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# INFLUENCE OF TOOLS INPUT/OUTPUT REQUIREMENTS ON MANAGERS CORE FRONT END ACTIVITIES IN NEW PRODUCT DEVELOPMENT

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## ABSTRACT

The object of analysis of this explorative research is the Fuzzy Front End of Innovation in Product Development, described by those activities going from the opportunity identification to the concept definition. Business scholars have shown that confusion in terms of goals and different ideas about opportunities; make this early phase of the innovation process uncertain and extremely risky. Literature suggests that the understanding, selection and use of appropriate tools/techniques to support decision making are instrumental for a less fuzzy front end of innovation. This paper considers the adoption and use of such tools and the ways that new product development processes can change accordingly.

The starting hypothesis that we test here, using 5 case studies in Italy and Denmark, is that managers have to fully understand the needed input requirements and be aware of potential of such tools, in order to experience the expected outcomes downstream. By means of in depth semi-structured interviews, questionnaires and an online survey, we will here investigate the dynamics of tools selection, exploring its effect on the level of difficulty of usage and the potential impact on the efficacy of the new product development process is carried-out.

First results show that managers have a low/very low awareness of tools' inputs/outputs requirements. This gives life to the problem according to which managers cannot select appropriate tools if they do not know their basic characteristics, challenging the opportunity to improve the efficacy of the NPD

process. The problem is exacerbated by the contrasting assessments got on the dimension of the tools' difficulty of usage: the low tools' inputs/outputs requirements awareness inevitably affect the level of perceived difficulty of usage which, in turn, pushes managers in the wrong direction when they have to cope with the tools selection problem.

*Keywords: Tools Requirements, Tools Adoption, Fuzzy Front End, New Product Development, Core Front End*

## INTRODUCTION

Three phases characterize the Innovation process: The Fuzzy Front End (FFE), the New Product Development (NPD), and the Commercialization (Koen et al., 2002). Although efficiency and effectiveness have been the two prominent parameters evaluated to set up a good market launch and get adequate payback and return on investments (Bonabeau, Bodick and Armstrong, 2008), (Lewis, 2001), (Schmidt, Sena and Olin, 2003), (Edgett, Shipley and Forbes, 1992), (Hart, 1992), (Alegre, Lapiedra and Chiva, 2006), the new products' failure rate is still high (Chin et al., 2008), (Easingwood and Storey, 1995), (Shepherd and Ahmed, 2000) and one of the reasons is the simplistic/vague approach towards the front end analyses. Every NPD process has a FFE in which products and projects are defined. However, the ways in which product ideas are generated, developed and assessed vary greatly (Koen et al., 2002), with great consequences to what happens to these projects downstream.

Two approaches are being used in the literature to depict the NPD process: sequential (Cooper, 2001), (McGrath and Akiyama, 1996) and non-sequential (Koen et al., 2002). The New Concept Development (NCD) (see Figure 1) developed by Koen et al. (2002) describes well the non sequential activities in the FFE. In such context comes the need for tools to help structuring, decision making or in general better handling of the NPD activities.

The model has a circular shape, to suggest that ideas are expected to flow, circulate, and iterate between and among all the five elements. Iteration and loop-backs are part of FFE activities (Koen et al., 2002). In contrast, the overall project cycle time and costs grow exponentially whenever there is redo activity as the project moves downstream through the NPD or StageGate™ process (Wheelwright and Clark, 1992). Even though the key elements of the FFE seem to have a clockwise progression, they are expected to proceed non-sequentially, as shown by the looping arrows between the elements (Koen et al., 2002).

