METHODOLOGY FOR THE CREATION OF VALUE CHAINS ADAPTED TO TECHNICAL AND RADICAL INNOVATION

François Petetin[a], Gwenola Bertoluci[b] and Jean-Claude Bocquet[c]

Laboratoire Génie Industriel, Ecole Centrale Paris, Paris, France.
Email: [a]francois.petetin@ecp.fr, [b]gwenola.bertoluci@ecp.fr, [c]jean-claude.bocquet@ecp.fr

Innovation, however beneficial for a company, introduces risks proportional to the degree of disruption caused by the suggested innovation. Moreover, the new product development process includes several operational, tactical and strategical decisions: new technologies involved, implementation and adjustment of manufacturing processes, make or buy decision, innovation protection, market introduction. . . Alternatives considered for each of these decisions can be translated into significantly different industrial and commercial scenarios. These scenarios will result in the creation and destruction of values for each stakeholder of the project and in a certain level of risk induced. In order to maximize this value creation and minimize the risks and value destruction, it is essential to have beforehand an accurate model of this value flow. In this article we describe a methodology that aims to simulate the value creation for each of these scenarios and apply it to the case of a small aeronautics integrator.

Keywords: Innovation, New product development, Systemic modeling, Decision making in design.

1. INTRODUCTION

In today's industrial world, the concept of innovation seems to be key for the subsistence of any company. It provides competitive advantages, helps a firm to increase its margins or enables it to access new markets. Does this mean that innovation is always good or should it always be a main target? All these benefits come with a price. Launching a new product induces lots of risks and changes within the company's structure. Are the benefits of the innovation worth it? Will the new values created for the firm and its partners by the innovation make up for the risks and the changes related to its development?

In some environments, this question is crucial. In the aeronautic industry innovating can be complicated. Some products are critical; they are subjected to a very aggressive environment and the safety of the flights relies upon them. Depending on the level of criticity of the system, the expectations in reliability can be extremely high; therefore innovation can face a difficult challenge coping with these expectations. A firm producing systems with high level of criticity will have a hard time convincing the certification authorities and their clients that their new products will work as well as the previous ones which were operating without problems for years.

Innovation is often presented as the result of a well defined process including analysis of the customer's need, conceptual design, detailed design, etc. But sometimes ideas believed to have some potential appear in structures which do not have a dedicated innovation process. What kind of approach can be adopted in such cases? Moreover, the new product development process includes several operational, tactical and strategical decisions: new technologies applied implementation and adjustment of manufacturing processes, make or buy decision, innovation protection, introduction market, etc. Especially when dealing with radical innovation, alternatives considered for each of

Research into Design — Supporting Sustainable Product Development. *Edited by* Amaresh Chakrabarti

ISBN: 978-981-08-7721-7

these decisions can be translated in significantly different industrial and commercial scenarios. These scenarios will result in the creation and destruction of values for each stakeholder of the project and involve a certain level of induced risk. In order to maximize this value creation and minimize both risks and value destruction, it is essential to have beforehand an accurate model of the flow of value.

This question of value modeling in decision making help is the heart of our research. This research is currently applied to a small aeronautic integrator developing a disruptive innovation intended to replace one of their key products. In this article we present the methodology we are implementing in this firm in order to help it assessing the potential value flows generated by the innovation.

Our first step is to clarify through a bibliography review the different kinds of value considered by the authors: economic value, quality, on time delivery, knowledge, know-how, social, environmental, ethical, etc. The notion of value being well defined and narrowed down to fit our context, we express the abilities required to design an organization able to create the optimal value aggregate for its stakeholders. We, then, carry out a review of the different tools and methods commonly used in enterprises and in the field of industrial engineering to manage this value. This review will show that none of these tools do have all the abilities previously quoted. The next step presents the methodology we developed. The implementation of this methodology is achieved in three steps: specifications drawing-up, model construction, value creation simulation. Finally, we present the ongoing application of this methodology to our case study.

