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INNOVATION INTERMEDIATION ROLE FOR THE DESIGN OF NEW PRODUCTS IN THE BIO-INDUSTRIES

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Keywords: open innovation, innovation intermediaries, innovation-oriented design process, performance measurement, bio-industries

1. Introduction

All companies appreciate innovation as a key factor for organizational success and economic survival, regardless the sectors it belongs to. However, classical closed innovation patterns don't enable companies to revitalize themselves anymore. That is why more and more firms have decided to externalize one part or their whole R&D activities in order to enhance the market entry of new products. This subversive innovation management policy was formalised for the first time by Chesbrough [2003] and called as the well-named Open Innovation (O.I.) paradigm. It was defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively" [Chesbrough et al. 2006]. Even if the risks of open innovation based policies are obvious, such as the crucial influence of intellectual property strategy for instance [Gassmann et al. 2010], many academics and industrials are convinced of its economic interest in all lines of business [Chesbrough et al. 2006]. Previous studies have shown that both SMEs [van de Vrande et al. 2009] and multinational companies [Mortara et al. 2011] have understood how promising open innovation policies are. However, the exchanges between organizations of different sizes need to be formalized. In this specific context, numerous organizations have emerged in order to improve the connection between innovative companies. These intermediary firms are defined by Howells [2006] as "an organization or body that acts (as) an agent or broker in any aspect of the innovation process between two or more parties." The targeted activities of these structures include the information providing service about potential partners, the brokering of in-progress transactions and the funding and support advice services. Since three decades, numerous innovation consulting firms have penetrated this market by offering a wide range of services, from research project funding to innovation policy management [Buijs 1987], [Muller et al. 2012]. Nevertheless, open innovation is not a within-country phenomenon and involves global sourcing of ideas. That is why online platforms have been set up by these innovation intermediary companies in order to embrace the most diversified community. Thus, several open innovation web-based platforms coexist on the market but stay differentiated by their own mechanisms and business models, as highlighted by Hossain [2012]. However, the performance issue of these intermediaries is just emerging in the literature [Lichtenthaler et al. 2008], [Hossain 2012] and concrete case studies at the new product development level are still extremely rare [Bahemia et al. 2010]. In this work, we examine the performance of these approaches in the bio-industrial sectors. Indeed, the economic and regulatory changes in these sectors had led to an upheaval of their innovation ability with a dramatic decrease in new bio-products discovery. Thus, the pharmaceutical companies are considered as pioneers in the opening of the firm boundaries. This observation raises the crucial issue of the spread of this paradigm in the other main bio-industrial sectors which are facing a similar innovation crisis.

To investigate these research issues, our paper focuses on two intermediaries' practices: an innovation consulting firm and an open innovation platform strategy in order to valorise the EBISilc® project, a new polyfunctional ingredient for the bio-industrial companies. The present paper is organized as follows. In the first section, we begin by a literature review leading to our research framework. In a second part, we formalize two research hypotheses and we present the concrete case study and the deployed research methodology to assess the validity of these assertions. Then, we present the results of both strategies and we identify the main features and limitations of these approaches in the bio-industrial sectors. Finally, we conclude by highlighting both theoretical and practical contributions of this paper and by presenting the main perspectives of this work.

