program has registered this information for 236 projects. The variable used in the analysis is a dichotomous variable, yes (1)/no (0). Publishing scientific papers in academic journals means that new technology/knowledge has been produced and that it is relevant for the scientific world.

Innovative technology

The question in the survey was the following: *To what extent is the created technology innovative?* There is a distinct difference between creating a new technology and the technology being innovative. An innovative technology can be a new energy technology, such as wave energy in a new format that has not yet been tested. The variable is an ordinal variable, scaled very high degree (5), high degree (4), average (3), low degree (2), and very low degree (1). The main purpose of R&D programs in the energy field is to create innovative energy solutions that can meet future climate demands.

Future energy research

The question in the survey was the following: *To what extent does the created technology affect future energy research?* This question measures if a project's results have an effect on future energy research. Thus, a further dimension of innovative performance is likewise whether the results of a project lead to the formulation of new projects or proposals. The variable is an ordinal variable, scaled very high degree (5), high degree (4), average (3), low degree (2), and very low degree (1). The energy programs have a long time horizon, which means that projects usually go through different phases of technology development. If a project's temporary results have importance for energy research, then the project is very likely to receive funding again and move into the next phase.

Dependent variables	**N**	**Min**	**Max**	**Mean**	**Std. deviation**
Did the project develop a new technology?	*104*	*0*	*1*	*.46*	*.501*
Did the project produce any publications?	*236*	*0*	*1*	*.45*	*.499*
To what extent is the created technology innovative?	*103*	*1*	*5*	*3.34*	*.966*
To what extent does the created technology affect future energy research?	*100*	*1*	*5*	*3.54*	*1.068*

Table 1: Descriptive statistics for the dependent variables

Independent variables

Knowledge integrator

One of the independent variables used is the knowledge integrator variable. The researcher engaged external experts to assist in identifying knowledge integrators on the basis of actor identities. As the names and addresses of all partners are provided in the application, the key challenge is primarily to identify in each phase of the project whether a particular partner is in fact an organizational knowledge integrator. To ensure the role was assigned to a credible candidate, the researcher developed a description of the knowledge integrator and carefully informed the experts about the particular conceptualization of knowledge integrators, before they coded each partner in each project application with either a 1 (for yes) or a 0 (for no). The researcher further crosschecked the coding of the first expert with the help of a second expert. This validation resulted in a revision of the coding on the basis of a discussion with each of the experts, in the cases where they disagreed about the coding. The experts are highly knowledgeable, not only about energy technologies; and one of the experts is especially experienced when it comes to this particular energy program (from which the applications are drawn). Today, this expert is still working in some of the technology areas underlying the projects. The expert therefore has the knowledge and expertise to evaluate if the knowledge integrator was in fact part of the projects. In total, the experts investigated 401 cases.

All the partners from the project applications were entered into a catalogue that further divided the partners into different groups (see *table 2* for descriptions). After coding each of the knowledge integrators in each project, the expert stated *who* the knowledge integrator was by applying the typology of knowledge integrators in the energy sector (*table 2*). The reason why the 15 categories were formed with such detail was to clarify the role of the knowledge integrator and to highlight the diverse nature of the knowledge integrators.

The identification of potential partners in the energy sector	**Description**
Suppliers of energy	This category includes companies that supply materials to energy production. Some of the companies can also produce electricity. Examples of companies are Shell and DONG Energy A/S.
Producers of energy (electricity and district heating)	The category includes producers of electricity and district heating. Examples of companies are EPZ Holland, Vattenfall A/S, Nordborg Kraftvarmeværk, etc. These companies produce electricity and district heating.
Transmission and distribution (energy companies – monopoly)	This category includes utilities and transmission companies. E.g. Energinet.dk is a transmission company, which owns the entire natural gas transmission system and the 400 kV electricity transmission system.
Trade and sales (energy companies)	National utilities are included in this category. They trade and sell electricity on the market. E.g. Dong Energy A/S.
Suppliers of plants and components	Companies in this category are different suppliers of components and plants. It can be anything from a national wind turbine producer to a local blacksmith shop.
Other private companies	This category includes companies that do not directly supply components, but their service is still beneficial to the projects. An example is Eurofins Steins Laboratorium A/S, which is authorized and accredited to perform analyses in agriculture, dairy, and food. Their services might be useful in biofuel projects.
Advisers and consultants	Advisers and consultants are incorporated in the projects to supply knowledge and expertise. The category includes normal consultant companies like Rambøll A/S as well as more specialized institutions with chemical expertise.
Universities and research institutions	The category includes national and international universities and research institutions.
RTO (Approved Technological Service institutes)	An RTO – Advanced Technology Service Institute – is a network consisting of nine independent Danish research and technology organizations. They support innovation and constitute the core of the technological infrastructure in Denmark.
Public authority	This category includes public institutions, like a municipality or the Danish Meteorological Institute (DMI) which provides meteorological information and forecasting in Denmark.
Politicians	Other national or international research programs are included in this category.
NGO (non-governmental organizations) and industry association	The category includes NGOs, but also industry associations that support the Danish energy industry.
Investors (funds etc.)	Investors like firms or funds that wish to support projects are included in the category.
Other research programs	Other national or international research programs are included in this category.
Households	This category includes household and end-users of electricity. Projects that are near market introduction can benefit from incorporating the end-users.

