UNDERSTANDING MANAGERS DECISION MAKING PROCESS FOR TOOLS SELECTION IN THE CORE FRONT END OF INNOVATION

Francesco P. Appio[1], Sofiane Achiche[2], Tim McAloone[2] and Alberto Di Minin[1]
(1) Scuola Superiore Sant'Anna (2) Technical University of Denmark

ABSTRACT
New product development (NPD) describes the process of bringing a new product or service to the market. The Fuzzy Front End (FFE) of Innovation is the term describing the activities happening before the product development phase of NPD. In the FFE of innovation, several tools are used to facilitate and optimise the activities. To select these tools, managers of the product development team have to use several premises to decide upon which tool is more appropriate to which activity. This paper proposes an approach to model the decision making process of the managers. The results underline the dimensions influencing the decision process before a certain tool is chosen, and how those tools impact the performance of cost, time and efficiency. In order to achieve this, five companies participated for the data collection. Interesting trends and differences emerge from the analysis of the data in hand, and several hypotheses are tested. A preliminary version of a theoretical model depicting the decision process of managers during tools selection in the FFE is proposed. The theoretical model is built from the constructed hypotheses.

Keywords: Fuzzy Front End, New Product Development, Tools, Decision Making

1 INTRODUCTION
Innovation in new product development (NPD) can be described as comprising the fuzzy front end (FFE), the product development (PD) process, and commercialization [9], where one of the influential factors is a concrete management mechanism [5]. Although there is no widely accepted definition of the FFE, the definition adopted here is the following: the FFE is defined as being all the activities that come before the more formal and well structured PD process [8]. It concerns the stages from the Opportunity Identification to the Concept Definition (see Figure 1), under conditions of high market and/or technological uncertainties, and low availability of valuable information [2][20]. Even though there is a continuum between the FFE and the PD, the activities in the FFE are often chaotic, unpredictable and unstructured [9]. Moreover, attention has nearly always been turned to the efficiency and effectiveness of the PD activities, in order to set up a good market launch and get adequate payback and return on investments. Nevertheless, new products failure rate is still high, as for every 3000 rough ideas only 1 becomes a successful product [17]. Every NPD process has a FFE in which products and projects are defined. Koen et al. propose a non-sequential relationship model [9], illustrated in Figure 1, which is used as a framework model for innovation in this paper and will be used for the classification of the tools.

For each stage of Koen's Model [9] several tools, such as brainstorming, mind-mapping, etc., exist and can be used by engineers/designers and managers (managers hereafter) to improve, structure and organise their decision making in the FFE context. Some of these tools are more effective during specific phases of the FFE [6] and according to Schilling and Hill [15], using appropriate tools to improve the efficiency of NPD activities is a strategic imperative. Furthermore, 70% of project cost is determined by the decisions made during the FFE [8] and that cost increases whenever there is a loop-back to the beginning of the process. Therefore, it becomes very critical to better understand the mechanisms leading managers to select tools, along with an economic and effectiveness evaluation of their use. The research presented in this paper combines both the effort in understanding the logic behind selecting tools during the early stages of NPD process and building a theoretical model which could help depict the process of the decision making process of managers in regards to tools selection and usage in FFE activities. In order to achieve this, five managers from five different companies, Danish and Italian, were used for the data collection.

Figure 1
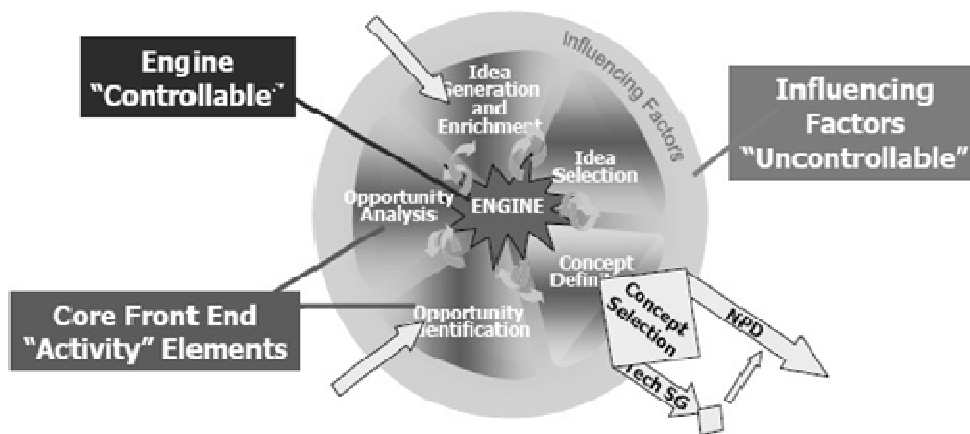
2 RESEARCH AIM

The aim of this research is to develop a theoretical model which aptly describes the decision making process used by managers to adopt and use tools during the FFE of innovation. Furthermore, the consequences of their uses are also studied in terms of money needed, people involved and effectiveness. In order to generate the theoretical model, one has to identify the input- and the output parameters in terms of macro-parameters and micro-parameters that influence the selection and usage of tools. Other variables, such as tools' usage frequency, are analysed to uncover interdependencies and the underlying decisional flow of managers during the FFE activities.