2. Literature review

2.1 Bio-industrial innovation context

Saives and co-workers [2005] define the bio-industries as the industrial sectors which answer the specific needs (reproduction, nutrition and health) of a distinct biological system (human, animal, vegetal or environmental). To make this definition more precise in the framework of our study, we highlight four main bio-industrial sectors: the pharmaceutical industry, by improving the human and animal health; the cosmetics sector, by answering to the human health/well-being; the food industry, by answering to the human nutrition issues; and the environmental sector, by preserving the natural ecosystem. This non-exhaustive list can be completed by other minor bio-industrial sectors such as the phytosanitary sector, fine chemical companies or the medical devices sector.
However, in spite of their large available resources and their technological advancements, bio-industrial R&D departments have trouble in developing new products and have to rethink their innovation processes. For instance, the pharmaceutical industry is facing several contextual issues such as the patent expiration dates also described as the "patent cliff" whereas Big Pharmas have trouble in discovering new bioactive molecules on their own efforts. That is why the bio-pharmaceutical sector is defined by Bianchi et al. [2011] as "a fertile ground for the adoption of the Open Innovation philosophy" and has widely integrated new in-sourcing and out-sourcing strategies in its innovation process. This observation is confirmed by the pioneering nature of pharmaceutical companies to develop platforms in order to find new partners and new sources of knowledge. The more relevant example is the Open Innovation Drug Discovery program (OIDD) set up by Eli Lilly and whose main objective is to renew the pipeline of molecules by exchanging more efficiently with academic partners. Otherwise, the cosmetic companies are also subject to strong economical regulatory constraints but open innovation practices are just emerging for a few years. Thus, the consumer goods company, including cosmetic products, Procter & Gamble (P&G) is considered as the pioneer in the adoption of open innovation practices, especially thanks to its Connect and Develop (C&D) platform. Since "the objective of the new strategy using open innovation practices is to turn more technologies into products" [Dodgson et al. 2006], the C&D platform was developed to be the right place to find new suppliers and innovation partners. This initiative was then followed by Unilever, another main consumer good company (U-Partner Open Innovation Submission Portal) and by companies specialized in cosmetics such as Beiersdorf with its Pearlfinder platform. In the same way, often considered as a mature and slow-growing sector with low research investments, the innovation processes in the food industry are facing deep changes. Sarkar and Costa [2008] reviewed the open innovation practices in the food industry where external sources of knowledge are screened to develop innovative technologies and products. This new innovation policy is emerging and several concrete models have already been formalised in this line of business [Bigliardi et al. 2012] and food-industry specialized platforms, such as the Allfoodexperts® platform, have emerged on internet.

2.2 Innovation and open innovation intermediation

The implementation of open innovation practices cannot be easily handled by all types of business organisations [Perkmann et al. 2007]. That is why innovation consulting firms, also called bridgers [Bessant et al. 1995] or third parties [Mantel et al. 1987], have penetrated this market by offering a wide range of services [Buijs 1987], [Muller et al. 2012]. Indeed, their complex strategies cover several steps of the innovation pattern, from initial recognition of opportunities to implementation and long-term use of technologies [Bessant et al. 1995]. They play a crucial role in the innovation processes by improving the research of partners thanks to standardized procedures. Because of the interest for the open innovation paradigm, these innovation players have understood their role at the interface of this model. Recently, a wide diversity of web-based platforms, also called ‘virtual knowledge brokers’ (VKB) by Verona et al. [2006], has appeared on the technology markets thanks to technological advances such as data mining and data searching [Dodgson et al. 2006]. Consecutively to the globalisation of ideas and technologies, open innovation firms have logically opted for using such platforms in order to help innovating companies to find potential collaborators. Indeed, companies of all sizes have trouble in selecting, connecting and initiating promising global innovation projects. However, only a few studies have been carried out on these open innovation intermediaries and they are mainly focused on their organisational mechanisms and their business models [Hossain 2012]. In our study, we will distinguish generalist open innovation platforms such as Yet2.com (1999), NineSigma (2000), Innocentive (2001) and IdeaConnection (2007) for the most developed ones and “corporate” platforms such as the P&G’s Connect&Develop platform, the Eli Lilly’s OIDD initiative or the General Mills Worldwide Innovation Network (G-WIN) which are emerging in all main bio-industrial sectors. Finally, it appears from this literature review that a systematic evaluation of the web-based strategies performance at the new product development level has not been proposed yet.

3. Formalisation of research hypotheses

Several fundamental issues are often raised when an open innovation strategy is targeted by research project team either from academics structure or industrial R&D departments: Are these (open) innovation intermediation strategies transposable in all bio-industrial sectors? How can we measure the performance of intermediaries’ practices when they are applied at the new product development level? That is why the aim of this paper is to investigate theses academic issues by means of empirical investigations. Thus, we first hypothesized that: *the integration of open innovation practices in the pharmaceutical industry is a trigger for the spread of this paradigm in the other bio-industrial sectors.* The second supported hypothesis is: *the practices of Open Innovation intermediaries are performing to find applicative sectors and potential partners to develop new bio-products.*