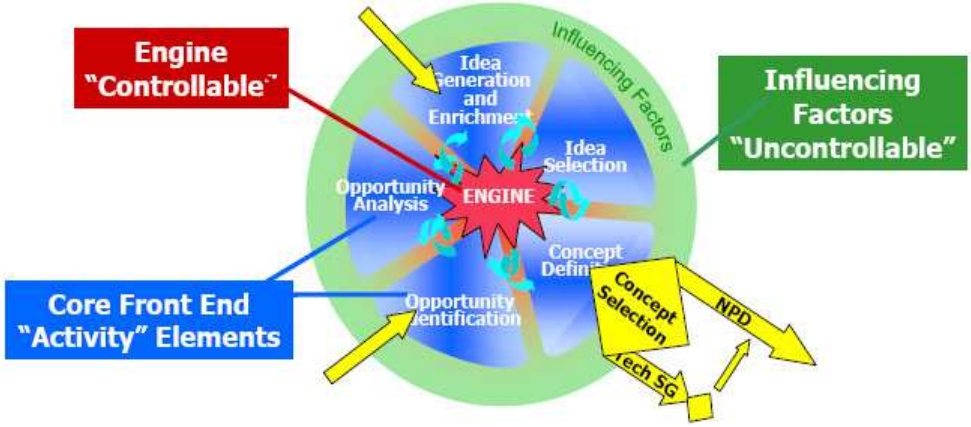



**Figure 1. The New Concept Development (NCD) model (Koen et al., 2002)**

Frequently, companies approach the FFE without a clear definition and analysis of the process to go from opportunity identification to concepts. For each stage of the

NCD model (Koen et al., 2002) several tools, such as brain storming, mind mapping, SWOT analysis, Technology Road Mapping, exist and can be used by designers and managers to improve, structure and organize their work in the FFE context. Despite the fact that failure rates of new products remain high, there is still resistance to adopt tools and techniques to support new product development, even when these are seen as clear opportunities to improve NPD output (Njissen and Frambach (2000). Furthermore, Nijssen and Lieshout (1995) have provided initial support for a positive relationship between the use of NPD tools and performance.

However, the devil is in the details: and these tools tend to be selected and used in a heuristic manner, while the way that these tools have been adopted has a big influence on the total cost of a NPD project, since 70% of project cost is determined by the decisions made during the FFE (Koen et al., 2002). Furthermore, some tools are preferred and more effective during specific phases of FFE (Commission and Innova, 2008), and according to Schilling and Hill (1998), using appropriate tools to improve the efficacy of NPD activities is a strategic imperative. It is exactly this last point that overarches in our explorative research. To be more precise, the objective of this paper is to point out the use of the word **appropriate**, where the term appropriate has been expressly highlighted.

Within the model proposed by Schilling and Hill (1998), we find the following assumption:

"Use of appropriate tools implies efficacy in NPD process".

That is, if decision makers adopt and use appropriate tools, this will have a positive impact on the efficacy of the New Product Development process. The use of appropriate tools implies the improvement in the efficacy dimension of the NPD process. *Appropriate* means being aware of *at least* tools inputs requirements and outputs potential (input/output requirements hereafter), besides their usage and interactions (this might introduce the other dimension of the appropriate usage).

It is worthy to note that inputs and outputs can be categorized as tangibles (products, services, spreadsheets, documents, etc) and intangibles (ideas, information, knowledge, etc). Managers who make decisions and who usually use tools to address them, have to understand what they need in terms of information, knowledge, procedures, ideas, theories both on the inputs and outputs sides to adopt and use a certain tool (or a combination of them), how can they select the appropriate one? This paradox can be represented as follows (see Figure 2):

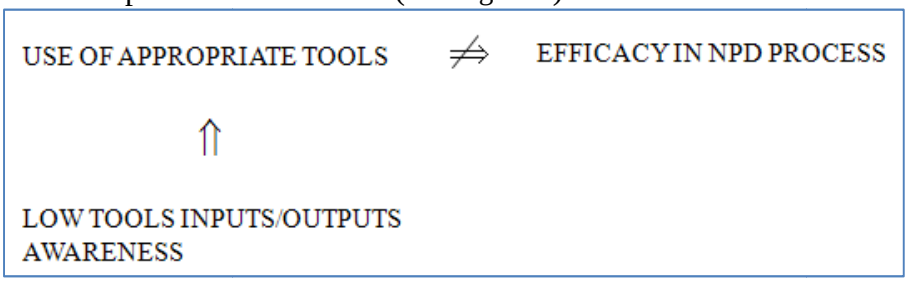



**Figure 2. Paradox of the appropriate tool adoption**

This lack of awareness on tools inputs/outputs requirements may create what we could call "a decisional gap".