3 RESEARCH METHODOLOGY

The research methodology adopted for this research began with an explorative approach, to classify relevant tools for FFE. Fifty-nine tools were assessed and considered. It is noteworthy that "Tools" embraces methods, models, systems, frameworks and techniques. Tools were assessed in terms of:
- Inputs, i.e. information, knowledge, procedures;
- Outputs, i.e. products, services, procedures, information, knowledge;
- Resources, i.e. two macro-parameters have been chosen from the analysis of the literature to describe the resource requirements. Both of them, divided into micro-parameters.

The tools were also classified according to the categories in which they were used, i.e. opportunity analysis and opportunity identification [8], as shown in Figure 1. In this paper we only focus on those two steps, also commonly known as the core front end (CFE) activities of the FFE. In order to link theory to practice, the case study methodology was carried out with two Danish and three Italian companies. The information collection was carried out by means of a four-step procedure. Once the data was collected, a number of hypotheses about decision making of managers during the CFE were tested and used to build a theoretical model.

3.1 Case Analysis Methodology

Two levels of complexity have to be considered to frame this research:
- Continuum between inductive and deductive approaches [7];
- Continuum between nomothetic (objectivist) and hermeneutic (subjectivist) approaches [12].

The research presented here is based on the observation, comprehension and interpretation of a phenomenon (hence hermeneutic); also, it is intent on generating new theoretical contributions in the field of Decision Sciences (hence inductive).

In this research five case studies (tool) are used as means to generate a specific theory (product). This approach is legitimised as a scientific methodology with high currency, as it refers to the characteristics of research that affect the contextual relevance of findings across measures, methods, persons, settings, and time, pertaining this to the generalisability of results [3]. The framework by Eisenhardt [7] also cited in [18] is followed by authors to structure the use of the case analysis methodology. In order to understand the *why* of this research [18] and the underlying theory of the FFE, a preliminary screening of the literature was carried out. The research focus was established around the general topic of decision support in the FFE activities. Therefore, using the Koen's NCD

model [8] the focus was put on the CFE activities, where one has to identify all tools used in these two stages, assessing them in terms of inputs, what users need to know to use every tool ($m_{INPUT\%}$); outputs, everything that could be obtained from using the tool ($m_{OUPUT\%}$); and resources (the use of monetary and non monetary resources).

3.2 Cases Studies

Five companies participated in the study. From each company, a manager, representing the company, participated in the four-step methodology. One of the limitations of this research can be found in that only one manager per company was surveyed and interviewed. However, this is offset by the fact that each of them has more than eight years of experience in product development and hence can be considered an expert. While this number might seem low, there is, in fact, no agreement about the sample size and no standards by which a sample size selection could be evaluated for expert participants [10]. Table 1 gives more information about the participants.

Table 1. Details of Companies Cases

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

3.3 Crafting Instruments and Protocols

Multiple sources of data were used to increase validity and reduce bias. These sources were in form of questionnaires, interviews and secondary data such as existing literature on the subject [4][8][15]. The four-step methodology for data collection is explained in details in the following subsections.

3.3.1 Step 1: Tools Reviewing

The aim of the step 1 is to map the tools' usage inside the companies' practices and processes and to discover other tools that did not emerge from the literature review or special combinations of tools the managers might use. From the literature review many tools used in the CFE emerged. A clustering of these tools was carried out in order to ease their analysis and assessment. Some of the tools utilised in the Opportunity Identification stage (structured approach) are Customer trend analysis, Road mapping, etc., whereas, it is possible to conduct analysis of the same stage in an informal way with tools such as Ad hoc sessions, Water Cooler, etc. [8]. In the Opportunity Analysis stage it is possible to use the same tools as in the Opportunity Identification stage [8]. Table 2 gives a brief example of the tools' clustering for each phase and their description. A document containing an introduction to the FFE context (focus on the CFE) and instructions about how to proceed was sent by e-mail, after a brief explanation of the context, to the manager. Then, the managers were presented with the complete version of Table 2. The managers were also asked to add in tools that were not listed or tools they use in combination with other tools (tool genesis). Furthermore, they had to state if the tools were used in the opportunity analysis or opportunity identification phase.

3.3.2 Step 2: Mapping Inputs and Outputs

This step is a semi-structured interview that was carried out face-to-face (onsite at the companies), or via Video Conference. The semi-structured interview approach 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 get 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 to draw a comprehensive mapping of the inputs and outputs of tools.