4. Research design

4.1 EBISilc® technology overview

In order to assess the validity of these hypotheses, two innovation intermediation strategies were carried out on a concrete research project in the bio-industrial sectors. The case study is based on one technology patented by the EBInnov Research and Development laboratory of the French engineering school “Ecole de Biologie Industrielle” (EBI). The laboratory has a strong expertise in the bio-industrial sectors thanks to its highly qualified professors (PhD degrees). The EBISilc® technology is a one-pot sol-gel inspired process for synthesizing polyfunctional clay particles [Lhéritier et al. 2013]. The inventive aspect of this technology lies in a double functionalization provided by a mixture of hydrophilic and lipophilic silanes. The first application tested by our team is the stabilisation of emulsions, i.e. the mixture of two or more immiscible liquids; for instance water droplets in oil or oil droplets in water. Nowadays, the majority of emulsion-based products are stabilized by surfactants, despite their environmental issues. That is why emulsions stabilized by solid particles, also named Pickering emulsions, can be considered as a substitution strategy since they have not penetrated the bio-industrial markets yet. The EBISilc® technology is expected to meet several expectations of the bio-industrial innovation context; such as the development of polyvalent new ingredients. Thus, the use of synthetic organoclays as drug delivery system [Yang et al. 2013] and water remediation method [Moscofian et al. 2008] were recently published. In order to find new partners having specific expectations and to bring this patented technology to its market(s), two intermediaries' strategies were rolled out; as detailed in the two next sub-sections.

4.2 Innovation consulting firm strategy

Two consultants (PhD degrees) were mandated to set up an innovation consulting office’s strategy.

First of all, an exhaustive bibliographic study was achieved to highlight four main applicative sectors: cosmetics, paint, environment and phytosanitary sectors. In a second step, a one-page brochure used as a communication medium during initial contacts and phone interviews was designed. It contains a brief description of the laboratory, the main characteristic of the project and the preliminary results, the future developments and the expected collaboration pathways. The last and main step of this intervention consisted in a session of prospective phone interviews carried out in each targeted sector. Data were collected in November 2011 during two weeks from semi-directed interviews of 17 R&D directors and 12 marketing managers who are directly involved in the companies' innovation process. Thus, the sample consists of a representative range of companies (n=24) which responded to the consulting firm's interviews. In most cases, they are multinational companies highly specialized in their business sector. The interviews were conducted by two consultants following semi-structured and open-ended guidelines (Figure 1) and they lasted between 30 minutes and 1 hour. Thus, they took the form of 'guided conversations' without structured queries.

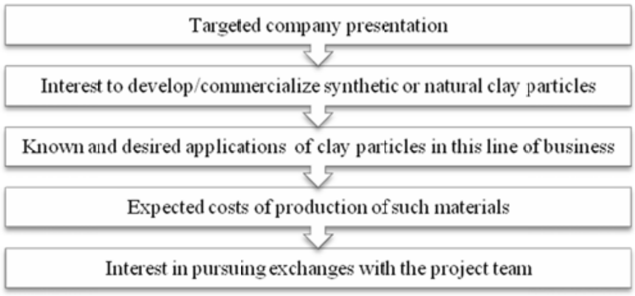

Figure 1. Open-ended interview guidelines

A semi-quantitative analysis of the data was realised by means of the written transcriptions of interview contents (resulting in over 40 pages of text). For each interviewee, the evaluation of the aroused interest was measured as follows:

- a low interest means that the technology is not in line with the expectations of the interviewee;
- a moderate interest means that more information was asked in order to better understand the added value of this technology;
- a strong interest is symbolised by sample requests or by the willingness to schedule a more formal meeting with the project team.

The technological background was estimated further to the obtained answers about the use of clay minerals in the targeted sector. The main objectives of theses interviews were to evaluate the interest aroused by the proposed technology and to initiate tangible exchanges with innovation managers of the four targeted sectors.

4.3 Open innovation platform approach

The second open innovation strategy consisted in broadcasting online a description of the technology on an open innovation platform. These web-based platforms are more and more investigated by academics [Natalicchio et al. 2014] and experienced by innovation practitioners. Thus, Yet2.com, the world's biggest online marketplace, is supported by more than 500 multinational companies and over 16,000 smaller technology companies. In our case study context, the online platforms based on the license-out model were evaluated as the most appropriate ones. Indeed, these platforms are involved in various fields including the bio-industrial sectors and works with large and small companies by exchanging patents, new products and technologies between buyers (also called tech seekers) and sellers (tech providers). The chosen platform is presented as an open innovation marketplace with, at the moment, around 100,000 active users from more than 40 countries with 600 active technology offers and 300 technology requests. This approach presents an obvious likeness with classical strategies by providing an interface of communication between firms. After having chosen a suitable platform, a briefly description of the technology was realized following the drill procedure named "TechOffer Form" and commonly structured as follows (Figure 2):

Figure 2. Technology offer description

In order to evaluate the contribution of this approach, the form was filled out with the information provided by the communication kit described in the previous section. Moreover, only contacts obtained in a one month period (March 2013) were taken into consideration and analysed. The assumed difference of data acquisition period stems from the active or passive characteristic to find new partners. Indeed, the passive web-based strategy was expected to present a greater inertia than the classical phone interviewing approach. For each contact, an evaluation of both aroused interest and technological background was realized by analysing the email exchanges with industrial contacts. The analysis of these two parameters was carried out following the same procedure as described in the previous sub-section.