Summing up, three stages seem to characterize the tools awareness to the NPD efficacy:

1. the Cognitive Stage (1), in which managers have a problem to solve and have to be aware of tools' inputs/outputs requirements to decide what tool(s) have to be selected in order to address the problem accordingly;

2. the Cognitive Stage (2), in which the "decisional gap" may occur. If a manager is not well-aware of tools input/output requirements, his/her perception of the *difficulty of its usage* would be distorted and he/she would probably not be able to select the *appropriate* tool (or he/she would not select it at all); if the manager selected the wrong tools (or the wrong combinations of tools), this might influence the NPD process efficacy;
3. the Implementation Stage, discussed in Schilling and Hill (1998).

## RESEARCH AIM

The aim of this paper is to understand the impact of application practices of such tools on NPD. To do so, we here explore in which way tools, methods and techniques (referred simply as *tools* hereafter) are used by managers, by mapping inputs/outputs requirements of each tool used in the core front end activities of innovation in the CFE of NPD before generating a valuable concept, and analyzing them against the dimension of the tools' perceived level of difficulty in usage. The latter becomes a relevant dimension as it can influence managers' choices about tools or their combinations.

This analysis will help practitioners to improve their use of decision and creativity support tools in order to be as effective as possible in identifying the right opportunities and discarding the 'false-negatives' (Chesbrough, 2003) from their portfolio, in the early stages of the NPD process. This would also help shortening the concept generation cycle time to approach the downstream phases of the NPD process more effectively and efficiently.

Furthermore, this study contributes to the debate among scholars on the relevance of the CFE of innovation and its impact on NPD, suggesting that adoption of tools to support decision making plays a critical role.

The hypothesis that managers have a complete set of information regarding tools to support the CFE, the hypothesis that they apply these tools according to *the manual instructions* are wrong and misleading. Research and practice in NPD needs to be acknowledge that the selection of **appropriate** tools is only the antecedent of complex and context-specific process of application.

## RESEARCH METHOD

This research uses a Sequential Exploratory Design approach (qualitative methods followed by quantitative techniques) (Creswell, 2009). The purpose of this strategy is using quantitative data and results to assist in the interpretation of qualitative findings; this is carried out with the primary focus of initially exploring a phenomenon.

An explorative analysis of the literature with the aim of classifying the tools was first carried out, from which 59 existing tools were assessed and considered.

The considered tools were assessed in terms of:

- Inputs, i.e. information, knowledge, procedures;
- Outputs, i.e. products, services, procedures, information, knowledge;
- Perceived level of difficulty of usage.

Tools were also classified according to the categories *Opportunity Identification* and *Analysis*, provided by Koen et al. (2002). **Errore. L'origine riferimento non è stata trovata.** illustrates the Koen's Model for FF E (Koen et al., 2002).

In order to build the link between theory and practice, the case study methodology was carried out with 2 Danish and 3 Italian companies. Both interviews and online survey were used for data collection. In this paper, the information collection was

done by means of a 4-step procedure that will be shortly described in the following sections.

## DATA COLLECTION

In order to collect information data from the companies' managers of NPD, a three steps procedure was carried out (see Figure 3). Many factors (e.g. available time, factors from inside and outside the work place, the relationship with the interviewer, the respondent's role experience, etc) could influence respondent's answers, and it is very difficult for the interviewer to control them. Given that and in order to reduce the effect of bias, it was decided to proceed with using both interviews and questionnaires. This is described in the following steps.