Table 2. Clustering of Tools

Stage of the NCD model	Context	Tool	Short description	Reference
Opportunity Identification	Technologies trend analysis	S-curve	Technology has a life cycle	[4]

			interpreted by a curve … etc	
			…	[14]
		Standard and dominant design		
	Market research	…	…	
Opportunity Analysis	Creative thinking	Brainstorming	It is defined as a semi-structured activity of a team. Its aim is to … etc.	[13]
		TRIZ	…	[19]
	Investment analysis	…	…	[1]

3.3.3 Step 3: Usage Intensity and Parameters Assessment

This step was carried out via e-mail. In this part the manager stated the use intensity of each tool using a five-point Likert scale. This was followed by an assessment of the macro-parameters and micro-parameters (described in details later in this paper), with a focus on the rate incidence (%) given by the interviewee during the interview. The aim of this step is to formalise results about the usage of resources implied by adopting a specific tool.
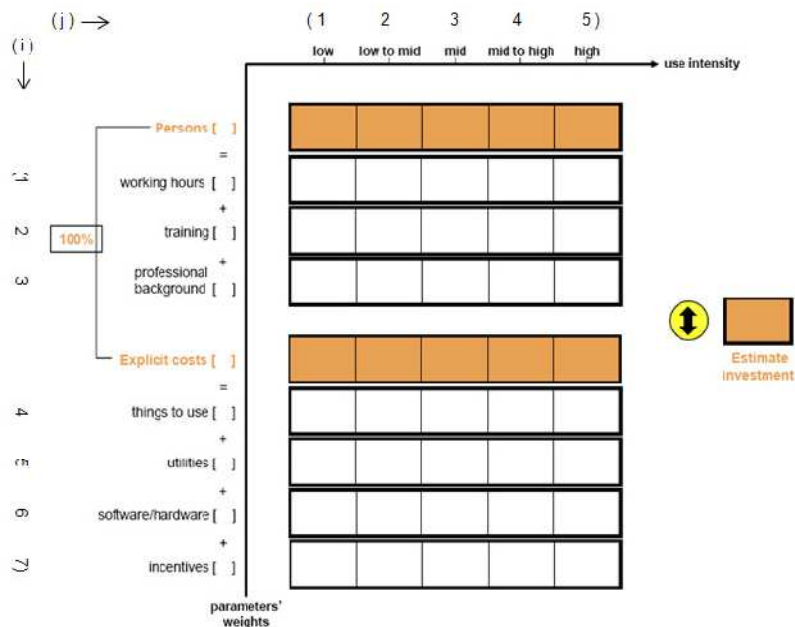

Figure 2. Final Evaluation Card (FEC)

After these three steps, the results were summarissed in a matrix called Final Evaluation Card (see Figure 2) this is composed of two axes, the vertical one for indicating the parameters' weights, and the horizontal one to represent the use intensity; two grids are constructed to obtain the Estimate Investment (qualitative evaluation) related to a single tool. For each tool selected by the manager an evaluation card was filled.

3.3.4 Step 4: Tools' Usage Preference and Frequency

This last step was implemented after a preliminary analysis of the previous ones was carried out. It was conducted in the form of online survey, by asking managers questions about Tools' Effectiveness, Frequency of Usage and Perceived Level of Difficulty in usage. It is worth noting that Frequency of Usage should not be confused with Use Intensity. The first concerns how many times a certain tool is selected to be used while the second, concerns the intensity to which a certain tool is used by referring to its sub-parameters. Each tool was evaluated individually and not relatively to each other. The online

survey asked, each respondent, questions concerning tools selection and use in the context of their company. It consisted of the following 3 statements:

1. For each tool listed below, please assess its effectiveness in carrying out activities during the core front end, where 1 indicates "lowest effectiveness" and 5 indicates "highest effectiveness";
2. For each tool listed below please indicate the Tool's frequency of usage, where 1 indicates "lowest frequency of usage" and 5 indicates "highest frequency of usage";
3. For each tool listed below please indicate the level of difficulty in using the tool, where 1 indicates "Very low level of difficulty" and 5 indicates "high level of difficulty".

4 RESULTS AND BUILDING OF THE THEORETICAL MODEL

This section explains in details the analysis made within the case and the search for cross case patterns. This analysis led to the building of the theoretical model and its hypotheses.

4.1 Within-Case Data Analysis

The recordings of each interview were transcribed, and the relevant information to the context of analysis was selected to find out relevant trends. Then the data of step 1 and 3 were combined to the findings that emerged during the interview (step 2). This process led to an assessment of tools in terms of the level of a quantitative investment required to use each tool. After the assessment of the usage of tools by the managers, a qualitative assessment is performed by the authors in terms of input/resources/output, an example is shown in Table 3.