2. RESEARCH CONTEXT

2.1. Value

As we said in the introduction, innovation is key to the survival of firms. Schumpeter, the early major author on the subject of innovation, presents it as one of the main causes of economic activity and growth [1]. Later, in his work about the stage-gate system, Cooper [2] describes innovation as "the strategic weapon" for a company to win the "product war" and shows that the innovativeness of a company is "the single strongest predictor of investment value". Hitt [3] in his work on technological knowledge management emphasizes that innovations produce core competencies and sustained competitive advantage for a firm. More recent works such as those of Jacobides [4] suggest that creating value through innovation should be seen as a prime objective when the way this value is shared (protection of the innovation, cession of licenses, etc.) comes second. Others, such as Van Horne [5] directly define innovation as "the use of innovative knowledge so as to create effective value for the stakeholders of the industry".

As we can see, there seems to be a wide consensus about the importance of innovation as a factor of value creation. However, since all these points of view come from different backgrounds-economy, engineering, etc.- that have different understandings of value, our next step was to concentrate on the different definitions of value in order to precise what kind of value creation can be expected from an innovation.

Companies have for a long time adopted a Taylorian view on value. In a context where demand was greater than supply, their only focus was the economic value created by their products and costs and profits the only measured indicators. Then, with the increase of supply, firms make more efforts to diversify from competitors. Products are no longer evaluated solely on their prices. The significance of the term value broadens and begin to include product quality and on time delivery [6].

The meaning of value evolves then with the economy. It is no longer linked only to the product but to the whole organization. The earlier definitions shift to include the factors increasing the capacity of organizations to create value. With the introduction of the concept of knowledge economy, knowledge, know-how and innovation are also considered as value [7]. Since Supply Chains are getting more and more complex, since the arrival of outsourcing, the quality of communication between actors begins to be also taken into account as a potential value for companies [8]. Finally, the increasing focus put on the notion of sustainable development since the 1990s made firms understand the capacity they have to create or destroy societal values. Nowadays, no company can pass on notions such as social,

environmental and ethical performances and employee satisfaction because of the impact it could have on their image among customers [9].

In conclusion, value can take many different forms. And with this complexification, organizations must adapt in order to enable such value creations. These values concern various internal or external stakeholders. All this makes the evaluation, the co-construction and the choice of a relevant values created by an innovation for its stakeholders very difficult. Conceiving an organisation able to create the optimal value aggregate for its stakeholders requires ability to:

— Identify the nature and the importance of each dimension of the value created in order to ensure that the launching of the innovation will sustain the strategy of the firm.
— Identify the activities and resources that can generate this value
— Select the best combination of these resources and activities in order to maximize the value creation for the stakeholders and satisfy the objectives of the firm.

2.2. Managing value creation

Achieving this goal is a complex task. However, lots of tools and methods have been developed through the years whose functions are to help organizations to manage value creation. Each of these tools and methods has a specific domain of application and focus. There are two fields of application: product-centred methods that tackle the issue of the management of the value created by a product and organization-centred methods whose objects of study is the organization that creates the value. One can also make a distinction between two main types of approaches: strategy-focused and tactic-focused methods.

Strategy-focused methods concentrate upon long term value creation. They usually try to advise their users on which are the best organizations or products to propose in order to ensure a good value creation. Tactic-focused methods on the other hand try to help an existing organization to increase their value creation on an existing product. In the next pages we are going to present an overview of the main methods used in industrial engineering.

2.2.1. Strategic-focused methods

Business plan is a tool used before the creation of a new business (be it profitable or non-profitable). It is the formalization of the business goals (including expected sales volumes and ROI), the plan devised to reach them, the investments required and the resource that are going to be used in the plan. The creation of a business plan reduces the risk that the organization will fail to reach its targets [10].

The *SWOT analysis* is a method used to show the Strength, Weaknesses (both determined through an internal appraisal), Opportunities and Threat (both determined through an external appraisal) of an organization in its environment and according to its objectives. Identifying these factors enables the organization to determine a strategy exploiting the positive ones to counter negative ones. This can be done through TOWS matrices that stimulate the elaboration of strategy built on a pair of factor: one internal (strength and weakness), one external (opportunities and threats).

