DESIGNING THE MISSING LINK BETWEEN SCIENCE AND INDUSTRY: ORGANIZING PARTNERSHIP BASED ON DUAL GENERATIVITY

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Industry-academic research partnerships are mostly considered interesting to increase industrial innovativeness, and its benefits have been discussed in the flourishing open innovation literature. However, how to create mutually beneficial partnerships seems to be a question that has not been sufficiently studied. Through this article, we discuss the goals of these partnerships by modelling different types of collaboration. We defend that their real value has to be evaluated not only by looking at the knowledge created, but also at the increase of generativity we observe, due to interactions between academia and industry. Furthermore, we propose a model based on C-K theory that can be used to design a research collaboration that increases generativity, going beyond problem solving and knowledge transfer logics. We illustrate it through a case study, which shows that value creation in an industry-research partnership is increased by a model of co-generation, instead of considering these relations as a one-way transfer. Furthermore, we show that conflicts in a partnership can be solved through a C-K based tool.

1 HOW CAN WE CREATE MUTUALLY BENEFICIAL INDUSTRY-UNIVERSITY COLLABORATIONS? IDENTIFYING A GAP IN COLLABORATIONS DESIGN

It has been shown by several authors that university research, and public research in general, plays a very important part in industry innovativeness (e.g. Cohen et al., 2002). Collaborating with academia has long been an important subject both for industrials trying to improve their products or propose innovations, and to draft public policies. Industries have increasingly engaged in "open innovation" (Chesbrough, 2003), engaging with academia not only through intellectual property transfer, but also through a variety of other research partnerships. If the value of collaborations is not always easy to assess, policy makers and industrials agree that there is much to be gained for industrials in them.

On the other hand, the profit of these collaborations for universities seems to have been the object of still fewer studies (Perkmann and Walsh, 2009). More, for some, it could be challenged that scholars could benefit of these collaborations. Some authors argue that too much industrial involvement can lead to a shift from basic research towards more applied topics or reduce the open-accessibility of science (Nelson, 2004), while others state that it is undeniable that both funding and usecases coming from industrial partnerships are important inputs for academic research (Davies, 1996).

As discussed by Cohen and al. (2002), it has long been shown that it is an oversimplification to consider relations between academia and industry as a linear process where scholars give research knowledge to industry, which manages innovation as a R&D process. Perkman and Walsh (2007) show that the simple transfer model, where knowledge from one of the domains is plugged into the other one, does not work most of the time. The collaborations between industry and academia are much more complex and can take a great number of forms. They differ not only in the types of interactions, but also on their level of formalisation and financing principles (Heraud and Levy, 2005).

According to Perkmann and Walsh (2009), these collaborations constitute a two-way exchange, from which both academia and industry can benefit under certain conditions. This means reciprocity is far more developed than some text would lead to assume. They believe academics are able to benefit from industry collaboration especially when (i) they are in disciplines associated with the "sciences of the artificial", like engineering; (ii) collaboration is highly research driven and (iii) the researchers collaborate with industry through several different mechanisms.

Despite the great variety of studies evaluating the impact of industry-university collaborations, Perkman and Walsh (2007, p259) draw attention to the fact that there is a lack of studies on the "search and match processes between universities and firms, and the organization and management of collaborative relationships". The great variety of studies showing that industry-academia collaborations can be beneficial for both academia and industry does not sufficiently study the design of these collaborations. We therefore identify that a gap exists, on how to create mutually beneficial collaborations between the industry and academia.

To tackle this gap, we will propose a model for how these collaborations could be designed based on design theories.

2 HOW DESIGN THEORIES CAN HELP US CLOSING THE GAP ON COLLABORATIVE DESIGN

Collaborations between industry and academia have been studied as one of the aspects of open innovation, where a company relies on researchers outside its boundaries to achieve results. Open innovation is a flourishing subject and has been the object of numerous publications and studies, but as stated by van de Vrande et al. (2010) scholars need to go beyond the open/closed innovation debate towards how open innovation strategies demand a different organisational structure and mindset. When looking at literature on open innovations, researchers agree that focus should be given to theory development on this field. As pointed out by Elmquist et al. (2009), there is still a need for a critical discussion of the open innovation concept, the strengths and weaknesses of this model have hardly been theorized.