Table 3. Tools Characterisation

Tool/Stage	Inputs	Resources	Outputs
CUSTOMER TREND ANALYSIS			
Category appraisal (Segmentation) Opportunity Identification	-customer-based approach -product-based approach -dependent variables -independent variables -questionnaire -interview -techniques	-PERSONS -working hours -time to decide what data will be collected, -time to decide how data will be gathered - … -training -professional background -marketing analysts -customer service analysts -EXPLICIT COSTS -things to use -audio recorder (for interview) -utilities	-complete definition of each segment -profile of each segment

Once all the tools were characterised, the authors carried out a classification of inputs, outputs and resources with the aim to uncover cluster dimensions (macro and micro parameters). The parameters that better depicted the resources consumption for tools usage were defined. The classification carried out by the authors gave the following results:

- Persons
    - Working hours
    - Training
    - Professional background
- Explicit Costs
    - Things to use
    - Utilities
    - Software/Hardware
    - Incentives

In the first macro-parameter Persons, "Working hours" refers to the hours dedicated from workers e.g. to select participants in workshops, to collect data, to analyze results, etc. "Training" refers to the necessary amount of hours to give adequate instructions, information or knowledge in order to perform a particular role e.g. in the conduction of a brainstorming session, etc. "Professional background" is a qualitative parameter, but it is possible to transform it in a quantitative one by means of simple data manipulations for instance comparing the background of the participant in comparison to what would be needed to use the tool efficiently, for example in order to use tools about category appraisal efficiently, the participant should have marketing analysts background, and customer service analysts skills. The second macro-parameter is Explicit Costs, where "Things to use" refers to things such as paper, pens, pencils, audio recorder, etc., that could be needed during the use of a specific tool. "Utilities" refers to room availability, internet connection, whiteboards, tables, etc. while "Software/hardware" is related to the use of things such as Office suite, printers, etc., as support to the decisions. Finally, "Incentives" refer to financial incentives to participate and/or adopt a specific tool.

4.1.1 Construction of the learning Data Sets

In order to understand how the data were gathered, we present here an example with one company. In this case "Company 1" will be used. In order to gather quantitative data, a formalization of results is carried out in terms of resources requirements per tool. The results can help the company to take into consideration the distribution and allocation of resources, as estimated by the manager (e.g. spotting inefficient allocation of resources). Company 1's Persons and Explicit Costs parameters usage are illustrated in Figure 3.
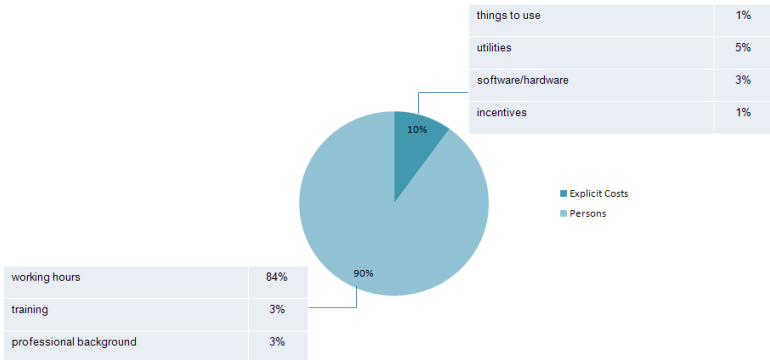

Figure 3: Incidence rate of Explicit Costs and Persons on the company 1's budget

The Persons' micro-parameters are expressed in terms of TIME. However the Explicit Costs' micro-parameters are expressed in terms of MONEY within the company. Considering the budget dedicated to the early stages of the Fuzzy Front End, the higher incidence is given by the macro-parameter Persons. Furthermore, for each tool the company's manager had to state the intensity of use of the tools based on a Likert scale 1-5, where 1 means Low Use Intensity and 5 means High Use Intensity. Figure 4 shows an example for the tool Brainstorming.
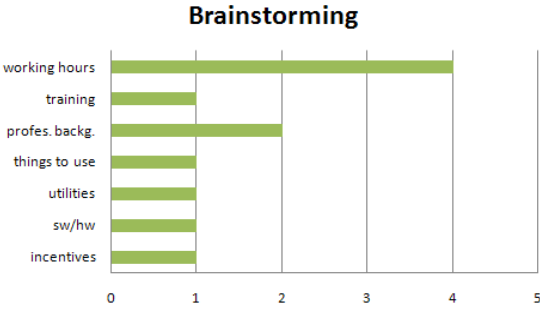

Figure 4: Company 1's manager Use Intensity levels for Brainstorming

Finally, the information collection is organized by the mean of the 3rd step, where the data is formalized. The third step aims at formalizing the resource requirements. The formalization is carried

out using the FEC, thanks to which it is possible to calculate the Estimate Investment (EI) per tool according to the following formula:

$$\sum_{i=1}^{7} w_i \left(\sum_{j=1}^{k} l_{jk} \right) = l_{EI} \tag{1}$$

where:
i = 1 … 7 (micro-parameters in the FEC);
j = 1 … 5 (Use Intensity levels);
k = the selected Use Intensity level in the FEC;
wi = micro-parameters' weights;
ljk = resultant Use Intensity level with the cumulative function;
lEI = Estimate Investment level.