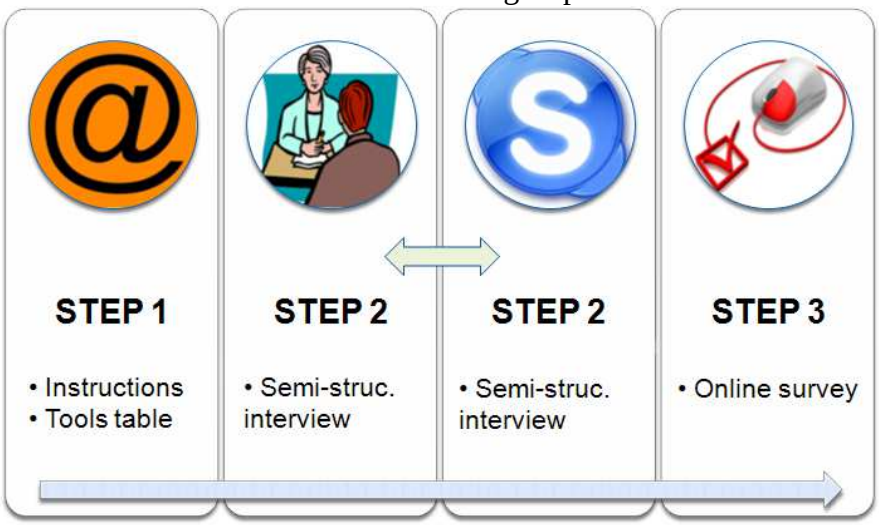



**Figure 3. Data collection process**

### Step 1: Tools reviewing

A PDF document containing indications about the context of FFE (focus on the CFE) and instructions about how to proceed was sent by e-mail, after a brief explanation of the context, to the managers that accepted to participate in the study. Then the managers are presented with a table containing all the tools reported by the authors from literature. This table is used to investigate if the company uses and/or knows the tools, in which of the two stages of the CFE they use them, and/or if they are used as a *standalone* tools or in combination with other tools. Additionally, the managers could add-in tools used within the organization and not listed in the table.

The aim of the step 1 is to map the tools' usage inside the companies' practices and processes and to uncover other tools that did not emerge from the literature review.

### Step 2: Mapping Inputs and Outputs

This step is a semi-structured interview that was carried out face-to-face (at the company's office), or via video conference.

The semi-structured interview used the last incident method as a starting point, followed by more specific questions about key FFE's parameters, to finally end with questions about the tools. The aim of this step is to have an in depth description of the environment in which the interviewee operates, to release further comments about step 1, to understand if the process is structured or not and, above all, to draw a comprehensive mapping of the inputs/outputs requirements of the used tools.

### Step 3: Assessing a critical dimension

An online survey was set up to assess the importance in regards to the used tools of the perceived level of difficulty in using them, by means of a five points Likert scale where 1 indicates "Very low level of difficulty" and 5 indicates "high level of difficulty". This dimension will contribute to highlighting how awareness of tools' inputs/outputs requirements can link to and potentially impact their adoption.

## REVIEW OF TOOLS USED IN OPPORTUNITY IDENTIFCATION AND ANALYSIS

From the literature review 59 tools used in the CFE of the FFE emerged. This section clusters these tools in order to ease further analysis and assessment.

Some of the methods utilized in the Opportunity Identification stage (structured approach) are:

- Customer trend analysis (17)
- Road mapping (4)
- Technology trend analysis (7)
- Competitive Intelligence Analysis (1)
- Market Research (11)
- Scenario Planning (1)
- Potential Problem/Opportunity Analysis (1)
- Opportunity Balance Matrix (1)

In the Opportunity Analysis stage, even though it is possible to use the same tools as in the former stage 0, the following tools were utilized:

- Team Building (1)
- Creative Thinking (13)
- Investment Analyses (1)
- Analytic Hierarchy Process (1)

Numbers in brackets indicate the number of tools that fit in each cluster.

### Qualitative assessment of tools

After the assessment of the usage of tools by the managers, a qualitative assessment is performed by the authors in terms of inputs and outputs. This step was carried out for all the 59 tools considered in this research. For example, by analyzing the literature about the Scenario Planning tool (Chermack, 2005), (Conway, 2004), (Drinkwater, 2003), (Godet, 2000), (Huss, 1988), (Ringland, 2006), (Schoemaker, 1993, 1995), (Wack, 1985), (Wheelwright and Clark, 1992) 31 relevant characteristics on the inputs side (i.e. all those things and characteristics a decision maker must know before selecting and using it), and 10 relevant points on the outputs side (i.e. all that the use of this tool can address, its potential outcomes) emerged.