The particular interaction of collaborative design with academia and how to make this profitable for both researchers and industrials has also, to our knowledge, not yet been sufficiently treated. As stated by Le Masson et al. (2013, 241), the goal of design theories is to "understand and support contemporary forms of collective action". They therefore seem particularly appropriated to help structure the debate on industry-academia research and to theorize this aspect of open innovation.

Furthermore, in the open innovation literature, despite the discussion of different degrees of openness, Enkel et al. (2009), divide the open innovation processes of firms into three groups: the outside-in process, the inside-out process and the coupled process. In the outside-in process companies integrate external knowledge to innovate. This is a problem-solving approach, where external knowledge is identified to solve an internal problem. In the inside-out process, companies look for a buyer or a market for a technology they developed. In this case we have a search for applications for an already acquired knowledge. And finally, the coupled process consists of combining the inside-out and the outside-in processes. In an industry-academia partnership, these open innovation processes translate to science application, when researchers try to find an industrial with an interest in application, and into problem-solving contests, where companies try to find external knowledge for an identified need. In both processes the required knowledge has been identified, so these approaches are not appropriated for when the required knowledge is unknown.

The value associated to these types of collaborations has largely been discussed in literature, but despite all the advantages associated to them they have one downside: the design effort is independent or sequential. In all these cases knowledge is created by one actor, and then adapted by another one to solve a problem. We believe that industry-academia collaborations should go beyond that, not only adapting existing knowledge, but also pursuing new designs and fostering each other's creativity. This belief is supported by the innovation management literature, which shows that innovation inside a firm does not emerge only from knowledge, but also from the firm's generativity, "the capacity to model creative reasoning and to relate to innovative engineering in all its aspects" (Agogué et Kazakci., 2014). Both the generativity on which knowledge to develop and on what desirable unknown to explore are key to innovation emergence. Table 1 illustrates the generativity, knowledge creation and design effort in the two types of academia-industry collaborations we have identified in literature.

We therefore state a first hypothesis (H1*): In a research-industry partnership, partners do not only look for acquiring new knowledge*. And we complete it through our second hypothesis (H2): *Participants of this kind of partnership are looking to improve their generativity. Each participant has a limited generativity, and the goal of the partnership is to increasing this limited generativity.*

According to Le Masson and Weil (2012) design theories have been developed to allow reasoning in the unknown. They allow developing new technologies or markets, and have even been used to handle situations of double unknown, where both technologies and markets have not yet been defined (Kokshagina et al., 2016). In the design of a partnership, the knowledge to be identified or the action logics can be unknown, and current open innovation models do not allow us to handle the unknown. Design theories therefore supply the kind of framework needed to design a research partnership between academia and industry that tries to go beyond knowledge transfer logic.

2.1 A first model to collaborate beyond knowledge transfer: creating common knowledge

As we have discussed previously, different collaborations between industry and academia exist. To increase the generativity of a research partnership, it is interesting to go beyond knowledge transfer through knowledge co-construction. In these kinds of innovation research partnerships, industrials and academics work together on creating common knowledge. The goal is defined jointly by both partners, who have different responsibilities in the partnership.
Common knowledge creation is often done by industrial PhDs, like the CIFRE[1] PhD in France (Heraud and Levy, 2005). The CIFRE aims to improve the collaboration between industrial and academic research, by allowing a PhD student to spend time both in a research institute and in a firm. Beyond the joint research goal of collaboration, a CIFRE also aims to create competencies for the PhD student. Due to the student's involvement with both the scientific and the industrial communities, he facilitates the creation and transfer of knowledge between science and industry. One of the particularities of this type of collaboration is that the PhD student personifies the research collaboration. The collaboration is furthermore limited to 3 years, due to the contract between the involved actors.
Table 1 recapitulates this first model's characteristics (M1). The goal in these collaborations is not to find existing knowledge and apply it, but rather to build on the existing and new knowledge to reach a desirable unknown (Hatchuel, 2013). The common purpose is often formalized between the two partners when the research proposition is drafted, allowing improved generativity and the joint knowledge creation. However, the outcomes of such a partnership are not always satisfying for all parties involved; difficulties to organise and manage these partnerships still exist.
Furthermore, some of these collaborations still tend to maximise sequential design efforts, applying both science application and problem solving logics. These are logics that are easy to integrate by both partners, since they are often used in partnerships. We believe the value of these collaborations for both partners can be increased by better designing the research collaborations and increasing their generativity. Applying a design model should therefore greatly contribute to better understand industry-academia collaboration beyond technology transfer or knowledge-brokering (Hargadon & Sutton, 2000).