Table 2: Description of the different potential partners in the R&D projects

The descriptive results show that a knowledge integrator is involved in 62.0 % of the projects (*table 3*).

	Frequency	Percentage
No knowledge integrator in the project	151	38.0
A knowledge integrator in the project	246	62.0
Total	397	100.0

Table 3: Incorporation of the knowledge integrator

In 217 of the projects it was possible to identify who the knowledge integrator was. More than half of the knowledge integrators were producers of energy (56.7 %) (*table 4*). The producers of energy also have a more general role in the energy system, as they are the potential users of the final innovations created in the R&D projects. Suppliers of plants and components are also a group that is quite strongly represented (22.1 %).

Identification of knowledge integrators	Number	Percent
Suppliers of energy	2	0.9
Producers of energy (electricity and district heating)	123	56.7
Transmission and distribution (energy companies)	4	1.8
Trade and sales (energy companies)	11	5.0
Suppliers of plants and components	48	22.1
Other private companies	2	0.1
Advisers and consultants	9	4.1
Universities and research institutions	13	6.0
RTO (Approved Technological Service institutes)	3	1.3
NGO and industry association	1	0.5
Public authority	1	0.5
Total	217	99

Table 4: The total number of knowledge integrators divided into categories

Furthermore, table 5 shows how the different knowledge integrators are divided into technological phases. The number of knowledge integrators in the demonstration phase is limited compared to other phases (*table 5*). A knowledge integrator is involved in 66.7 % of the projects in the applied research phase, whereas this number is slightly lower (63.1 %) for the basic research phase. The demonstration phase may be less inclined to involve knowledge integrators, simply because these projects are represented by fewer partners (43.6 % of the demonstration phase projects only have one partner).

Presence of a knowledge integrator in the projects?	Basic research	Applied research	Demonstration	Total
No	31	68	45	144
	39.9 %	33.3 %	47.9 %	37.7 %
Yes	53	136	49	238
	63.1 %	66.7 %	52.1 %	62.3 %
Total	84	204	94	382
	100 %	100 %	100 %	100 %

Table 5: Use of knowledge integrators in different technological development phases

Knowledge integrator as project leader

The variable explains if a knowledge integrator is also the project leader in the main project. The variable used in the analysis is a dichotomous variable where a knowledge integrator is also a project leader (1), compared to R&D projects where the project leader is not a knowledge integrator (0). In 41.1 % of the R&D projects a knowledge integrator is the project leader of the project.

Knowledge broker (RTO)
As mentioned before, a Research and Technology Organization (RTO) can be a partner in a network that facilitates the R&D project and constitutes the core of the technological infrastructure. A knowledge broker is incorporated in 13 % of the R&D projects. The variable is a dichotomous variable.

Size (LN)
The full amount of financial resources used on R&D projects by Energinet.dk from 1988 to 2008 is divided into each energy area that has received funding through the years. The variable size of the energy area was calculated by summing up the amount of funding from each energy area and, thereafter, the percentage of each project's funding in the given area was calculated. The variable is a continuous variable, shown as a logarithm because the original variable was skewed.