We calculated a matching coefficient index. The coefficient helps comparing the managers' statements about tools inputs/outputs requirements with what has been found in the literature, with the aim to understand if they adopt and use those tools consistently and appropriately. The matching coefficient is calculated by means of the formula shown in equation 1:

$$m\% = \frac{\#\,manager\_requirements}{total\_\#\_requirements} \qquad (1)$$

where the denominator indicates the total number of requirements for either the inputs or outputs, whilst the numerator indicates how many of those requirements have been covered by the statements and descriptions provided by managers regarding each tool.

Five intervals were set up depending on the level of matching; this will help turning a numerical value into a semantic meaning:

- If m% ≤ 0,2 (low matching=1)
- If 0,2 < m% ≤ 0,4 (low-to-mid matching=2)
- If 0,4 < m% ≤ 0,6 (mid matching=3)
- If 0,6 < m% ≤ 0,8 (mid-to-high matching=4)
- If m% > 0,8 (high matching=5)

In the following sections the use of the matching index and how it is compared to the investigated dimension of Tools' Difficulty of Usage will be investigated.

## CASE STUDIES AND RESULTS

Five companies were involved in this study. As Geschka (1978) points out that to implement NPD tools and techniques successfully, a positive attitude of a firm's top management toward the use of such tools and techniques is essential, the managers with whom the interviews were conducted and their roles in the companies have been chosen accordingly (see Table 1): they are all experienced managers directly involved in the product development process.

**Table 1. List of Companies and Managers**

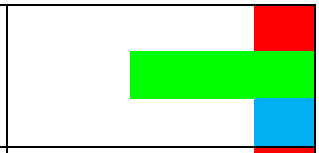
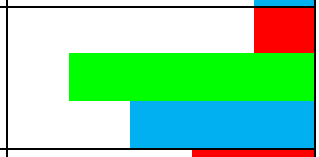
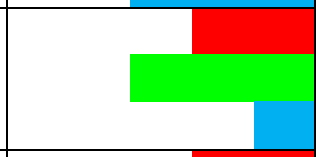
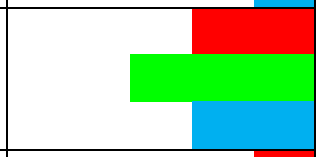
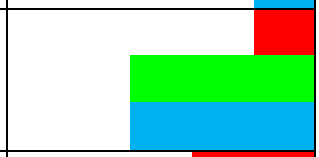
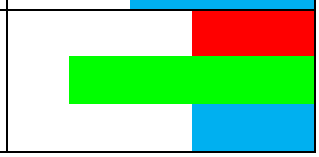
| Company | Location | Industry | Experience | Representative's role |
|---|---|---|---|---|
| 1 | DK | Engineering Consultancy | 25 years | Senior Engineer & Manager |
| 2 | IT | Engineering Handicraft | 8 years | Export Manager |
| 3 | IT | Plant Protection | 13 years | R&D Manager |
| 4 | IT | ICT | 8 years | Project Engineer Manager |
| 5 | DK | Healthcare | 9 years | R&D Innovation Manager |

### Tools Analysis by Category

This section will focus on the categories where the tools belong. This will help giving us a more comprehensive overview of how the managers under study use them.

**Table 2. Tools Categories analysis**

| **Tools Categories** | **$m\%_{INPUT}$**<br>**Difficulty**<br>**$m\%_{OUTPUT}$** | | | | |
|---|---|---|---|---|---|
| *Likert scale* | 5 | 4 | 3 | 2 | 1 |
| **Customer Trend Analysis** | | | | | |
| **Road mapping** | | | | | |

| | |
|---|---|
| **Technology Trend Analysis** |  |
| **Competitive Intelligence Analysis** |  |
| **Market Research** |  |
| **Scenario Planning** |  |
| **Creative Thinking** |  |
| **Investment Analyses** |  |
| **Analytic Hierarchy Process** |  |

Managers' choices highlighted some interesting trends about the tools categories. They use more frequently the tools belonging to the following categories:

- Creative Thinking;
- Market Research;
- Customer Trend Analysis;

whereas 38% of the tools reported from literature were never selected. Precisely 2/3 of them were chosen as "not-used" (mainly in the Customer Trend Analysis, Technologies Trend Analysis, Creative Thinking and PPA&OBM categories), whereas the remaining part, as "not-known".