2.2 Proposing a model for industry-academia collaboration through design theories

Having shown the need for a design model for industry-academia partnerships that maximise value for both partners by increasing both generativity and knowledge creation, we will try to answer the following research question: Can design theories help us to improve the global performance of industry-academia collaboration?
To answer our research question, we will build a theoretical model based on design theories, which we will refer to as innovation design partnership (M2). Its characteristics are described in Table 1.

Table 1. Generativity and knowledge creation expected through our theoretical model compared avec the previously discussed models

	Science application	Problem solving	Innovation research partnership (M1)	Innovation design partnership (M2)
Academia	Develops new knowledge in a scientific field	Develops knowledge based on the industrial problem	Develops knowledge linked to an industrial problem in an identified scientific field	Develops new knowledge and increases its generativity
Industry	Adapts the developed knowledge for a market	Proposes a problem	Proposes a problem, contributes to develop knowledge	Develops new knowledge and increases its generativity
Knowledge to be created	Defined by academia	Defined by academia given the industrial problem	Co-defined by industry and academia	Defined by both partners
Generativity	Limited generativity by the company to adapt knowledge; Limited generativity by academia to create knowledge	Limited generativity by the industry to propose a problem; Limited generativity by academia to create knowledge to solve the problem	Generativity is increased, but limited by the common purpose	Joint generativity is higher, as is individual generativity
Design effort	Sequential	Sequential	Combined in pursuing the common goal	Combined

1 CIFRE (Convention industrielle de formation par la recherche) could be translated as "Convention for Learning by Industrial Research". This collaborative mechanism has been in operation in France since 1981. The CIFRE PhD student is partly funded by the ANRT (Association Nationale de la Recherche et de la Technologie), the National Agency for Technology and Research, an association that assembles the public and private research actors in France since 1953. More information on the ANRT and the CIFRE device can be found on http://www.anrt.asso.fr/

In the study of innovation partnerships, design theories, and more specifically C-K theory, have been mobilized to better understand them and to show how they can be build (Gillier et al., 2009). The C-K theory is a design theory proposed by Hatchuel and Weil (2009) that has largely been used in industrial context to develop tools and methods, allowing to better understand the innovation process and to coordinate innovation efforts. It is based on the interplay between two distinct, but interdependent, spaces: the concept space (C), containing undecidable propositions, from which we cannot say if they are true or not; and the knowledge space (K), containing only propositions that are true or false. According to the authors, C-K theory is a rigorous and unified formal framework for Design. The main difference between C-K theory and other frameworks proposed in literature is its ability to describe the generation of new objects and of new knowledge.
C-K based tools have proved to be helpful in an industrial context, and also in cross-industry partnerships. Gillier et al. (2012) show how building C-K profiles and applying a method they call "matching/ building" can be a way in innovative partnerships to create a common purpose, and orient cross-industry exploratory partnerships.
Despite its numerous applications in industry, to our knowledge C-K theory has not been widely applied in the academic research contexts. Although the theory has been discussed in other academic fields than design, and Agogué and Kazakci (2014) listed 44 peer-reviewed publications on the subject, to our knowledge no specific method or tool based on C-K theory has been created for the academic research context, or for the collaboration between academic and industrial research. Being a theory on the design reasoning, the C-K theory is nevertheless well-positioned to be applied in this context, allowing to explicit the reasoning behind a research program. It furthermore allows, through its structuration of the knowledge and the concept space, to show both where new knowledge has been created (in the K space) and generativity has been increased (in the C space).
In designing an academia-industry partnership, we observe the same difficulties as identified by Gillier et al. (2009) in cross-industry partnerships: (1) the difference of strategies and goals between partners; (2) the difference of needs and competencies and (3) the fact that great differences can exist in the knowledge and concepts of two partners. We can furthermore add one more topic to that list in an academic-industry partnership: (4) the different evaluation criteria of success between the partners (Dulaurans, 2015). As stated by Nooteboom (2004), each partner will have his or her own goal and agenda. This has to be taken into account in the construction of the partnership, to make sure both parties can identify the benefits of the collaboration.
We therefore propose a method we will call "C-K co-generation" to allow all involved parties to jointly design a research program that is mutually beneficial, allowing both a knowledge expansion