Duration
Projects that started in 2005 or later are registered in the year the project applications announced the projects would be completed. The end year might be the factual year; if the projects experienced problems that could have caused delays, the end year might have been changed. The variable is dichotomous and covers 1-5 years (0) and 6-12 years (1). A reason why the variable was divided into a dichotomous variable was because the average duration of a project was 3.56 years.

Project leader
This variable explains who the project leader is: a private company, an RTO, or a university. The project leader is assumed to be the main responsible for a project, implying that he or she is the main organizer and applicant with regard to project management and financial resources. The variable used in the analysis is a dichotomous variable, where universities and RTOs (research institutes) constitute one group (0) and private companies another (1). In 73.2 % of the R&D projects a private company is the project leader.

Control variables
The control variables used in this paper are related to the technology areas specified in the application: wind energy, solar energy, and fuel cell energy. Further areas include biomass and fossil energy. Wind, solar, and fuel energy represent technologies in different stages of development and they are therefore included in the further analyses. Wind and solar energy represent relatively mature and commercial technologies, but Denmark has not focused as much on solar energy as it has on wind energy. Fuel cell energy is a relatively new technology that is still immature, compared to wind and solar energy.

Wind energy
Wind power represents the technologies that can convert wind energy into electricity through wind turbines. The variable is coded as a dichotomous variable that illustrates wind technology compared to other technologies (biomass, wave energy, wind energy, solar energy, biofuel, fossil energy, and smart grid). 17.1 % of the R&D projects are wind projects.

Solar energy
Solar energy is the conversion of sunlight into electricity through solar panels. The variable is coded as a dichotomous variable that illustrates solar technology compared to other technologies (biomass, wave

energy, wind energy, fuel cell, biofuel, fossil energy, and smart grid). 10.2 % of the projects are solar energy projects.

Fuel cell energy
Fuel cell technology is a conversion of chemical energy into electricity. Hydrogen is a common fuel, but other fuel sources such as natural gas and alcohol (e.g. methanol) are also used. Fuel cell technology is different from normal batteries, because it can continue to produce electricity if it is given a constant source of fuel and oxygen. The variable is coded as a dichotomous variable that illustrates fuel cell technology compared to other technologies (biomass, wave energy, wind energy, solar energy, biofuel, fossil energy, and smart grid). 11.7 % of the R&D projects are fuel cell energy projects.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. New technology	1	,012	.500**	.400**	,137	.204*	,000	-,093	-,007	.217*	-,064	-.216*	,087
2. Publications		1	,163	,108	,103	-,020	,040	,080	,076	-.212**	-,119	,006	-,099
3. Innovative technology			1	.688**	,005	,175	-.200*	,073	,036	,085	-,002	-.288**	,007
4. Future energy research				1	,049	.314**	-.272**	,005	.204*	,167	-.247*	-,115	,083
5. Knowledge integrators					1	.679**	,089	,009	.164**	.102*	,021	-,007	-,018
6. Knowledge integrator as project leader						1	,062	-,053	.230**	.367**	-,011	-,045	-,051
7. Knowledge broker (RTO)							1	,015	,040	-.186**	-,041	.139**	-.120*
8. Size LN								1	,068	-.123*	-,053	,078	.117*
9. Duration									1	,057	-,086	-,034	-.121*
10. Project leader										1	-,014	,000	-.104*
11. Wind energy											1	-.157**	-.168**
12. Solar energy												1	-.124*
13. Fuel cell energy													1

*Table 6: Correlation table (** correlation is significant at the 0.01 level [2-tailed], *correlation is significant at the 0.05 level [2-tailed])*

Qualitative study
The researcher personally interviewed 18 informants, employing a semi-structured interview technique to provide as wide a scope as possible for data collection in a structured way (Fontana and Frey, 1994). The interviews lasted approximately 60-90 minutes. After conducting the interviews, a relatively large amount of email correspondence was made with research coordinators, evaluators, and project managers about the final empirical results and clarifications. The knowledge integrator terminology was not used in the

interviews, but the role of the knowledge integrator was explained, and the wording used instead of *knowledge integrator* was e.g. *user of the technology* or *carrier of the technology*.

The interviews were immediately transcribed, and the transcript covered over 100 single-spaced pages.

