HOW TO ADAPT THE INNOVATION PROCESS TO THE CONTEXT AND OBJECTIVES OF THE PROJECT

VINCENT BOLY,

Laboratoire ERPI, Institut national polytechnique de Lorraine,

Nancy, France.

MAURICIO CAMARGO,

Laboratoire ERPI, Institut national polytechnique de Lorraine,

Nancy, France

DANIEL GALVEZ,

Laboratoire ERPI, Institut national polytechnique de Lorraine,

Nancy, France

JOHAN CLAIRE,

Chambre de Commerce et d'Industrie de Lorraine, Metz, France

ABSTRACT:

Literature about innovation attests to a high variability at the new product development process (NPDP) level. Numerous models are proposed to describe the innovation process, including:

- Kline and Rosenberg and the Fuzzy Front-Ends

- The idea life cycle

- The open innovation model

- The Stage Gate model

However, even taking into account these meta-models, the description at the micro-level of the sequence of tasks and methodologies during the period between idea emergence and new product launching is scarcely identical, considering companies of the same sector and similar projects. Hence, adjusting the NPDP to the context and objectives of the company represents a key success factor.

Consequently, one theoretical challenge consists in finding interrelations between some initial characteristics of an innovative project and recommendations in the progress of the development phase. This requires the identification of some descriptive criteria characterising an innovative project, focusing on criteria that are documented and evaluable from the start, more precisely the fuzzy front

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ends of the project. Then the objective is to define methodology assisting decision-making in the field of new development process design based on these descriptive variables.

The research approach integrates a literature review about evaluation criteria available during the fuzzy front ends, including the degree of newness and the inner impacts of the new project (changes to product, production, sales). Secondly, choosing the stage gate model as a reference, a list of best project management practices is elaborated and a maturity grid is defined for each of these practices. Finally, an expert consultation is conducted and a multi-criteria algorithm established in order to define minimum maturity thresholds for each practice according to the outcomes of the evaluation of the descriptive criteria of the project.

This paper provides the main theoretical aspects. The limitations of the research are discussed, including the necessary evolution of the methodology.

Key words: Stage-gate, complexity, newness, innovation, project.

1. INTRODUCTION

Nowadays, companies have to offer products in constant renewal, to take new technologies into account and to satisfy increasingly exigent and diversified customers. From the original idea to the successful marketing of the product, the innovation process is long and complex and involves different persons from inside as well as outside the company (Kapsali, 2011). To be considered amongst the most innovative, a company must be competent throughout the entire New Product Development Process (NPD project).

Observation campaigns regarding NPDP within innovative companies attest to a high degree of variability (Boly, 2000). The sequence of tasks processing an idea is scarcely the same between two projects. Purposely or due to a lack of resources (time and competencies amongst others), people in charge of the project may or may not achieve some design activities. The way these tasks are ordered is also variable, hence marketing studies either precede or follow technical investigation. To be considered amongst the most innovative, a company must be competent throughout the entire New Product Development project (Kahn, 2012). Moreover the methodologies used by design teams depend on the type of data to be processed. Finally, if an open innovation strategy is followed, NPDP is the result of an adaptation between the practices of the partners involved. Then NPDP constitutes the outcome of the project team manager's choices and environmental constraints. Identifying the must-be activities and ordering represent major concerns when launching a new project (Mc Curdy, 2013). The project manager's capacity to select and order these activities influences success rates.

Note that this NPDP will evolve throughout the project and the initially planned version changes as knowledge is elaborated, intermediary design objects are produced and understanding increases about the main obstacles to be solved (Boujut and Blanco, 2003). As a result, the formalisation of this process is also important for managing ongoing projects.

Consequently, this research focuses on one aspect of MoT: the description of key success factors when launching a new project. More precisely, the fuzzy front end period is considered. Consequently, attention is directed towards the integration and anticipation of some basic variables when formalising an NPDP before launching new design studies. The final objective is the elaboration of a decision-aided methodology in the field of NPDP definition. This paper focuses on NPDP models from the literature and presents some adjustment variables between the process and the context. Then a methodology is proposed to help the formalisation of the NPDP. Experimental results are described and discussed.