and an increased generativity, which means the exploration of new desirable unknowns for both partners. We start from the hypothesis that the goal of the academia-industry partnership is to collaborate in joint research: The partners agree that they want to go beyond transferring knowledge. They also have dedicated resources to work during a limited time on their common goal.
The "C-K co-generation" method we propose consists of two main steps, illustrated in Figure 1:

1. Creating a first partnership intention leads to build distinct academia and industry C-K maps, based on the action logic of each actor: The academia's map describes the scientific program of the research institution; The industrial's C-K map figures the firm entity's R&D topics according to its activity.
2. Jointly building the C-K map that should dynamically guide the R&D partnership and the daily working agenda of the dedicated resources. The two C-K maps evolve through the discussion on the joint research program and through confrontation.

This method tackles the difficulties we had previously identified in academia-industry partnership:
(1) and (2) The difference of strategies, needs and competencies between partners can be discussed once each one of the partners has formalized its own C-K map with help of independent C-K experts.
(3) The fact that great differences can exist in the knowledge and concepts of two partners even if they work on the same topic. Once more, formalization of concepts helps identify common knowledge and concepts. And the work done around building the C-K map to position the PhD allows finding common ground for the partners on the concepts and knowledge they wish to work on together.
(4) The different evaluation criteria of success between the partners can be discussed and integrated in step 3, when building the C-K map of the research partnership.
The clear positioning of the research partnership through the C-K maps not only helps to design the partnership's scope, but it also gives a clear vision of both industrial and academic issues that are outside the partnership's scope. This makes it easier to justify why these issues should be tackled otherwise.

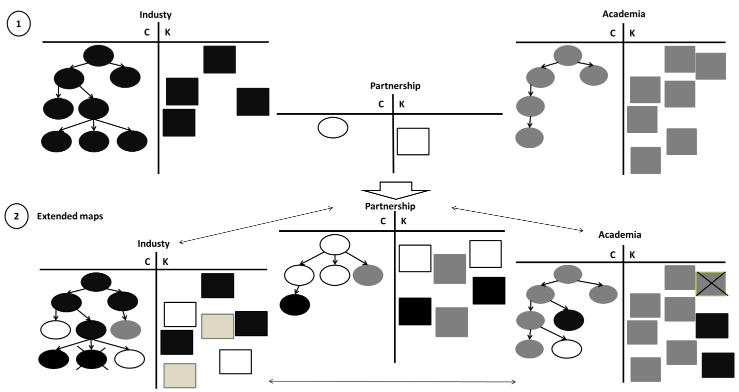

Figure 1. The two steps of C-K co-generation, showing that both academia and industry had their concepts and knowledge, which were extended by the work done and the partnership combined them and created new concepts and knowledge

Finally, using C-K maps gives us a common language to mediate interactions between scholars and industrial in the research program design. Creating a common language is essential in cross-sector partnerships, allowing a common understanding of topics. It is one of the particularities of C-K theory (Hatchuel and Weil, 2009) and helps the co-generative process by identifying common challenges.
We expect an increased generativity to be a result of a partnership designed using our design model, as well as increased knowledge creation. Several metrics have been proposed to evaluate research partnerships, and many of them are based on economic impact. Limits of economic impact evaluations have been discussed by several authors (e.g. Hall et al., 2003), and as defended by Rejeb et al. (2008), evaluations combining both management processes as well as the learning process and cognitive