Selection of respondents
The informants were selected based on their involvement in energy research programs. *Evaluators* are affiliated with the energy programs, and they are assigned by Energinet.dk to evaluate the projects, using their expertise in their particular field of expertise. They provide a thorough evaluation of the projects, which they later passed on to the research coordinators. *Research coordinators* are responsible for the administrative tasks in connection with the programs, and some of them participated in the evaluation of which projects to support. *Project managers* are applicants, who seek funding for their projects from the program. The project managers were also included, as these individuals are often the originators of the project ideas. Two of the project managers were university employees, and two of them were affiliated with private companies.

	The Energy Technology Development and Demonstration Program (EUDP)	**ForskEL**	**Elforsk**	**The Danish National Advanced Technology Foundation (DNATF)**	**The Danish Council for Strategic Research (DSF)**	**Evaluators**	**Project managers**
	Research coordinators						
Actual number of persons	7	5	2	4	3	52	28[3]
Interviewed persons	2	2	1	1	1	7	4

Table 7: The number of interviews in the article

Using a qualitative method can help to achieve a greater understanding of the processes involved in energy research, including its underlying factors, and it may support the interpretation of the quantitative results. The aim of the qualitative study was to understand why knowledge integrators might have an impact on innovative performance and to identify potential causes for the quantitative analysis.

Empirical sample results

Knowledge integrator and new technology
The purpose of this section is to show if the presence of knowledge integrators has an impact on the development of new technologies. The following section uses logistic regression to assess each of the dependent variables. First, projects differ, with regard to the development of new technologies, when they incorporate a knowledge integrator. The model has a good fit with a Nagelkerke R^2 at 0.191 and the significance level of the overall model at 0.026. The model includes knowledge integrator, size, and project leader. As control variables, the paper uses wind, solar, and fuel cell energy. The Hosmer & Lemeshow test is not significant, implying that the model is trustworthy.

[3] In 2010 there were 28 active project managers.

	New technology
Knowledge Integrator	.948**
Duration	-.541
Project leader	1.067**
Size LN	-.376
Solar energy	-2.214**
Fuel Cell energy	.219
Wind energy	-.362
Nagelkerke R2	.191
Cox & Snell R2	.143
-2 Log Likelihood	126.094[a]
Hosmer & Lemeshow	.602
Number of observations	103

Table 8: New technology (***p<.001, **p<.05, *p<.1)

The results show that if projects incorporate a knowledge integrator, the likelihood of the project developing a new technology increases, compared to projects that do not incorporate a knowledge integrator (supports *hypothesis H1a)*. The results also show that when a private company acts as the project leader, the likelihood of the project resulting in a new technology increases. Furthermore, the control variables are only significant for solar energy projects (negative). To sum up, R&D projects incorporating a knowledge integrator have a high probability of developing a new technology. Second, when a private company acts as project leader, the probability of an R&D project developing a new technology increases. Lastly, R&D projects in the area of solar energy have a high probability of not producing new technology.

Knowledge integrator and publications

The following is a logistic regression analysis (*table 9*), which tests whether a knowledge integrator has an effect on innovative performance measured as scientific publications. The model has a good fit with a Nagelkerke R^2 at 0.130 and the significance level of the overall model at 0.001. The model includes knowledge integrator, duration, and project leader. Since size LN did not have a significant effect in table 8, it has been excluded in the following regression. The control variables are wind, solar, and fuel cell energy. The Hosmer & Lemeshow test is not significant, implying that the model is trustworthy.

	Publications
Knowledge Integrator	.558*
Duration	.210
Project leader	-1.113***
Solar energy	-.285
Fuel cell energy	-1.107**
Wind energy	-1.014**
Nagelkerke R2	.130
Cox & Snell R2	.097
-2 Log Likelihood	298.320[a]
Hosmer & Lemeshow	.203
Number of observations	234

*Table 9: Innovative performance measured as publications (***p<.001, **p<.05, *p<.1)*

R&D projects incorporating a knowledge integrator have a higher likelihood of producing publications, compared to R&D projects that do not incorporate a knowledge integrator (supports *hypothesis H1b)*. On the other hand, the results show that when a private company acts as project leader, the likelihood of producing scientific publications decreases. The control variables are significant and negative for wind and fuel cell energy, implying that for projects in these energy areas the likelihood of producing scientific publications is very low.