The cumulative summation was adopted so that the real weight of each level was better represented (instead of linear evolution). On a scale showing the low-level to high level, in reality the value for low-to-mid-cell is 3 and not 2 as shown, the same goes for the mid-cell as it is 6 and not 3, etc. The approach described above was carried out for each company and tool and used to build up the data sets.

4.1.2 Data Analysis per Company

Each company analysis was treated as a stand alone case. In this section, the analysis of the results obtained for Company 1 are explained in details, followed by a summarised analysis of the results obtained for companies 2, 3, 4 and 5. It is noteworthy to observe that only 62% of tools were selected by managers. Of the remaining 38%, up to one third were not selected because unknown; the rest were not selected notwithstanding they were known. Of the latter category, a really small percentage of tools were not used as they had just been used by the upstream companies (this is in the case of Companies 1 and 4). Figure 5 illustrates the conjoint effects of the 4 dimensions under study i.e. Effectiveness (Eff), Frequency (Freq), Level of Difficulty (Diff) and Estimate Investment (E.I.), obtained for Company 1.
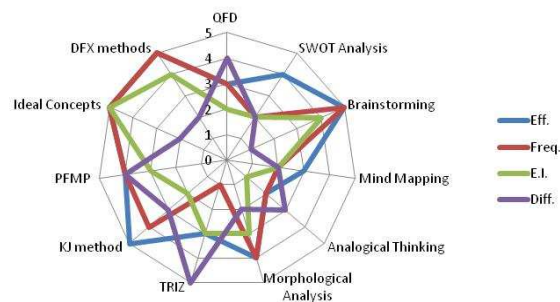

Figure 5. Company 1's dimensions evaluations

Tools that are at the same time Highly Effective, Extremely Costly and Highly Used are Ideal Concepts, Brainstorming and DFX (Design for X) methods. These tools require high investment, but can guarantee maximum effectiveness. Moreover, they are the less difficult tools to use. Hence, managers might be encouraged in frequently using them in their CFE activities. SWOT analysis, QFD and especially KJ-method, are low in terms of estimate investment required. However, QFD is not perceived to be as effective, which might be due to the fact that it is difficult to use. In fact, SWOT is used as a standalone tool but not very frequently, whereas KJ-method is used more frequently but usually in combination with Brainstorming. QFD is used in combination with PFMP or Ideal-Concepts. That might be the reason why it is used less frequently than the others. TRIZ is perceived as the most difficult tool to use and this may be the reason why it is less frequently used. Moreover, when used, it has a moderate effectiveness and generally in combination with Brainstorming. PFMP, even though it is one of the most difficult tools to use, is also one of the most used and is effective while requiring a moderate investment. It is also usually used in combination with QFD. Analogical Thinking, Mind Mapping are the less effective and less used tools. They are however used in

combination with Brainstorming, they only perform a supporting role which could explain their performance. In order to extract possible patterns in the decision making process, a similar analysis, as presented above, was performed for each of the four remaining companies. Figure 6, **Errore. L'origine riferimento non è stata trovata.**, **Errore. L'origine riferimento non è stata trovata.** illustrate the evaluations of the 4 dimensions for each of them.
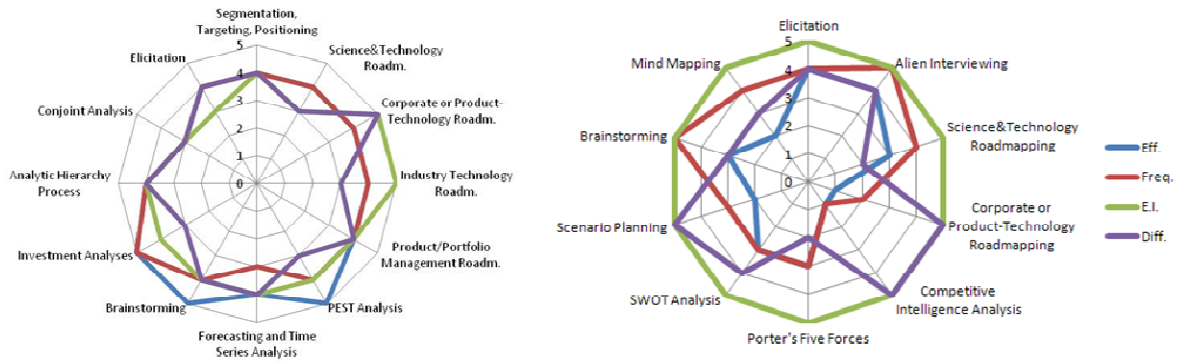