aspects help overcome these limitations. We will therefore evaluate knowledge creation by the new knowledge explored and generativity using the criteria of value, originality and producibility, as proposed by Magnusson et al. (2003) when evaluating the quality of created ideas.
C-K maps facilitate this evaluation by its structure, knowledge creation being a consequence of desirable concepts. And for each concept, value, originality and producibility are part of the associated knowledge. By comparing the C-K maps produced by each of the partners to the partnership C-K map, we should find in the partnership new concepts and new knowledge that were not found in either of the previous maps. This would indicate generativity in C and knowledge creation in K. Furthermore, comparing the first and final C-K maps for the industry and academia after the C-K co-generation, we should find evolutions both in the C and K spaces for both partners, showing their learning from the process. These evolutions might not be addressed through the partnership, but through other projects defined by the concerned actors.
This theoretical model was built based on the knowledge we had on the difficulties of industry-academia collaborations using C-K theory expertise delivered by scholars from the Mines ParisTech Design Theory and Methods for Innovation (DTMI). We illustrate the use of our theoretical model though one empirical case, which we will discuss in the following item.

3 APPLICATION TO A CIFRE PHD, EXAMPLE OF A COLLABORATION ON THE SCIENTIFIC FIELD OF HYDROLOGY BETWEEN IRSTEA AND SNCF

We will discuss one application of our theoretical model in this part, through a reconstruction of an industrial PhD following a CIFRE contract, which was done after having identified difficulties and the need for method by the involved parties concerning the research program definition. The CIFRE collaboration we studied was in hydrology, between the IRSTEA's (National Research Institute of Science and Technology for Environment and Agriculture) Hydrology-Hydraulic research unit and SNCF Réseau's (a French railway network manager and maintainer) Hydraulic-Drainage team. The design process was accompanied by Innovation and Prospective SNCF corporate team (Innovation & research department) and the Chair Design Theory and Methods for Innovation (Mines ParisTech).
The subject of the studied collaboration is "Evaluation and development of the IRIP method for intense storm runoff mapping: Application to the railway context." According to the first collaboration proposition drafted when the PhD was decided between the two organizations (2014), the PhD student was expected to develop the IRIP method, a multi-scale, cartographic runoff water indicator, comparing the results to those of other models and verifying its validity at different cartography scales. After the model validation and calibration under railway specific conditions, the PhD student was supposed to adapt the model to SNCF's available data to assess its potential to prevent water overflow risks for the railway network. To do so, the PhD CIFRE contract provides shared time for the student between institutions (academic and industrial units).
Six months after the PhD's beginning, the two research teams and the PhD student started identifying some difficulties in how to articulate the joint research program in a way that should be beneficial for all. Mainly, they had a divergence about the focus of the research: applied science (i.e. transfer logic from science to industry) or problem-solving (i.e. R&D). The PhD student was therefore torn between two different strategies. After seeing a presentation of the C-K theory's potential for managing PhD portfolios and designing the PhD strategy, the industrial tutor and the student believed this could be a way to discuss the research partnership. They therefore agreed to deepen the research partnership and, eventually, redefine its goal and activities using the C-K co-generation method to position research and industrial issues.
The proposed device involved three actors: the industrial partner (SNCF Réseau's team), the academic partner (IRSTEA's research unit) and a third party on innovation methods (Mines ParisTech Chair DTMI and SNCF Innovation & Research Scientific direction). The third party was an essential part of the device, since PhD redesign needed a structured and guided method following C-K theory principles and this third party was in charge of structuring and guiding discussions. Innovation intermediates as these we introduce here have been increasingly studied, and their value in improving the innovation capabilities of other stakeholders has been shown (Agogué et al., 2013).
Our research was done following an intervention research method (Radaelli et al, 2012). The authors actively participated in building the research programs and the C-K maps. They were positioned as