Another method more centred on the analysis of the environment is the *Porter five forces analysis* [11]. This method underlines the existence of the five main forces that impact the performance of an industry: threat of new entrants, threat of substitute products, suppliers' bargaining power, customers' bargaining power, competitive rivalry in the industry. Analysing these factors enable a company to adapt its strategy on its environment and thus to increase its chances of success.

The *stakeholder theory* is also based upon an analysis of the environment of the organization. The objective is to take into account different kinds of values, especially non-economic and different kinds of stakeholders. Lepineux [12] enumerates five categories of stakeholders: shareholders, internal stakeholders (employees and trade union), operational associates (customers, suppliers, subcontractors, banks, insurance companies) social community (authorities, associations, NGOs) and natural environment.

Unlike the former one, the *Resource Based View* is an approach that focuses on an internal vision of an organization. It analyses the resources that present interesting value creation potentials. Barney [13] gives four attributes that can help assessing this potential:

— Valuability (capacity a resource has to exploit a strength or neutralize a weakness)
— Rarity (characteristic necessary to procure a competitive advantage to the firm)
— Imperfect imitability (characteristic necessary to ensure the advantage is sustainable)
— Difficult substitutability (no equivalent resources can be found by competitors)

This approach has been extended afterwards to knowledge (Knowledge Based View) as being an immaterial resource with particular characteristics (transmission, stocking…)

All these tools help organizations to conduct a reflection on their strategy and to adopt one that fits the specificities of the external or internal environment. But in order to implement this strategy throughout the organization, the results of this reflection must be traduced into inputs for tools having a more tactical focus. In the next paragraph we will focus on more tactic-focused tools and methods.

2.2.2. Tactic-focused methods

Total Quality Maintenance (TQM) is a method developed mostly by J.M. Juran, P.B. Crosby and W.E. Deming whose objective is to help a company ensure customer satisfaction through a good process management that induces continuous improvement. The Deming management method issues guidelines consisting of "14 points" that has to be respected in order to escape 7 deadly "diseases" and several "obstacles" [14].

Lean Manufacturing is a method which aims to help a production system to decrease the level of input resources necessary to deliver a product of a given value to a customer. This is achieved through an optimisation of the flows of material and information and an elimination of waste in the process.

Balanced Score Cards (BSC) is another tool, relatively new compared to the previous ones since it appeared during the 1990s. Its purpose is to reconcile the strategic and the operational visions in the global measure of the performance of a firm. It concentrates on four perspectives [15]: the financial perspective (vision the shareholders have of the company), the customer perspective (vision the customers have of the company), the perspective of internal processes (processes that need to be improved in order to be more competitive) and the development and learning perspective.

For each perspective targets that need to be reached in order to fulfill the company's strategy are defined. The fulfillment of these targets, measured through indicators, represents the position of the firm in relation to its strategic targets.

Value Analysis is a method that aims to optimize the value created by a product. To achieve this optimisation, Value Analysis recommends taking into account the value created by every function of the product during the design phase, these functions being determined through functional analysis. It is then possible to concentrate the effort of the design team on the function that creates value for the end-user.

Along with porter's value chain [16], value analysis is at the root of *Value Management*. This company management approach was developed during the 1990s. According to European and British standards, *"Value Management integrates the operational managers' efforts with those of higher management […] by concentrating objectively on outcomes which are in line with overall corporate objectives, in preference to local or short-term priorities"* [17]. This large approach conciliates several management tools.

Value Analysis is also a support to *Design to Cost* a method that includes a target cost as a design parameter. Adding this approach to Value analysis enables a design team to better arbitrate between the cost of a function and the value it creates.

Finally, *Concurrent engineering* is a method whose focus is in-between strategic and tactic. It advocates cooperation between marketing, engineering, manufacturing in the design phase of a product in order to shorten development time and improve quality.

All these tools are used by various categories of people: from executive committee to middle management and in different sectors such as financial or technical services. All aim to increase the value generated. However, in a phase of new product with radical innovation creation, there are very few ties between them.