Knowledge integrator as project leader

Two OLS regressions are used to test *hypotheses H2a and H3b (table 10)*. The VIF for all models are between 1.03 and 1.06, and mean VIF for all models are close to 1.00, which indicates that there is no problem with multicollinearity (Field, 2009). R^2 is 0.189 and 0.231, and the significance levels of ANOVA of the models are 0.013 and 0.000. The variables used in the regression are knowledge integrator, project leader, and knowledge broker (RTO). As control variables, the paper uses wind, solar, and fuel cell energy.

	Innovative technology	**Energy research**
Knowledge integrator as project leader	.213**	.303**
Knowledge broker (RTO)	-.210**	-.251**
Solar energy	-.225**	-.095
Fuel cell energy	-.041	-.031
Wind energy	.009	-.205**
N	100	98
R^2	.189	.231
Significance	.013	.000

*Table 10: Innovative performance and responsibility (***p<.001, **p<.05, *p<.1)*

The models indicate that knowledge integrator as project leader is positively related to the project creating an innovative technology (supports *hypothesis H2a)*. Contrary to expectation, there is a significant and negative relationship between the presence of a knowledge broker in the project and the resulting technology being innovative. This rejects *hypothesis H3a*. Once more, it should be noted that the control for solar energy is significant and negative, meaning that the likelihood of creating innovative technology in this area is low. Second, the relationship between a knowledge integrator as project leader and energy research is significant and positive (supports *hypothesis H2b)*. Furthermore, the relationship between knowledge brokers involved in an R&D project and energy research is significantly negative, thereby rejecting *hypothesis H2b*. The control for wind energy is significant and negative, strongly implying that for projects in the energy area the likelihood of producing results that may affect future energy research is low.

In summary, the empirical analyses find that R&D projects involving a knowledge integrator have a tendency to develop new technologies and publish more scientific articles, compared to projects that do not incorporate a knowledge integrator. Knowledge brokers have a negative impact on innovative technology and new energy research. Finally, when a knowledge integrator acts as project leader, the relationship between creating innovative technology and affecting new energy research is positive. An important, yet unanswered question is what can explain these empirical patterns? The following will present the qualitative findings.

Qualitative findings

Knowledge integrator and development of new technologies
The qualitative study finds that one reason why knowledge integrators have a positive impact on innovation performance through the development of new technologies is that they seem to hold an important role in the final (after development) implementation of the technology in the energy system. E.g. a research coordinator believes that it is crucial to have the relevant partners in the project, from the research community to the industry. But he also stresses that the recipient (knowledge integrator) of the technology must be a part of the project. He establishes that it is important to consider the entire value chain in a project, including the end-user of the technology. On the other hand, one project manager mentions that the problem with only having one knowledge integrator in a project is that innovation may end up being too specific and thus have only one "user" of the technology. A project manager points out that there are certain advantages of involving the knowledge integrator from the beginning of a project, a.d. in basic research.

"One advantage of having knowledge integrators in the project is that you from the start direct things to go in the right direction so that the development goes in a fruitful direction, but it can also hinder research by going the beaten path and thus does not discover new things."

When the project manager mentions the knowledge integrator, he mentions energy utilities, and when asked about knowledge integrators and their function in the project, the project manager answers:

"When we talk about projects that include the entire value chain, then it is natural that the user (knowledge integrator) is included. For project success, I think it's really good that you have close contact with the next link in the chain. I consider this as an important criterion for success."

Having a knowledge integrator involved in a project and having close contact with the next phase, bringing the knowledge from one phase to another, can affect innovative performance.

Knowledge integrator as project leader and innovative performance
Furthermore, one evaluator mentions that the advantage of having a knowledge integrator as project leader is that it is easier to implement the outcome in the next phase. As holders of the formal responsibility for the project, they can decide how, what, and when, and they thereby have the authority as well as a wish to end the project successfully. A disadvantage can be that projects become too focused on implementation, not the innovation itself. A research coordinator contributes to the discussion by implying that the project leaders are indifferent if they are not knowledge integrators or do not have a strong incentive for making projects successful, because they are responsible for the outcome. But a knowledge integrator might need and use the technology created and, therefore, the knowledge integrator might be more interested in success. When asked about knowledge integrators and the role of the project leader, a research coordinator said the following:

"It means a lot that one can feel that a partner's needs are fulfilled and that gives a bigger ownership to the project."