methodological experts during the entire process, which lasted around 6 months. In this time there was both work done in meetings and individually by the participants.
To start discussions on the collaboration, two plenary meetings were held, where a presentation of the PhD and of the state of the art on research on the PhD's subject was made to all partners. The purpose of these meetings was also to present the C-K co-generation method, and the benefits expected from applying it. These meetings also provided first elements for the C-K maps. The main outcome was an agreement of all the involved partners to apply the method, and a strategy to build the C-K maps with each partner (IRSTEA, SNCF Réseau).
The second step consisted of building the C-K maps. These were built with strong guidance of the methods team. The PhD student had separate meetings with both teams to build each partner's C-K map. We were able through the different sessions to observe an evolution of the C-K map of each of the partners and to observe how the research collaboration C-K could be built.
A further plenary meeting was organized to build the PhD's C-K map to guide the collaboration. It was furthermore the occasion to confront the academia and industry C-K maps. The PhD student was encouraged to build his C-K map as a coherent research program, and not as a consequence of the industry and academia C-K maps built previously.
At the end of the process we had three C-K maps, one for the industrial's team, one for the academic research team and one for the PhD research collaboration that had been discussed and agreed upon to guide the research partnership. At that stage, it could be seen that a science-industry transfer model is not relevant to understand how the research partnership was built, and that there was an increase in generativity. Debates during working sessions showed that both research and industry could leverage each other through co-generation. We will discuss these results in the following session.

4 MAIN RESULTS

Our main result is showing that academia - industry partnerships can profit from a design process, by increasing generativity instead of searching for a common goal. We therefore propose a method that can allow the design of a partnership that is beneficial for industry and academia, giving elements to help overcoming the research gap of how to design these partnerships. The proposed model not only allowed designing a mutually beneficial partnership, it also allowed solving a conflict between the involved partners. We confirmed our hypothesis thanks to the constructed C-K maps and showed that the value of research partnerships is linked to increasing generativity for both partners. Due to its specific structure, the C-K maps clearly separated the existing knowledge and concepts in each of the two structures. This allowed us to clearly map interactions. Knowledge transfer existed and led to new applications and small value creations, but allowed little evolutions in the partner's generativity, The most important value creation came from new concepts, proposed thanks to several interactions between partners and to the specific mechanisms used when building a C-K map. The highest originality was also achieved in this way.
Our case study allowed us to validate the value of using a method based on C-K theory in a specific kind of collaboration, a CIFRE PhD. Both the firm and university participants agreed that use of C-K tools, based on C-K theory, allowed to evaluate the PhD's relevance according to research and industry issues, improving their understanding of partner's needs and expectations. More, applying C-K to a CIFRE PhD revealed a generative power to redesign the research's relevance; opening new questions for industry and research.
Another important result was showing that, despite the fact that literature often speaks of concepts coming from the industry (as industrial applications) and knowledge coming from science, both industry and academia have complete C-K maps with concepts and knowledge. However, the concepts for academia are on new research strategies, and not on industrial problem solving.
We furthermore observed that building a C-K map of a research field had a reflexive effect on both partners. The process we observe during the different meetings is more subtle than only a co-construction: Each one of the actors evolves thanks to the work done together. Both the firm's as well as the university's research team stated that drafting their C-K map led them to ask themselves why they did or did not include some concepts or knowledge. Formalization in a C-K map and discussion among team members allowed generating new concepts and making implicit knowledge explicit.
Our case study also allowed highlighting how co-generation was done through the design of a research partnership. Before the effort of building the two C-K maps was done, there was little intersection