2.2.3. Conclusion

As we have seen there are numerous tools that exist and that can help a company manage its value creation, be it from a tactic or a strategic point of view. However while facing the development of an innovation; it is necessary to keep both aspects into mind. It is widely accepted in today's literature that the success of an innovation relies partly on the compatibility of this innovation with the strategy of the firm that launch it [18–20]. However, in order to ensure the quality of the innovation and to shorten its development time it is also key to adopt a tactic-focused approach [21].

Moreover, these tools can be centered on the innovation or on the organization that will produce it (cf. Figure 1). A product-centered approach seems essential for us since we want to study the value created by the innovation. Yet such an approach is not sufficient; a company dealing with radical innovation may be confronted to important changes in its production system. It is thus essential to be able to study not only the value created by the product but also the organization that enables this value creation.

In conclusion of this study of the research context, we can state that the tools we described are not sufficient to help us resolve our problematic. All of them are useful in their own area. However, the positioning that needs to be adopted in order to satisfy the three abilities outlined in the introduction of our research question must include both the tactical and strategical aspects as well as both the

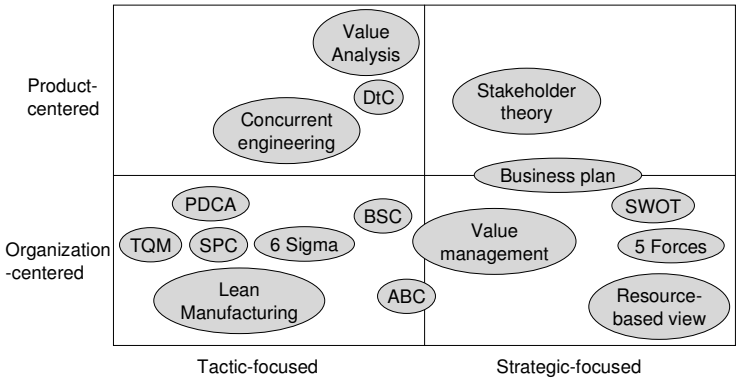

Figure 1. Tactic/strategic and product/organization positioning of value creation management tools.

Table 1. Positioning of the requirements of our methodology.

	Tactic	Strategic	Product	Organization
Identify the nature and the importance of each dimension of the value created in order to ensure that the launching of the innovation will sustain the strategy of the firm.		X	X	
Identify the activities and resources that can generate this value	X			X
Select the best combination of these resources and activities in order to maximize the value creation for the stakeholders and satisfy the objectives of the firm		X		X

product and organizational aspects (cf. Table 1), which none of tools described do. Thus we devised a methodology that does not replace other tools but can serve as a framework for the use of some of them while covering the four areas required (tactical, strategical, product and organization) and that aims to facilitate decision-making in the various phase of the innovation development.

3. PROPOSITION OF A METHODOLOGY FOR THE CREATION OF A VALUE CHAIN ADAPTED TO TECHNICAL AND RADICAL INNOVATION

The methodology we propose adopts the four points of view brought to light in the previous part, a condition necessary to answer the three requirements we identified. The implementation of this methodology is done in three steps: specifications drawing-up, model construction, value creation simulation.

3.1. Specification drawing-up

The first step in implementing a methodology is to be able to synthesize the expectations of the company and of the other stakeholders. This is done through a series of interviews inside and outside (if possible) the company. Considering the results of the bibliographic research we carried out, we specifically included in the questionnaire we devised the multi-facet vision of value. This questionnaire addresses two main topics: the innovation and the product that it might replace.

3.1.1. Current product

Part of the interview is devoted to gather information about the product the innovation aims to replace. The first step is to identify the different markets it is positioned on. Then for each of these markets we identify the main competitors and customers and try to characterize the relationship the company has with them. The interview then moves on to the identifications of the major strength of the product for the different stakeholders.

3.1.2. Innovation

The interview then focuses on the innovation. First we try to identify the different stakeholders of the innovation. Then, for each one of them, we identify their various expectations and concerns regarding the innovation and traduce them in terms of potential value creation or destruction. The next step is to identify through interviews with internal stakeholders the main technical, tactical and strategical choices that need to be done before the innovation can be launched. With these data, different scenarios for the innovation introduction and production can be elaborated.