2. NEW PRODUCT DEVELOPMENT PROCESS FORMALISATION

Many publications are available that describe the NPDP in different contexts: product, organisation or service innovation (Kanh et al., 2012). Authors propose models describing the different phenomena at the project level. The NPDP is considered as:

- A decisional process
- A process characterised by the transformation of objects called intermediary design objects. These objects are, amongst others: specification, drawing, prototype and marketing document.
- A sequence of tasks
- An informational process
- A cognitive process

Amongst the numerous models developed in the literature, some are often used as reference, including:

- Kline and Rosenberg and the Fuzzy Front-Ends (Koen *et al.*, 2005): this model highlights the interrelation between innovation stakeholders. Information flows connect people in charge of the successive tasks, including return on experience steps at the end of each work package. Decisions are made by groups of people integrating all the constraints and aspects of the project thanks to these informational links.

- The idea life cycle, (Gao *et al.*, 2007): highlighting the processing of concepts

- The open innovation model (Chesbrough *et al.*, 2008): this representation focuses on information exchanges between the company and its environment. Thanks to its NPDP, the company valorises external resources: from partners, contributors through the web, customers and various data producers. It is the outside-in process. Moreover, the company agrees to let part of its innovation results be valorised by external stakeholders: partners or suppliers. This is the inside-out process.

- The Stage Gate model (Cooper, 2008): this model divides the whole NPD process into several phases, separated by Gates (Preston, 2004). At each gate, results are analysed and propositions suggested by designers. Gates are supervised by top management and decisions are fixed: “go” meaning to go forward in the project (next stage can start), “no go” corresponding to termination of the development.

According to Preston, the structured methodologies give the project management process the advantage of some order. The Stage-Gate approach is considered an effective tool to manage, direct and control a project (Cooper, 1990). It is a conceptual and an operational model which is easy to formalise. Consequently, the main issue of this research is defined as follows: what are the variables to integrate when elaborating a specific stage gate model?

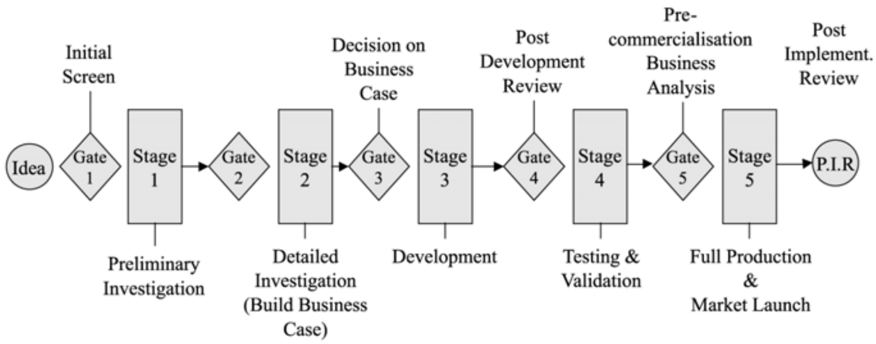

Figure one: stage gate model (Cooper, 2008)

3. ADJUSTMENT VARIABLES OF THE STAGE GATE MODEL

Different characteristics of innovative projects are studied in order to define the variables to be taken into account when elaborating the NPDP. These characteristics are: novelty and complexity.

Novelty

There are no generic evaluation criteria assessing the degree of newness of a new product being studied (Lorenz, 2010), but different measurement approaches have been developed and Garcia and Calantone (2002) have established a comparison between all of them. They base their analysis on the concept of discontinuity. More precisely, they distinguish discontinuity on a micro point of view (within the company) and on a macro point of view (company environment). Macro or micro discontinuities may affect the technical and/or commercial fields. Finally, three main degrees of newness are defined:

- Radical innovation when technical and commercial micro and macro levels are impacted

- Incremental innovation: when the macro domain does not change

- Really new innovation in other cases

Boly et al. (2012) suggest criteria quantifying these discontinuities: the effort needed to acquire the expertise relating to management of the future activity (including product manufacturing) is suggested in order to evaluate the technical discontinuity. Then the duration of the technical study is proposed, considering the internal dimension. More precisely, a threshold, *Tmax,* is set by top managers. Below this threshold, internal discontinuity is defined as being weak and above as being strong. Considering the environment of the company, accessibility of the required expertise is proposed. The external accessibility of knowledge is considered as low to high when it is available: in education institutions, in local technical centres, in research laboratories or by international experts.