Ownership and the drive for success can be significant when a partner is responsible for a project. This may be the reason why knowledge integrators have an impact on innovative performance, including when they act as project leaders.

Knowledge brokers and innovative performance

The interviewees see the RTO as a broker between the university and the industry. The goal of the knowledge broker is to translate research into practical implications. One evaluator mentions that RTOs can have an important role, if the partners from the industry do not understand how to convert the research results into practical application. On the other hand, knowledge brokers can also have a negative effect on innovative performance in an R&D project if they are a substitute for an industrial partner. Another evaluator mentions that knowledge brokers are also motivated by the potential economic turnover. If an R&D project is not economically beneficial in the middle of the process, they might give up. However, according to the evaluator they may not stop the project, but continue with a low operating crew and time, and this might explain the low performance. An evaluator states that:

"If RTOs are in a project they might drag the project for too long before they involve or integrate potential knowledge integrators."

By having one foot in research and another in business, the knowledge broker might take the role of knowledge integrator, without fulfilling it. This might result in dragging the project in a direction where there is no need or use for the final project results. Furthermore, he mentions that the knowledge broker's focus is on information/knowledge for consulting. This can be a reason why knowledge brokers have a negative impact on innovation. A research coordinator points out that knowledge brokers can be good at knowledge sharing and spreading knowledge to other projects and customers. But the potential knowledge sharing element might also become an obstacle for the knowledge broker. According to the research coordinator, the industry might feel that the knowledge broker sponges off the knowledge and does not contribute to the competitive part of the process.

In sum, the qualitative study identified underlying reasons why knowledge integrators have an impact on innovative performance. First, when a knowledge integrator is involved in a project, it might make the project more goal-oriented, because the knowledge integrator wishes to use the developed technology. Second, when a knowledge integrator acts as project leader, the drive for success might increase, because the knowledge integrator has a specific need to fulfill and is not just a part of the project. Third, knowledge brokers and knowledge integrators do have some characteristics in common, but they are also significantly distinct from each other. Knowledge brokers have a broker function in R&D projects, while organizational knowledge integrators tend to push the projects forward with the goal to develop an outcome.

Discussion and conclusion

The paper shows that involving a knowledge integrator has a positive effect on R&D projects' innovative performance, such as the development of new technologies, scientific publications, innovation, and new energy research. Overall, the empirical results show that projects incorporating a knowledge integrator have a strong tendency to develop new technology, compared to projects that do not incorporate a knowledge integrator. A reason for this may be that when a knowledge integrator is involved in a project, it is because the knowledge integrator has the necessary expertise to contribute to the development of a new technology. Specialized knowledge can contribute to knowledge integration (Tiwana, 2008). Another reason may be that the knowledge integrator might use the output and, therefore, seek to be involved in projects where the purpose is to create new technology. On the other hand, the qualitative findings showed that involving a knowledge integrator might make the project rigid and too specific, preventing other actors from using the developed technology.

The results also show that when a private company acts as project leader, the probability of creating a new technology increases, compared to projects where a university or a knowledge broker acts as project leader.

Creating new technology should be a main driver for all the actors, but it can be discussed if universities and knowledge brokers, as opposed to private companies, have the right competences or skills to be the main driver of a project. It is found that research institutes and industry interactions can be very important in regard to science-based technologies (Meyer-Krahmer and Schmoch, 1998, Beise and Stahl, 1999). But it is essential to emphasize that the core purposes of collaboration between e.g. the university and the industry differ. Universities are primarily driven by producing new knowledge and education; companies are primarily driven by capturing the knowledge and utilizing it as a competitive advantage (Dasgupta and David, 1994). For this reason, private companies might be more motivated to create results that are not only theoretical but also applicable. Going one step deeper into the analysis of R&D projects involving a knowledge integrator, the results show that projects with knowledge integrators have a tendency to produce scientific publications, compared to R&D projects that do not incorporate a knowledge integrator. The results also confirm that when a private company acts as project leader, the likelihood of producing scientific publications decreases. Private companies might not be interested in publications, even though they are interested in new technology, and these diverse interests can be problematic in R&D projects that involve different partners. Mansfield (1998) claims that the collaboration between university and industry could focus more on short-termed projects, which may also affect research in general. Universities depend on scientific publications and this can lead to controversies in a project, if other partners such as private companies do not want to make the findings public. According to Santoro and Chakrabarti (2002), successful collaborations require that universities are willing to be involved in research that the industry finds important. At the same time, the companies must be willing to use and assist the types of research that universities are conducting.