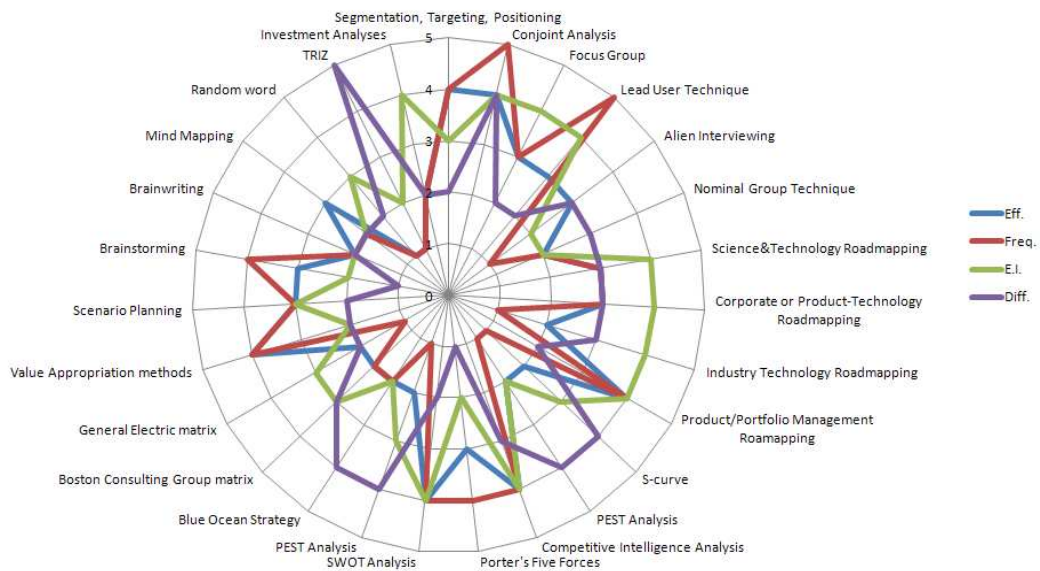*Figure 6. Company 2 and 3's dimensions evaluations*

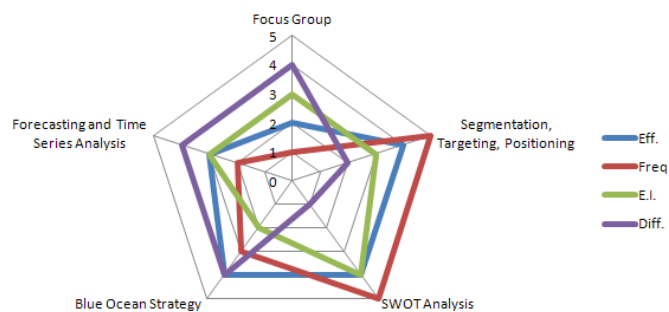*Figure 7. Company 4's dimensions evaluations*

Figure 8. Company 5's dimensions evaluations

At this stage we calculate the frequency (%) of occurrence of the evaluation scale (1, 2, 3, 4 and 5) on each level of the four dimensions cited above, and then we cluster them into two groups as follows:

1. the first containing scores 1, 2 and 3 on each dimension: this represents the low to moderate levels of the considered dimension;
2. the second containing scores 4 and 5: this represents the moderate to high levels of the considered dimension.

This, allows us to get an aggregate view of how managers in Company 1-5 gave his/her evaluations on the four dimensions, which is explained in the following paragraphs. Results from Company 1 show that 64% of tools were evaluated as highly effective; 55% of them are used very often. 73% of tools are judged to be moderately easy to use. Finally, 73% of tools require a low to moderate investment. Evaluations by the manager of company 1 were collected by using a five-point Likert scale with a Cronbach's α equal to 0.78 which proves a good internal consistency. It is worth noticing that according to Nunnally [11], α should be at least 0.70 for a scale to demonstrate internal consistency; this is a widely accepted rule of thumb. Results from Company 2 show that all tools used in the FFE phase (100%) are highly effective; almost all of them (90%) are used frequently. More than a half (60%) of all tools are considered difficult to use. Finally, only 10% of all tools require a low to moderate investment. The five-point Likert scale used to collect data in this case has a Cronbach's α equal to 0.66, a value close to the threshold value of 0.70. Company 3 results highlight that the majority of tools (80%) are not so effective in coping with FFE activities; half of all tools are used very frequently. More than a half of them (60%) are perceived to be difficult when used. Furthermore, all tools require a high investment. The five-point Likert scale has a Cronbach's α equal to 0.68, close to 0.70. Company 4 results highlights that 78% of tools used in the FFE phase are not effective; many tools (63%) are not frequently used. More than two third of the tools (78%) are difficult to use once selected. Finally, approximately two third of all tools (63%) require a low to moderate investment. The five-point Likert scale has a Cronbach's α equal to 0.59, lower than 0.70 but can be considered acceptable. Results obtained for Company 5 show that 60% of all tools are very effective; but only a 40% is used frequently. About 60% of all tools are perceived as difficult to use. The majority of tools (80%) do not require high investment. The five-point Likert scale used in this last case has a Cronbach's α equal to 0.80, a value clearly over the threshold value of 0.70.