Moreover, commercial discontinuity is considered weak when the customer type, the sales force and the distribution organisation are unchanged, coupled with a commercial investment under Cmax. In other cases: commercial discontinuity is considered strong.

As long as the project manager can easily assess these discontinuities before launching the project, they are proposed as adjustment variables when elaborating the stage gate model specific to this project.

Complexity

Innovative projects are considered as complex (Coates et al., 2001). New specifications applied to a product, a production process or an organisation interact with each other. Moreover, they impact the structure of the company, its competencies and its value creation dynamic. Kahlil (1999) also states that innovation influences the technological system of the company. As a consequence, each design decision potentially modifies the future structure of the company considered as a system. Complexity also emerges from the necessary combination of a design process and a learning process (Hull and Govin, 2010). As a project team aims at novelty, it is confronted with new problems to solve. Learning is then a key success factor (Jimenez and Valle, 2011).

A systematic approach may be mobilised to define assessment criteria about complexity. In line with the concept of discontinuity, the number of company descriptive variables impacted by the future product may be considered. Three main company elements are suggested: the product, the manufacturing process and the sales organisation. An environmental variable is added: the market. Indeed, any change concerning the targeted market of the company represents a new challenge (Talke et al, 2009).

Other variables may be taken into account, such as uncertainty. However, as the objective is to elaborate a methodology linking the description of the project and the elaboration of the NPDP, the number of descriptive variables has been minimised initially. And uncertainty may be partly considered as a consequence of novelty and complexity.

4. CONTRIBUTION TO THE DEFINITION OF A METHODOLOGY FOR THE STAGE GATE MODEL ELABORATION

The proposed methodology is based on:

- The descriptive variables presented in the preceding section
- Best innovation management practices suggested through the stage gate model
- Expert consultation and a multi-criteria algorithm established in order to define minimum maturity thresholds for each practice according to the outcomes of the evaluation of the descriptive criteria of the project.

Experts involved in the study are: three academics specialising in technology management and three innovative company managers. They suggest multi-criteria weights used to classify variables or to evaluate impacts. Note that the outcomes of the methodology are sensible to the expert's statements, but the objective is to develop a learning cycle requiring several successive experiments and return on experience about weighting. A methodology adaptable to sectors or certain contexts is envisaged based on a possible adjustment of weighting. Different phases are suggested to help a project manager define its specific stage gate model.

The first phase consists of project characterisation through novelty and complexity measurement.

The technical discontinuity is the first evaluation index used. A plan is elaborated with the internal effort of the company in ordinate and the accessibility of external knowledge in abscises. The first expert consultation consists of defining project categories on this map. More precisely, experts determine a score for each of the sixteen zones of the plan. The rule is then: the higher the score the higher the degree of newness. This means that the degree of newness is considered as equivalent (score = 2) between a fairly new project requiring a short study and facing the acquisition of knowledge in research laboratories, and a project of medium length NPDP facing traditional knowledge available in educational institutions. In fact, the four domains (product, process, sales organisation and market) are positioned on the grid.

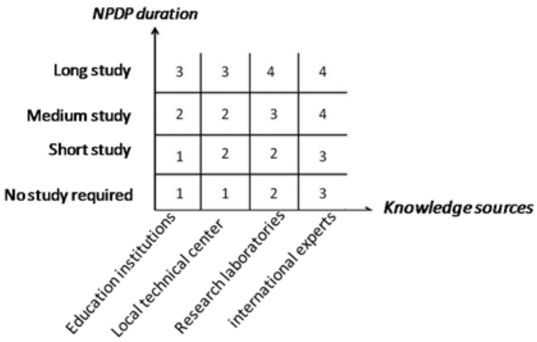

Figure two: a novelty grid to adjust NPDP (according to Garcia et al, 2002)

The project is then described, considering the number of elements it influences within the product, the production process, the sales organisation and the market. In order to obtain a complexity index, experts are asked to put a score on the importance of these impacts (Table One). Note that the present scores are calculated with the overall mean of each expert assumption. In further versions the goal is to define a set of scores specific to the considered sector in order to elaborate a genuine decision-aided tool.