Additionally, the results show that even though a majority of the knowledge integrators are private companies, they do have a tendency to produce scientific publications when they are involved in projects. This shows that the role of the knowledge integrator is distinct from private companies in general. A reason for this may be that the knowledge integrators have a higher absorptive capacity (Cohen and Levinthal, 1990) as well as the essential capabilities and resources to produce or encourage scientific publications. de Faria et al. (2010) find that high-technology companies tend to have a higher absorptive capacity compared to low-technology companies. Therefore, knowledge integrators in R&D partnerships in the energy sector might have a high degree of specialized knowledge and the capacity to absorb technically demanding knowledge.

Furthermore, when examining knowledge integrators as project leaders, the results show that the likelihood of the created technology being innovative increases. From this, one might argue that knowledge integrators may not only have the necessary knowledge and expertise to create new technology, they may also have the relevant project management skills and drive to achieve innovative goals. This shows that the knowledge integrator can be a crucial partner in R&D projects, where the goal is to create innovative technology. Moreover, the findings demonstrate that R&D projects involving a knowledge integrator have a high tendency to create results that may affect future energy research. This confirms that knowledge integrators are not only important in the process of developing new technology, but that the results can be used in future research and thereby to create new knowledge worth exploring if the knowledge integrators are responsible for the project.

The results also show that when knowledge brokers are incorporated in R&D projects, they do not have a positive effect on innovative technology or energy research. This might confirm that the knowledge broker's role is limited in areas of innovation and research development. They might be act as knowledge brokers between the different partners in the R&D project, but not as the main driver for creating results. This confirms that knowledge integrators and knowledge brokers are not to be confused. Although they are alike in some ways, the results show that knowledge integrators, unlike the knowledge brokers, have a significant impact on innovative performance.

Overall, the results confirm with regard to the *first research question* that R&D projects involving a knowledge integrator experience a significantly higher innovative performance, compared to projects that do not involve a knowledge integrator. The results also confirm the *second research question*, showing that there is a significant difference in regard to innovative performance between R&D projects incorporating a knowledge broker and a knowledge integrator, respectively. The results of this paper are not limited to R&D projects in the energy sector, but can also be used in other areas such as CIT, where public programs provide financial support and where the constellation of the projects is similar.

The limitations of the paper are the following. First, the data comes entirely from one energy program in Denmark, meaning that it is not possible to generalize the findings to other non-public programs with different approaches in regard to program objective, constellation of partnership projects, purpose, etc. Second, the ForskEL program does not support R&D projects in the stage of commercialization and, therefore, it is unknown if the role of the knowledge integrator is important in R&D projects at the commercialization stage. Finally, the paper fails to demonstrate the degree of involvement of the knowledge integrators in R&D partnership projects. Based on the paper's limitations, the recommendations for future research are therefore: First, future research should aim to explore how the knowledge integrator operates in R&D projects. This could give an understanding of how the knowledge integrator interacts with partners and help identify which kind of behavior promotes innovation in R&D partnership projects. Second, qualitative in-depth interviews with active knowledge integrators in R&D partnership projects could provide better insight into the degree of involvement. Third, a larger set of empirical data on a project level, across different sectors, is needed. This can contribute to the exploitation of knowledge integrators in other sectors. Finally, a study of the knowledge integrator in other technology phases than basic research, applied research, and demonstration is needed. The effect of the knowledge integrator may be different in the commercialization phase.

The findings inspire two managerial recommendations. First, on a project level, research coordinators and evaluators in the different public programs should thoroughly consider if knowledge integrators are involved in R&D projects and what their role is, before allocating funding to a project. This can be done by identifying who the knowledge integrator in the project is and which of the technology development phases the project is in (see Bulathsinhala & Knudsen, 2012). Second, the different partners in an R&D

partnership should carefully gather the different partners and consider who is going to use the knowledge created. They should identify which competences the R&D partnership project requires in order to become a success, and they should consider who the knowledge integrator is and how he or she can contribute to the project. These implications might help R&D projects become successful.

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