between the fields in which the two actors declared they were working in. Both partners worked in the same field but with very different points of view. The research team's focus was on a method to produce storm runoff mapping (IRIP method), based on a new Production-Transfer-Accumulation (PTA) concept of pluvial flooding representation. Industry's focus was on risk management against flooding in specific conditions (railway infrastructures resiliency facing critical situations) that drive to integrate, for example, civil engineering infrastructures as evolving obstacles to run-off. Despite the fact that both partners had a clear interest in developing the academic model IRIP, how to do so was unclear. The PhD had been launched to bridge the gap between the scientific existing knowledge and the application field, but the involved parties did not agree on a methodology. Building a common C-K map for the CIFRE PhD allowed mapping the way between the existing knowledge and the desired concept, clearly drafting which actions were to be taken and which not. It also allowed mapping out the possible alternatives if the chosen path turned out to be a dead end.
The construction of the common research program demanded a discussion of the existing knowledge between both parties, and their appropriation in the partnership C-K. It furthermore demanded the creation of a series of concepts and activities around knowledge creation that did not exist in either of the two maps. This can be exemplified by one of the concepts in the CIFRE C-K, which was "To create new approaches for risk management using a new IRIP model". This concept led to the analysis of the actual water related risk management process within SNCF and the identification of elementary tasks where the actual IRIP model can bring direct contribution to the process and where both the IRIP model must be adapted and the actual process must evolve (Lagadec et al., 2016). To achieve this work, knowledge coming from IRSTEA on the IRIP model was needed, as well as knowledge on the railway network and the types of risks coming from SNCF.
Building C-K maps greatly helped to allow a dialog on co-generation, since it gave participants a common language basis and allowed going beyond traditional research programs. By confronting their C-K maps, the two partners were able to add relevant knowledge and concepts to their own C-K map. And the discussions between the actors led to explicit and clarify implicit knowledge, also leading to advances on the reformulation of certain aspects of their C-K maps. We were also able to observe knowledge re-ordering (Poitier et al., 2015). The new knowledge integrated from one of the partners forced to rethink existing knowledge bases, opening up new knowledge bases. The co-generation effects described above are the ones expected through our theoretical model, as illustrated in Figure 1.
In the words of research-industry partners the C-K PhD co-generation method helped them to clarify their own needs and expectations, as well as the research program behind the PhD. The PhD C-K map shed new light on what could be inside PhD and what had to be outside, but could be treated in complementary research projects driven by the same or different partners. It helped to manage the time constraint to finish the research program in three years. Thanks to the C-K map they were able to better evaluate which paths could be included inside the PhD's limited time, and which should be the object of other partnerships or research programs. The drafted C-K maps were seen by both the research teams as interesting tools to challenge their activities and research goals. Both teams agreed that the C-K map they build was a powerful tool to help in internal management and to place their activity regarding the rest of the firm or the scientific community. The firm's research team further declared it was a useful tool to present their activity to other research teams inside the firm, since it helped to clarify their research strategy and to formalise the logic behind their actions. These C-K maps are living tools, and have to be regularly updated to be able to develop their full potential.
These results and their interpretation using a C-K framework illustrate how the research partnership went beyond a simple transfer of knowledge or a transfer of concepts, to a co-generation, both of knowledge and concepts.

5 LIMITATIONS OF OUR STUDY AND FURTHER RESEARCH

We believe the results from our case study are promising for the design, organisation and management of industry-academia partnerships beyond an industrial PhD. Our theoretical model has however only been tested on one type of collaboration so far. The models we propose try to characterize specific partnerships, in practice they can clearly be combined between them and a firm should explore all of them, since different situations will demand different approaches. Further research should focus on experimenting on the different types of identified research partnerships.

Despite the need for more research to confirm our results, our case leads us to believe not only that the research program for the partnership can be co-generated and therefore create value for both partners, but that this co-generation is valuable for each one of the partners because it allows them to make their own research programs evolve. The use of a C-K framework furthermore leads to a reflexive approach of the research programs, that the concerned parties had trouble achieving before. C-K mapping seems to be helpful for elaborating and managing new relations between science and industry on a more equal basis, reducing by a dialog in the conceptual space. However, we still need to further investigate the inputs from the partnership C-K mapping to the innovation and research strategies.

Evidence from our case study shows that firms and academia can and should engage in co-generation in their partnerships, since it allows creating more value for both partners. We do however identify another limitation linked to the setting we chose. As has been highlighted by several scholars (e.g. Perkmann and Walsh 2007), in disciplines like engineering, where academia is closer to industry, it is easier to create value in industry-academia partnerships. Our case study was placed in this kind of setting, it would be valuable to verify if in other contexts and disciplines the model proposed by us and a framework based on C-K theory might reach the same kind of results.

We further believe this method could be used to coordinate two or partnerships for a university or firm on similar subjects. In this case the method would not only allow the university or firm to coordinate, but also the ressources to coordinate between them, creating synergies. We conclude by stating that other usages for this model might exist, and that the results found so far with it encourage us to test it in different contexts.

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