Number of affected variables	1	2	3	4
Complexity Index	0	2	3	4

Table one: complexity index

To help the description of the future personalised stage gate, a list of typical innovation management practices is proposed. Once again, as the methodology has to be evolutive, this census is supposed to move as robustness strengthens and the adaptation to certain situations is effective. And it is even envisaged for each company to define its own referential list based on the specificity of its environment. Based on the literature, this list constitutes an operational referential to help the project manager to model its stage gate model. The selection is based on two criteria: an existing link between the given practice and one of the five stages defined by Cooper (2008), and the agreement of the experts.

1.	Technical skills development
2.	Project management skills development
3.	Financial skills development
4.	Management skills development
5.	Netwoks integration
6.	Organizational process design
7.	Governance
8.	Creativity
9.	External partners management
10.	Technological intelligence
11.	Design activities
12.	Tests
13.	Intellectual property

14.	Communications tools implementation
15.	Regular project debriefing and planification
16.	Budget elaboration
17.	Financing plan definition and implementation
18.	Business plan elaboration
19.	Adequacy between the strategy and the project
20.	Financial risks analysis
21.	Financial security of partners analysis
22.	Investment plan elaboration
23.	Strategy definition
24.	Value analysis
25.	Technological benchamrking
26.	Impact on the organization study

27.	Business plan
28.	Support services study
29.	Impact on equipment evaluation
30.	Impact on value chain evaluation
31.	Market study
32.	Customer need analysis

33.	Target costing and sustainable centered design
34.	Identification of suppliers
35.	Identification of competitors
36.	Price determination
37.	Distribution modes design
38.	Communication support design

Table two: list of referential innovative project management practices

Each practice is associated with a maturity grid elaborated from a literature review and validated by experts. Attention is then directed towards the relative importance of these innovation practices whether innovation concern is a product, a production process, a sales organisation or facing a new market. A cross-impact matrix between innovation management practices and these four items is defined with experts. This matrix is completed with three degrees of intensity: no impact (value = 0), moderate impact (value = 0.5) and high impact (value = 1).

$$IM = \begin{pmatrix} X_{1p} & X_{1f} & X_{1s} & X_{1m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{38p} & X_{38f} & X_{38s} & X_{38m} \end{pmatrix}$$

The resulting gross impact of the project is calculated using this matrix:

$$Aggregate\ Gross\ Impact\ Score\ per\ practice = P * X_{ip} + F * X_{if} + S * X_{is} + M * X_{im}$$

Where:

P= Level of novelty for product variable

F= Level of novelty for fabrication variable

S= Level of novelty for sales variable

M= Level of novelty for market variable

X_{ij}= Intensity of the impact of variable j on practice i.

Hence, if a project is characterised by a level of 3 in the degree of novelty grid corresponding to the product variable (P = 3) and a degree of novelty of 2 for market variable (M=2) and without changes for fabrication and sales (F=S=0), the following net gross impact is obtained.

$$Net\ GIS_i = 3 * X_{ip} + 0 * X_{if} + 0 * X_{is} + 2 * X_{im} = 3 * X_{ip} + 2 * X_{im}$$

Then, in order to assist the project manager, the minimum requirements that must be met to improve the success rate are fixed. Finally, the project manager will focus on one particular innovation practice if the theoretical importance of this practice (gross impact index) is under the minimum threshold.

The basic hypothesis is then: the newer and more complex the project is, the more robust the stage gate must be. Then the sum of the novelty index of each of the four domains (product, process, sales organisation and market) plus the complexity index is calculated. It represents the challenge to be faced by the project team. This sum is between 0 and 20 (GIS maximum = 16 + complexity index maximum = 4). Experts are asked to determine categories (intervals) based on this sum in order to determine which projects require a high investment in stage gate management. They give a score corresponding to a level of strictness of the requirements in terms of stage gate modelling.

Global Impact interval	[0;4[	[4;8[	[8;12[	[12;20]
Stage gate strictness Threshold	1	2	3	4

Table three: stage gate strictness level

Experts also consider that these thresholds attest to some problems in some borderline situations. More precisely, table three does not differentiate cases characterised by only one domain of innovation but a high level of novelty (a complexity index maximum of 1 and a gross impact score maximum of 4 for a threshold of 2), from cases with more domains of innovation but a low level of novelty.

As a consequence, minimum threshold principles are determined:

- If the degree of novelty of one or more variables is equal to or higher than a value of 3, the minimum threshold of requirements must not be less than 2.
- If the degree of novelty of one or more variables is the maximum (value 4), the minimum threshold of requirements must not be less than 3.