4.2 Searching for Cross-Case Patterns

The comparative analysis between the five companies was only carried out with reference to the use, selection and dimensions of Tools. Even though a description of the context in which they operate has been provided, that was not the object of this analysis. However, what has clearly emerged is that there are many common patterns in the use of Tools, despite the companies being fundamentally different. Companies tend to use some of the tools only in the Opportunity Identification stage or the Opportunity Analysis stage. To make things concrete, by considering e.g. Company 5, it uses 14 out of 27 tools either in Opportunity Identification or in Opportunity Analysis stage. Some tools, instead, are used in both stages, thus validating what Koen et al. report [8], where it is clearly explained that all tools can be used in both stages of the CFE. For instance, Company 1 uses 90% of tools in both of the stages, whereas Company 4 uses 40% of them both in the first and the second stage. From steps 1, 2 and 3 some interesting trends emerged. Tools in the Creative Thinking, Market Research and Customer Trend Analysis categories were used most, while 38% of the characterised tools were never selected. From steps 3 and 4, and from the description in the section 4.1.2, Companies 2 and 4 show opposing tendencies. On the one hand, Company 4 has all the studied dimensions belonging to the group low to moderate. It considers the tools used in the CFE not so effective; hence not using them so frequently which, as a result, impacts moderately on the available budget while not meeting big levels of difficulty in using them. On the other hand, Company 2 has all the dimensions belonging to the group set to high. Companies 1 and 3 behave nearly in a complementary way, by having Company 1 effectiveness and frequency of usage dimensions set at a high level and Company 3, at a low level; *et contra* for the other two dimensions. In other words, one could say that Company 1 considers tools used in the CFE activities very effective and it is reasonable to think that this is the reason why it uses them frequently. Another incentive for using them frequently may be the perceived ease of usage. Additionally, from this explorative analysis, it was possible to investigate the genesis of new tools. These occurred in three distinct situations:
- when companies use tools in combination with another one;
- when companies customise the tools usage to their specific needs;

• tools directly stated by managers and not reported by authors.

4.3 Shaping Hypotheses

The building of a theoretical model underpinning the selection and use of the tool, given the input data, output data, consumption of resources, and evaluations about tools perceived effectiveness, frequency of usage, perceived level of difficulty and estimate investment, is the long term objective of this research. If, for the five cases considered in this research, links between the same factors will emerge, then the upcoming model may have a basis for abstraction. The aim here is not generalising the theoretical model but rather to abstract it. Analysis of subsequent cases to the ones considered could test the model later on. Figure 9 illustrate the model built from the observation gathered during this study. It is worth noting that besides the four dimensions discussed in the former sections, Figure 9 considers $m_{INPUT}\%$ and $m_{OUTPUT}\%$, briefly introduced in section 3.1. $m_{INPUT}\%$ indicates the level of awareness about the inputs as in the awareness of the requirements for a tool to be used correctly. $m_{OUTPUT}\%$, is the level of awareness about the outputs, as in the awareness of the potential of a certain tool, of how it can contribute to solve a certain problem and what its deliverables are.
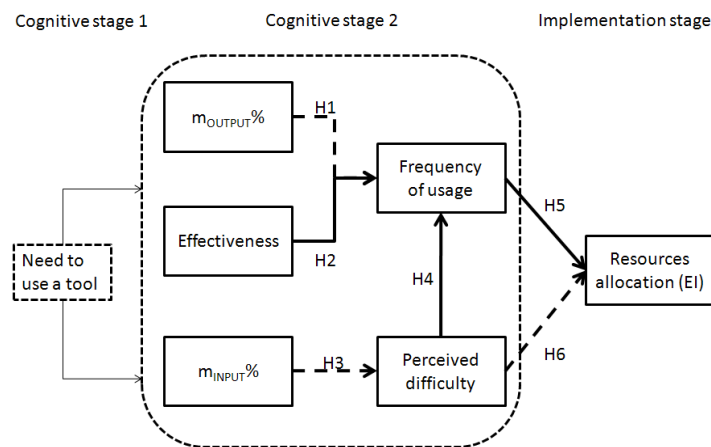