5. Results and discussions

5.1 Innovation consulting firm strategy

By the use of patent databases, search engines, scientific database and market studies, this technological surveillance has highlighted twelve potential applicative segments (data not presented). Starting from these sectors of interest, a first filter based on the field of the project team's competences was applied to finally target four potential market segments. Paint segment and cosmetics were considered as the main potential sectors whereas the environment protection and the use in phytosanitary products were prospected to a lesser extent. Moreover, it should be noted that the regulatory barriers of the pharmaceutical industry sector was expected to slow down the innovation process. That is why this line of business has been ruled out of the scope of investigations (see Table 1), in spite of the potential applications of the EBISilc® technology in pharmaceutical products.

Table 1. Overview of interviewed companies and innovation players

	Interviewee's position			Organization's position in the value chain		
	Sales / marketing manager	R&D manager	**Total**	Ingredient supplier	Finished product company	**Total**
Cosmetics / paint	6	11	**17**	10	2	**12**
Environment	2	5	**7**	4	3	**7**
Phytosanitary	4	1	**5**	2	3	**5**

First of all, the total number of innovation actors is higher than the total number of interviewed companies because several employees have been interviewed in some companies. The entire value chain was covered by interviewing companies from reactant and equipment suppliers to integrators in the environment sector and from ingredient suppliers to end-product firms in the three other lines of business. Moreover, in each segment, both R&D and marketing managers were interviewed in order to get a global vision of the technical expectations and the market needs for new bio-products. Even if the geographical origin of interviewed companies is limited by the consulting firm's address book (France, Netherlands and Germany), several requirements were raised during the interviews.

Table 2. Summary of interviews' transcription in the four lines of business

Sector	Technological background	Expected applications	Interest for the technology
Cosmetics	Strong	Emulsion stabilization / Formulation thickening agents / Active ingredients release / Transparency and washing properties	High
Paint	Strong	Formulation thickening agents	High

Environment	Low	Air, soil and water detoxification Heavy metals absorption / Oils treatment	Low
Phytosanitary	Low	Bioavailability improvement / Emulsion stabilization / Active ingredients protection	Moderate

Interestingly, a good uniformity of both technological background and interest for the technology in each line of business was observed. That is why each sector was characterized by a unique description of these two parameters. The cosmetics and paint sectors were considered as the more mature markets showing a strong technological background and a high interest for the EBISilc® technology. The two other sectors showing a low technological background and high regulatory barriers present a moderate interest for the technology. Nevertheless, in all cases, the business and market needs have raised several expected functions for such materials; what is consistent with the versatility of the technology. Finally, it was shown that this approach which leads to direct contact with both technological and marketing managers is adapted to better understand the industrial expectations. This result is really interesting for technologies under development and whose final applicative sectors are still undetermined. On a practical aspect, this first strategy initiated tangible exchanges with three companies: one finished product firm and one ingredient supplier in the cosmetics industry and a pharmaceutical laboratory. Even if this last contact is out of the scope of the presented study, it is an indirect consequence of the consulting firm's work.

5.2 Open innovation platform strategy

In the framework of the EBISilc® project, the technology offer was also posted on an open innovation platform for one month. The evolution of the number of active users and information requests was followed day after day during this period as presented in Figure 3.

Figure 3. Evolution of active users and information requests (black stars)

It was observed that around 1,500 active users have clicked on the title of the technology offer, showing a first interest. Among these solution seekers, 6 information requests were received as summarized in the Table 3. Even if, at first sight, the ratio between active users and information requests could seems very low, this approach presents several interesting characteristics.