3.2. Model construction

Once the specification drawing-up stage is done, the next stage is, for each of the scenarios identified in the last phase, to build a model representing the value chain of the current product on the one hand and of the innovation on the other hand. This is done by:

— Identifying the relationship between each stakeholder.
— Detailing the processes of these value chains in order to be able to identify the value created and the resources used in each activity. A particularly detailed focus must be adopted for activities responsible for important value creation or destruction and/or that uses a lot of resources.
— Quantifying each value creation using production management software.

3.3. Value creation simulation

The final step of our methodology is the simulation of value creation for the different scenarios. First, we simulate the value creation for the current product. These preliminary results are used to check

the accuracy of the model. Then we simulate the values created by the other scenarios. Finally, in order to help deciders to make the most coherent choice according to the strategy of their firm, three different aspects are presented: the values created by each scenario (represented on a radar chart), the different value chains related to these scenarios and the prospective scenarios for the introduction of the innovation.

4. CASE STUDY

4.1. Industrial context

In order to validate our methodology, we are using it on an innovation developed by an aeronautic integrator. This company is a small firm (a hundred of employees) whose engineering department, specialized in development rather than research deals mostly with incremental innovations. Their products are critical for the security of the aircraft and thus face very high expectations in term of reliability. The innovation developed is based on the use of a specific ceramic whose manufacturing process is not mature yet. The principles of operation of the innovation are also radically new. This paper only present the first steps of the methodology, the others still being in the pipeline.

4.2. Specification drawing-up

Due to confidentiality reasons we were only able to conduct interviews inside the company, with the exception of the ceramic supplier. The people interviewed were working in different areas of the company in order to obtain as broad a vision as possible. Nine persons were interviewed: the chief executor, the technical director, the chief financial director, the operations director, the commercial director and two people of his team, the quality manager and the purchasing manager. These, however helped us to bring to light different values thought to be expected by the stakeholders (cf. Figure 2).

A second batch of interviews conducted within the executive committee and with the ceramic supplier enabled us to narrow down the main technical, tactical and strategical choices: the ceramic manufacturing process, the level of integration of the manufacturing process, the types of customers that will have access to the innovation when it will be launched and the possibility to negotiate manufacturing licenses to the main competitors.

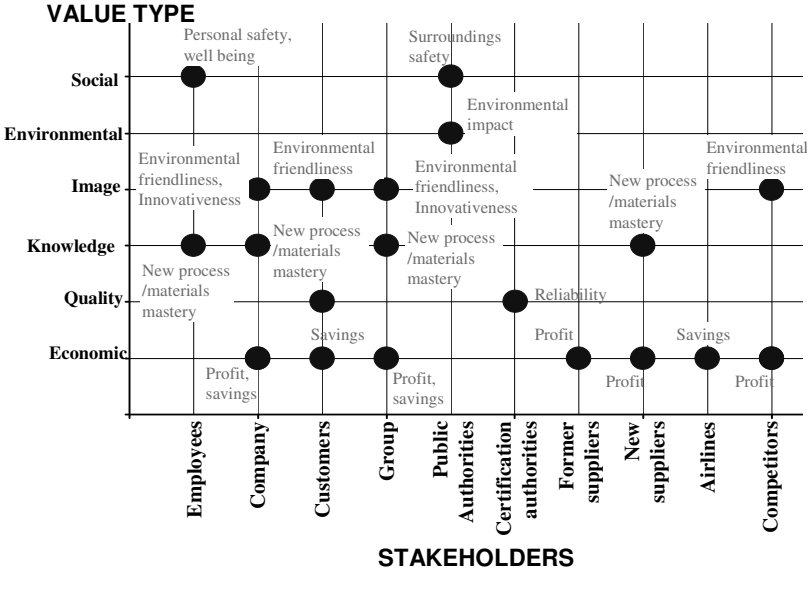

Figure 2. Stakeholders of the innovation and expected values.