Figure 9. Theoretical Model

By considering the observations made in sections 4.1 and 4.2, the following hypotheses emerged:
• H1: *there is a link between $m_{OUTPUT}\%$ and the Frequency of Usage*, i.e. the higher is the knowledge and awareness about the potential results a manager can get by using a certain tool, the more the manager will think to it as being a useful one for his/her decisions, and the more frequently he/she will use it.
• H2: *there is a link between Effectiveness and Frequency of Usage*, i.e. the higher is the perceived effectiveness of a tool in carrying out specific activities of the Core Front End phase, and the more the tool is used.
• H3: *there is a link between $m_{INPUT}\%$ and Level of Difficulty*, i.e. the higher is the knowledge and awareness about what a certain tool requires for proper usage, the more clear is its use and it will be perceived less difficult to use.
• H4: *there is a link between Level of Difficulty and Frequency of Usage*, i.e. the more is a tool perceived difficult to use, the less frequent is its use.
• H5: *there is a link between Frequency of Usage and Estimate Investment*, i.e. the more is a tool frequently used, the higher the allocation of resources will be towards it, increasing the level of investment required by its use.
• H6: *there is a link between Level of Difficulty and Estimate Investment*, i.e. the higher is the perceived level of difficulty of a certain tool, the less time and money a manager will prioritise to use it.

By calculating the Spearman's rank-order correlation coefficient (for small samples), and by considering the correction factor related to tied observations [16] the test of hypotheses on Spearman's coefficients calculated (two tailed) was carried out. The null hypothesis is "H0: there is no association between X and Y" and the alternative being "H1: there is association between X and Y." For Company 1, H2 was supported (r_s = .854, p<.01), as well as H4 (r_s = .532, p<.10) and H5 (r_s = -.726,

p<.05). H1, H3 and H6 were not significant (p<.10) and were therefore rejected. For Company 2, H2 was supported (r_s = .638, p<.05), while the others were rejected (p<.10). For Company 3, H2 was supported (r_s = .734, p<.05), whilst H1, H3 and H4 were rejected. H5 and H6 showed an independency between the variables under study. For Company 4, H2 was supported (r_s = .776, p<.05), H3 showed independency between the two variables, while the rest were rejected as they were not significant (p<.10). Finally, for Company 5, only H5 was rejected. H1 (r_s = -.649), H2 (r_s = .917), H3 (r_s = -.823), H4 (r_s = -.860) and H6 (r_s = .750) were all supported. However, the sample in this case was too small to calculate a p-value based on the normal distribution. Figure 9 illustrates the Theoretical Model based on the Hypotheses stated above. The bold arrows represent the supported hypotheses while the dashed represents the one stated but not totally supported by the data obtained in this research. The model contains 3 levels: the Cognitive stage 1, in which a particular situation (or set of situations) forces managers/designers in making decisions by using certain tools. This stage was not considered in this paper. The second stage is the Cognitive stage 2, where once the needed tools are selected, managers/designers enters this stage where five parameters interact; helping him/her understanding to which resource allocation those decisions might lead in the last level; the Implementation stage. The model proposed in Figure 9Figure 9. Theoretical Model, shows that there is indeed a link between perceived effectiveness of the tool and how frequently it is used, which influences the cost of usage it in terms of people and money. Additionally, the perceived difficulty of using a tool influences similarly on the estimated investment. In order to further validate the model and test the other observed hypotheses one needs to survey more managers in order to have a more diversified data.

CONCLUSION

A theoretical model based on emerging evidences about tools selection and usage was proposed in this paper. Additionally, a set of hypotheses describing the relationships between four dimensions governing the tool selection were developed and studied for validity. The proposed theoretical model for decision making in tool selection during the core front end activities of new product development describes the interaction between four main dimensions (Effectiveness, Frequency of usage, Perceived Difficulty and Resources Allocation) at a cognitive level. A four-step methodology was used to gather data from 5 companies from which interesting conclusions were drawn. The use of tools is not free from cognitive processes as they are not applied automatically and rationally. This aspect has to be taken into account especially when those processes can impact qualitative measures such as cost and time. The obtained results in this research show that a perceived efficiency of a tool leads to the tool being preferred to others. However, the frequency of its usage depends on its perceived difficulty. The awareness of the inputs and outputs requirements of the tools also influences tools adoption. In fact, the most supported associations presented in this paper are those around the parameter Frequency of Usage. Moreover, tools are used differently in each context; as the same tools can be used differently and at different stages of the FFE. This could be related to the influence of the context in which managers/designers adopt such tools, leading to different decisions and different ways to cope with the CFE activities. Some of the observed associations between dimensions were confirmed with the data at hand, however some others still need to be validated, which represents the next step of the work presented in this paper.

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Contact: Sofiane Achiche
Technical University of Denmark
Department of Management Engineering
Produktionstorvet
Building 426, R155
2800 Kgs. Lyngby
Denmark
+45 4525 6279
soac@man.dtu.dk

Sofiane Achiche is an Associate Professor in the Department of Management Engineering, Technical University of Denmark. His research interests focus upon understanding and modeling activities of new product development processes for decision support purposes. He also works in the field of evolutionary computational intelligence applied to engineering problems.