As one can easily notice from the Table 2, the average score reached by each tools category is nearly never greater than 2, meaning that the awareness about tools inputs and outputs sways from low to very low. The perceived level of difficulty, instead, is around level 3, except for Competitive Intelligence Analysis and Analytic Hierarchy Process tools categories.

**Analysis of Tools Used by all the Companies**

In this section, a comparison of the tools usage based upon the tools that are used by all the 5 companies is carried out.

The tools that were selected by all the managers as being used during their CFE activities are the following:

1. Brainstorming
2. SWOT Analysis

3. Mind Mapping
4. Science&Technology Road mapping
5. Corporate or Product Technology Road mapping
6. Category Appraisal

From Table 3, again one can notice that all these tools are used with a low level of awareness (level 2 is the maximum obtained), both on the input and output requirements sides, with the exception for SWOT Analysis whose awareness is on average around 3 (not considering assessment given by Company 4).

By evaluating the inputs/outputs awareness against the perceived difficulty in usage, some contrasting behaviours emerge: there are managers who, despite the low awareness and knowledge about tools inputs and outputs, state they are not difficult to use when making decisions; there are others, instead, who state their difficulty in using certain tools in their decisional processes, mostly due to their low knowledge about them. The former situation is more common, then more interesting for this study to investigate.

**Table 3. Cross-Company tools analysis**

| **Tools** | **Cross-Company's Awareness and Dimensions evaluation** | | | | | |
|---|---|---|---|---|---|---|
| | Company # | C1 | C2 | C3 | C4 | C5 |
| **Brainstorming** | $m\%_{INPUT}$ | 2 | 1 | 2 | 1 | - |
| | $m\%_{OUTPUT}$ | 1 | 3 | 1 | 1 | - |
| | Difficulty | 1 | 4 | 3 | 1 | - |
| **SWOT Analysis** | $m\%_{INPUT}$ | 3 | - | 4 | 1 | 3 |
| | $m\%_{OUTPUT}$ | 2 | - | 3 | 1 | 3 |
| | Difficulty | 2 | - | 4 | 2 | 1 |
| **Mind Mapping** | $m\%_{INPUT}$ | 2 | - | 2 | 1 | - |
| | $m\%_{OUTPUT}$ | 2 | - | 1 | 1 | - |
| | Difficulty | 2 | - | 3 | 2 | - |
| **Science&Technology Road mapping** | $m\%_{INPUT}$ | - | 2 | 2 | 1 | - |
| | $m\%_{OUTPUT}$ | - | 1 | 1 | 1 | - |
| | Difficulty | - | 3 | 2 | 3 | - |
| **Corporate or Product Technology Road mapping** | $m\%_{INPUT}$ | - | 2 | 2 | 1 | - |
| | $m\%_{OUTPUT}$ | - | 1 | 1 | 1 | - |
| | Difficulty | - | 5 | 5 | 3 | - |
| **Category Appraisal** | $m\%_{INPUT}$ | - | 2 | - | 1 | 2 |
| | $m\%_{OUTPUT}$ | - | 1 | - | 1 | 2 |
| | Difficulty | - | 4 | - | 2 | 2 |

A question arises: how can managers formulate a consideration about the tools difficulty in usage when they do not know almost anything about its peculiar characteristics? Of course the moderate to high levels of perceived difficulty stated by managers signal that something has to be known before the system is used; but they select tools and use them! The paradox is that even though they are not well-aware of the inputs and outputs, they use them regardless of their peculiar characteristics. Due

to the low awareness on both inputs and outputs side, we could argue that judgements formulated have little to no foundation. Moreover, judgement expressed about similar tools by different managers in different contexts is difficult to compare (see Table 3). Tools, in different contexts, in the hands of different managers, are often used differently. From this, at least two questions arise at this point:

1. Is it possible to carry out general tools analyses involving many companies working in as many sectors without taking into account those differences?
2. Is it possible to ignore the way in which managers and designers use and adopt tools (probably due to their experience and good-sense) in their contexts?
3. Is it possible to assume that tools represent a strategic imperative to make more effective the NPD process without considering first, managers' knowledge about them and second, its impact on the managers' real difficulty in using tools?