5. CONCLUSION

In this paper, we described a methodology we propose for companies that want to develop radical innovations and that do not posses an internal dedicated structure. A first bibliographic review on the notion of value enabled us to bring to light several types of value that can be created by an innovation. These values concern different stakeholders and can be economical, social, environmental, etc. they can be linked to a product (profit, quality) or to an organization (knowledge, quality of communication). This review enabled us to decide on the abilities required to devise an organisation able to create the optimal value aggregate for its stakeholders.

Our next step was to study some of the most common tools used in industrial engineering to manage value creation. In this study we presented different focus these tools can adopt: tactic or strategic focus and organization or product focus. Since all four aspects are required in the definition of the abilities presented above, we identified a need for a methodology covering both a tactical and strategical point of view as well as product and organization focus, which could serve as a framework for the use of some of the tools described.

We then presented the methodology we advocate and its three steps: specifications drawing-up, model construction, value creation simulation. Finally we gave an example of a work in progress of the application of this methodology on an ongoing case study.

REFERENCES

1. Schumpeter, “Business Cycles”, Mac Graw Hill Book Co. Inc., 1939.
2. Cooper, “Stage-gate system: A new tool for managing new products”, Business horizons, May-June 1990, 1990.
3. Hitt, Ireland and Lee, “Technological learning, knowledge management, firm growth and performance: an introductory essay”, Journal of Engineering and Technology Management, 17, 231–246, 2000.
4. Jacobides, Knudsen and Augier, “Benefiting from innovation: Value creation, value appropriation and the role of industry architectures”, Research Policy, 35, 1200–1221, 2006.
5. Van Horne, Frayret and Poulin, “Creating value with innovation: From centre of expertise to the forest products industry”, Forest Policy and Economics, 8, 751–761, 2006.
6. Lebas, “Performance measurement and performance management”, international journal of production economics, 41, 23–35, 1995.
7. Le Masson, Weil and Hatchuel, “Processus d’innovation : conception innovante et croissance des entreprises “, Lavoisier, 2006.
8. Eckert and Clarkson, “If only I knew what you were going to do: communication and planning in large organizations”, 2004.
9. Déjean and Gond, “La responsabilité sociétale de l’entreprise: enjeux stratégiques et stratégies de recherche”, 2003.
10. Pic, Richard and Charron, “A chaque enjeu son Business Plan”, 2007.
11. Porter, “How competitive forces shape strategy”, Harvard Business Review, 1979.
12. Lépineux, “Dans quelle mesure une entreprise peut-elle être responsable à l’égard de la cohésion sociale”, Ph.D. Thesis, Sciences de gestion, Conservatoire National des Arts et Métiers — Laboratoire d’Investigation en Prospective, Stratégie et Organisation, 2003.
13. Barney, “Firm resources and sustained competitive advantage”, Journal of management 17, 99–120, 1991.
14. Rungtusanatham, Forza, Koka, Salvador and Nie, “TQM across multiple countries: Convergence Hypothesis versus National Specificity arguments”, Journal of Operations Management, 23, 43–63, 2005.
15. Michalska, “The usage of The Balanced Scorecard for the estimation of the enterprise’s effectiveness”, Journal of Materials Processing Technology, 162–163, 751–758, 2005.
16. Porter, “L’avantage concurrentiel: comment devancer ses concurrents et maintenir son avance”, Intereditions, 1986.
17. CEN, “Value management, European standard BS EN 12973:2000.” 2000.
18. Garcia-Muiña and Navas-Lopez, “Explaining and measuring success in new business: The effect of technological capabilities on firm results”, Technovation, 27, 30–46, 2007
19. Boly, “Ingénierie de l’innovation. Organisation et méthodologies des entreprises innovantes”, Lavoisier, 2008
20. Massa and Testa, “Innovation and SMEs: Misaligned perspectives and goals among entrepreneurs, academics, and policy makers”, Technovation, 28, 393–407, 2008
21. Boly, Morel, Renaud and Guidat, “Innovation in low tech SMBs: evidence of a necessary constructivist approach”, Technovation, 20, 161–168, 2000