Table 3. Industrial and academic contacts from the web-based strategy

Position of the contact	Organization type	Line of business	Country	Interest for the technology
R&D manager	SME	Coating	Belgium	High
Researcher	University	Chemistry	Philippines	Low
Marketing manager	SME	Chemistry	India	Low
CEO	SME	Cosmetics	South Korea	High
Lab manager	Government agency	Pharmaceutics	Tunisia	Moderate
R&D manager	SME	Cosmetics	USA	High

Firstly, the innovation players who contacted us through the platform are not only R&D managers but also marketing managers and CEOs. This result confirms the involvement of all professional experts in the open innovation process, particularly in the in-sourcing of new ideas and technologies. The received information requests come from the same industrial sectors as the ones which were screened after the innovation consulting firm's work. This result confirms the relevance of the targeted market segments of the first approach. The aroused interest for the technology is also in accordance with the classical strategy: high for the cosmetics sector, moderate for the pharmaceutical sector and low for the chemical sector. Interestingly, the coating sector, which was not identified during the first approach have shown a high interest for the technology. This result raises the potential of this approach to highlight other applicative sectors which were not envisaged by the project team. In addition, it was shown that the global spread of the technology offer leads to contacts from four continents what is consistent with the international dimension of the open innovation paradigm. Finally, this strategy has led to contacts with a wide variety of organizations: SMEs, universities and government agencies. It should be noted that it is in agreement with the Triple Helix model formalised by Etzkowitz and Leydesdorff [2000] in which the University, the Industry and the Government are defined as the main institutions involved in the "knowledge-based economy".

5.3 Analysis of both approaches

In order to analyse the performance of both strategies, the performance triangle Effectiveness-Efficiency-Relevance was used as an appropriate comparative indicator by taking into consideration the resources, the results and the objectives of the study, as depicted in Figure 4.

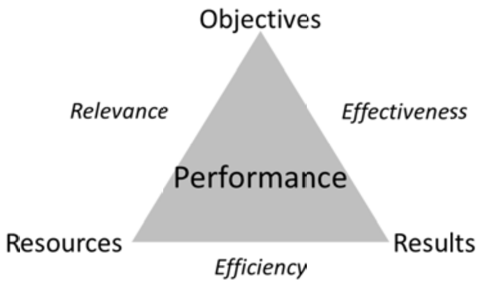

Figure 4. Performance triangle

The effectiveness measures how obtained results fit with the targeted objectives, the efficiency is the achievement of the objectives at lower cost and the relevance measures how resources allocation is consistent with the objectives. Firstly, the difference of financial resources injected to find new partners is important; approximately 15,000 euros for the consulting office compared with less than 100 euros for the web-based strategy. This difference is mainly explained by the external human resources involved in each strategy. Moreover, this estimation excludes the internal human resources for both strategies and a bias is due to the use of the same communication kit in the web-based approach. Nevertheless, it seems reasonable to consider the web-based approach less resource-intensive than the consulting firm strategy. The second apex represents the obtained results and the first aftermath is promising. For both strategies, several industrial contacts were obtained and technical and non-technical specifications were raised thanks to interviews' transcriptions. Otherwise, a "synergistic effect" between both approaches can be hypothesized. Indeed, the limitations of each strategy can be counterbalanced by the specific features of the other one; such as the interesting geographical spread of the technology of the web-based platforms. To conclude, the main advantages and disadvantages of both strategies highlighted by our case study are summarized in Table 4.

All these observations confirm previous works dealing with innovation intermediation. Open innovation platforms cannot provide a complete intermediation but ideas and feedback from the front end to the back end of the innovation process [Sieg et al. 2010]. Moreover, the use of Internet to communicate with potential partners limits the transfer of tacit knowledge; as highlighted by Afuah

[2003]. This observation can explain why no concrete exchanges have been formalized by means of this digital intermediation. In contrast, traditional innovation consulting firms have access to a limited number of companies in different sectors (24 in our case study versus around 1,500 active users for the web-based strategy) but they seem to be more effective in sharing tacit knowledge.

Table 4. Comparison of both approaches

	Main advantages	Limits
Innovation consulting firm	Complete intermediation Concrete exchanges	Contacts limited by the address book of the consulting firm Cost of the study
Open innovation platform	Highlighting of other applicative sectors Global approach Diversity of contacts	Intellectual property issues Difficulty to make exchanges concrete