Then the stage gate strictness level is:

$$Final\ threshold = Max(brut\ threshold; threshold\ at\ limit\ conditions)$$

Finally, comparing the Net Gross Impact Index and the Stage Gate Strictness Level for each practice gives information about the most important tasks to pilot (high threshold) and about abilities to develop ($Net\ GIS_i$ under the threshold).

5. EXPERIMENTATION

Experimentations are driven in order to strengthen the methodology. Adopting a constructivist approach, the aspects to be tested about the methodology are:

- Relevance: meaning that users are able to make decisions with its outcomes
- Easy to adopt: the autonomy of users after one presentation is considered
- Reproducibility: whether users develop the methodology several times in different situations

Three innovative projects have been conducted within a panel of small and medium companies. The sectors of application are wide: aeronautics, food and services. The innovation concerns products (material or immaterial) or production processes and sometimes they have an impact on the sales organisation. The selection criteria of the experimental panel include: geographic proximity, the degree of novelty, the implication of top management and the agreement of the project manager. For confidentiality reasons, the name of the company and the nature of the innovation are not given. Researchers spend between two and five days (cumulative time) within each company. The following data are centred on the aeronautic project.

	Product	Process	Sales	Market
Project 1	3	2	3	2

Table four: novelty index of the experimental project

This project attests of an impact on each of the four innovation domains.

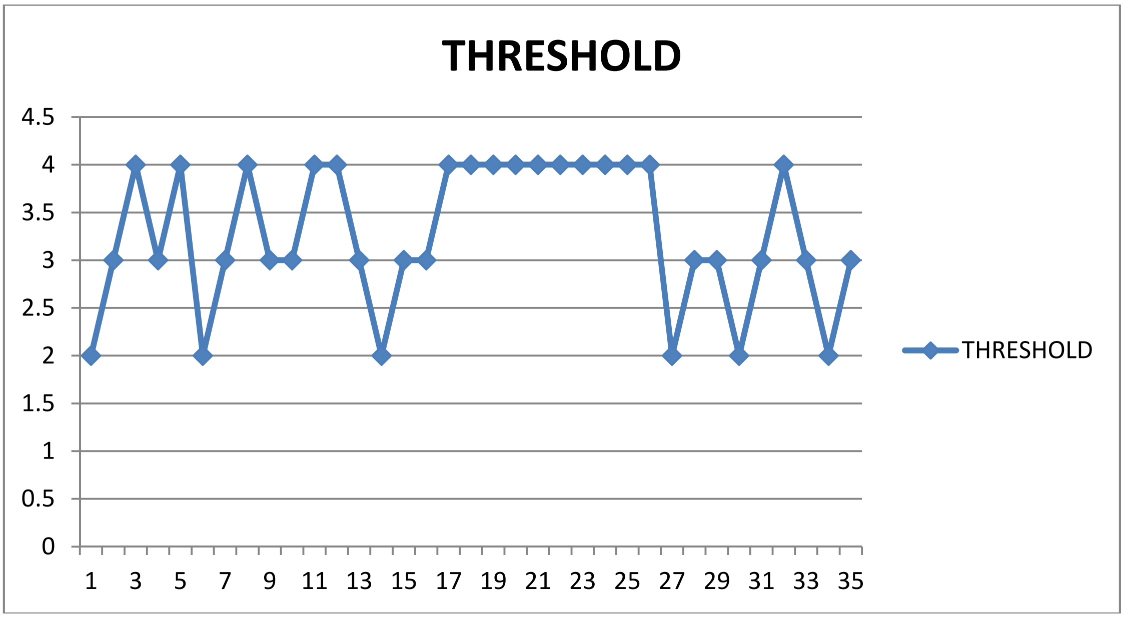

Figure three: stage gate strictness level for each of the 38 practices of project one

Figure three attests to a generally high level of stage gate strictness. Indeed, most of the calculated threshold scored at 4. This means that the abilities of the project team at each step of the project must be very professional. In this case, some decisions have been made by the project manager and its top management in consideration of these outcomes. First, the company maintained its project because of the targeted value creation. And an open innovation strategy was decided on as the size and resources of the company do not permit the allocation of all the competences required for the stage gate model elaborated. Partners were therefore contacted. An internal learning programme has been defined to help people manage this NPDP. At this stage, the maturity grids associated with the 38 practices were used. Considering Practice 13 (Intellectual Property) as an example, the maturity grid (Figure Four) provides elements to identify the skills to develop: in this case, it corresponds to the ability to supervise an industrial property expert.