The results from this study question a vast range of previous work based on tools which have taken for granted both the dynamics of tools adoption and their use, ranging from studies carried out by (Schilling and Hill, 1998), (Gonzales and Palacios, 2002), (Urban and Hauser, 1993), (Sheu, 2009), (Componation and Farrington, 2000), (Njissen and Frambach, 2000), (Thia et al., 2005), (Chai and Xin, 2006), (Maylor, 2001), (Driva, Pawar and Menon, 2001), (Corso et al., 2007), (Phelps, Chan and Kapsalis, 2001), among many others.

The risk is to shape the firm context in the decision making process of tool selection and usage, on what could be the management arbitrary approximations. The routine could become less effective, and the subsequent projects could be negatively influenced by the previous cumulated errors.

Appropriate tools become a strategic imperative if and only if they are known and selected not heuristically by managers.

## CONCLUSIONS AND FUTURE WORK

*Conclusion 1*: as tools are used coherently with the context in which managers/designers operate, tools-oriented analysis cross firm/industry are very challenging if not impossible to carry out. It is however possible to study their adoption and usage within the context of a single company. Of course, researchers can address questions about what kind and how many tools are used in a certain firm/industry (this can be done with a cross-firm/industry perspective), without making reference to the appropriateness of their selection and use. It follows that, being it a logic implication, the use of appropriate tools cannot be considered a strategic imperative (in the terms of Schilling and Hill, 1998) with the peculiarity of being generalizable, rather it might be considered such if and only if within the context of a single company. This, in turn, would make impossible any kind of cross-company study.

*Conclusion 2*: since tools cannot be evaluated in objective terms, nothing can be concluded about the process of selection of appropriate tools and the same goes for the downstream implementation stage. The link between the selection of the appropriate tools and the subsequent effectiveness of the NPD process cannot be supported because of the subjectivity level of tools selection, adoption and usage process.

*Conclusion 3*: it is no longer sufficient to say that tools have to be used to improve NPD activities; rather what has to be investigated is their adoption and usage by managers. Especially when, as highlighted in this study, there is a significant

difference between what theory reports as what managers should use and what they usually use in their context.

Future work has to be carried out, by evaluating other critical dimensions (such as Perceived Tools Effectiveness, Frequency of Usage, etc) and putting them against each other to explore the opportunity of building a theoretical model of the managers' decision making flow. To reduce the probability of bias, more managers should be interviewed, to eventually improve the understanding of the tools selection-adoption-use process, the ideal would be to investigate the decisional flow by being closer to the manager in its daily decision making, to have a more closer look at the phenomenon. Finally, other interesting analyses can be undertaken by taking into account the combinations of tools used by mangers and their determinants and effects on the effectiveness of the NPD process, especially in the early stages.

## MANAGERIAL IMPLICATIONS

This explorative study highlights the importance for managers to be aware of peculiar characteristics of tools they usually use in their decision making activities. Adopting and using tools without knowing their inputs and outputs requirements may have a negative impact on the performance first, of the fuzzy front end and second, of the more downstream activities of the innovation process. Not taking into account those basic requirements may nullify the assumption upon which is posed the link between tools selection and efficacy of the new product development process as a whole. Using appropriate tools and using them appropriately is decisive to make right decisions. By avoiding personalization in tools usage and standardizing/systematizing their adoption process (even in combination) may be of help for making the fuzzy front end much less fuzzy.

Findings point to the relevance of the context of use, as we found no support to the idea that understanding and selecting the appropriate tools to assist front end activities streamlines the innovation process. Application is extremely context specific: personalization and adaptation play an important role, deviating results of adoption from expectations. As companies find their own way to navigate the fuzzy front-end waters of innovation, the personalized application of standardized tools leads to unexpected and context specific results. Given managers' contrasting behaviours in selecting decision making tools, what can be done to make them aware of the importance and relevance of the problem? How can researchers undertake tools-oriented studies if those who use them do not know the tools' fundamentals? A potential solution might be that of using e.g. Decision Support Systems which compensate for managers' lack of tools knowledge, or difficulty in recalling all the tools characteristics when they need them. Especially to dull the probability of bad adaptations and (re)inventions of tools within the firm context (Njissen and Frambach,1998).

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