6. Implications and perspectives

6.1 Implications

In all probability, the development of new products will go hand in hand with a systematic collaboration between firms [Chesbrough 2003]. This trend is more and more observed in the large bio-industrial companies which are directly concerned by the research and development activities of their ingredients suppliers. That is why open innovation intermediary companies are expected to play a central role in the future innovation patterns [Muller et al. 2012]. Thus, the concrete deployment of intern platforms by large companies is documented in the literature [Dodgson et al. 2006] and several best practice case studies were reviewed by Natalicchio et al. [2014]. However, the emerging topic of markets for ideas is too recent to evaluate how many companies opt either for consulting firms or for innovation platforms. Otherwise, previous studies [Howells 2006], [Lichtenthaler et al. 2008] concluded to a limited success of open innovation platforms owing to the low number of initiated technology transactions on these internet marketplaces. To better understand these statements, the present work attempts to analyse how performing these intermediation practices are in the bio-industrial sectors. The adequate relevance of such strategies lies in the balance between the allocated resources according to the main objectives of the project. Thus, our concrete case study has shown that the well-defined study specifications during the early phases are one of the main success factors. These observations highlight the effect of the intermediary's maturity on its ability to formalise partnerships between solution seekers and innovative organizations and are in agreement with the main challenges highlighted by Sieg et al. [2010] (gathering internal human resources, selecting appropriated problems and formalizing these problems to get constructive solutions). In addition, the characteristics of bio-industrial sectors are key parameters to explain the obtained results. Thus, the regulatory contexts in these sectors can either be seen as a driving-force or an obstacle for further exchanges. In the pharmaceutical industry, the research of new drugs and innovative excipients is continual and in the first explorative steps, the performance of new ingredients and/or excipients prevails over regulatory and economic constraints. That is why this sector is considered as the more "open" bio-industrial sector [Bianchi et al. 2011]. Thus, concrete exchanges with pharmaceutical laboratories have been initiated in the EBISilc® project framework. Otherwise, in the cosmetic industry, the regulatory constraints are driving forces to integrate new technologies in this sector. For instance, the European Cosmetics Regulation imposes to stop testing finished products on animals. This specific regulatory constraint has led to design, for instance, new predictive models (reconstructed tissues such as skin, cornea, gingiva and pulmonary mucosa). Such examples highlight the positive aspect of the regulation on new products development in the bio-industrial sectors. However, on the other hand, the expected performance, the price and the regulatory aspects (toxicity, INCI names, REACH registration of precursors etc…) can be critical obstacles for the integration of new technologies in this line of business. All these observations are distinguishing features of the open innovation paradigm in the main bio-industrial sectors. Finally, this study also raises future research directions, such as the need of methods and measurements to analyse the innovation activities and especially open innovation practices. Thus, the performance triangle used in this study is proposed as a relevant measurement of the innovation intermediaries' performance.

6.2 Perspectives

The main perspective of this study lies in the two-sided feature of the "marketplace" platforms. In the presented study, we used the inbound open innovation aspect in which companies are looking for new ideas and new technologies in order to integrate them in their "innovation funnel". The other side of such intermediaries consists in the ability of companies to post their technology needs and to find partners to answer it. These "tech needs" can be considered as innovation-oriented bills of specifications taking account not only technical needs but also regulatory constraints, marketing expectations, intellectual property status and economical needs. Finally, this work aims to propose a model of the innovation process in which the specificities of both platforms' activities are taken into account; in order to improve the new (bio)-product design process.

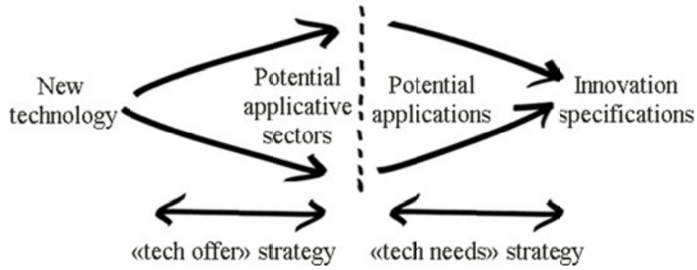

Figure 5. Innovation-oriented design process

Firstly, the "tech offer" strategy presented in this paper is modelled by a divergent phase. It aims to open up the field of possibilities by finding potential applications and potential applicative sectors. In our case study, this first step led to tangible contacts with their own expectations and constraints. The second step of our proposed innovation process can be modelled by a convergent phase. The "tech need" strategy allows the writing of several innovation-oriented bills of specifications following targeted companies' requirements. Thus, in the EBISilc® project framework, several industrial needs were raised by screening both intern and extern open innovation platforms: antimicrobial activity (11 technology requests), modification of drug release profile (4 technology requests), polyfunctional cosmetic ingredients (7 technology requests), heavy metal removal (4 technology requests) and anti-sebum / antiperspirant (4 technology requests). Concretely, all this information will be used to redesign the technology in agreement with the industrial technical and non-technical expectations. Finally, such design process aims to improve the innovation potential of the developed technology, by meeting as closely as possible to technical and non-technical industrial needs.

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