Maturity grid associated to practice 13: intellectual property management			
No IP required	Survey required on pattents and norms	Supervising necesssary pattenting (subcontracted)	Pattenting

Figure four: maturity grid of practice 13: intellectual property management

Within the three-project panel, some similarities appear. First, all the project managers are highly involved in the degree of novelty and complexity indexes definition. They do not know about the newness evaluation. Second, in the four cases, modifications are made to the NPDP initially targeted (projects one and two) or help the first elaboration (project three). Thus, the process of NPDP definition is always impacted by the methodology. Third, the maturity grids are used to evaluate the impact matrix but also to define the operation to be initiated in order to improve the NPDP. In this last case, it often consists of passing from a case of the maturity grid to the successive one. Differences between the four projects are observed.

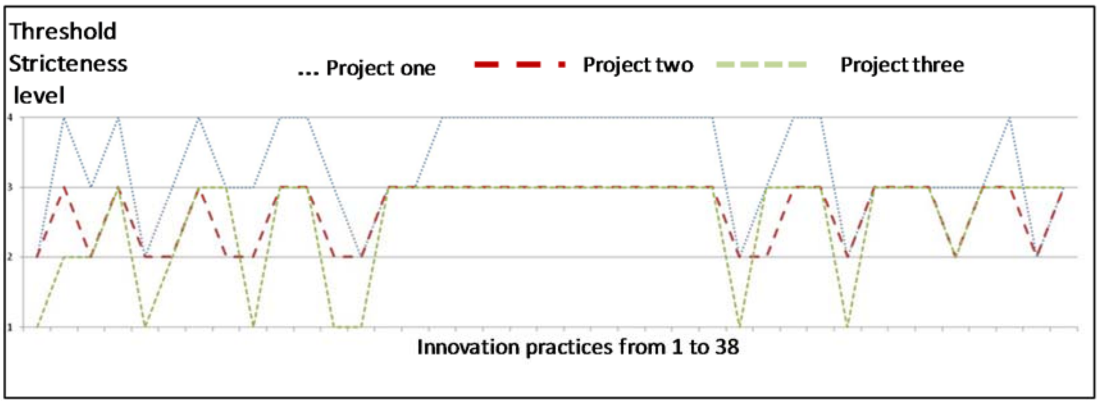

Figure five: stage gate strictness level for each of three experimental projects

First, project one is the only one to concern the four innovation domains (product, production process, sales and market). The profiles of the four threshold curves are totally different but no company decides to give up the project.

Therefore, the pertinence of the methodology is effective within the panel and project managers may be considered as autonomous after one utilisation. An experimental limitation remains: only one project per company has been studied; consequently, the capacity of the methodology to be duplicated is not proved.

6. DISCUSSION AND CONCLUSION

During the fuzzy front ends, the elaboration of an NPDP represents a complex task. Information is highly incomplete, not all problems are not clearly formalised and the environment remains partially unknown. Facing uncertainty, top managers need a methodology in order to structure a project approach that concerns all the people involved. The proposed methodology is based on two main criteria: degree of newness and complexity. These are easy to assess before launching a project. Minimum scores are elaborated as thresholds for a list of basic innovation management practices. Top managers may compare the measurement of each of these practices with these thresholds when they initially plan to achieve them. Experimentation attests to the pertinence of the approach: top managers succeed in calculating their scores and in giving priority to project management activities. However, this methodology is still under development. It is based on experts' propositions to weight the variables used. The weight evaluation is based on the mean of the propositions within the panel of experts, which constitutes a limitation, and other aggregation methods have to be studied. More experiments are also required, and a learning dynamic is even necessary in order to get more adapted weights. Obviously, the multi-criteria approach is sensible to the sector and time. The evolutive character of the methodology has yet to be studied. A list of 38 practices is therefore proposed after validation by experts, but this list has to be validated and versions are necessary to adapt to the sector and context. Nevertheless, as the objective is ultimately the elaboration of a decision-aided approach in the field of NPDP definition, attention is mainly directed towards techniques where managers will be able to calibrate the weighting, taking their priorities and external constraints into account.

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