

Group-based ER-AHP system for product project screening

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Abstract

New product development (NPD) is highly risky because of fierce competition, as well as rapid technological and market changes, which results in high rates of NPD project failure. A lot of research has found that the high mortality rate is, to some extent, accountable to the selection of wrong NPD projects. NPD project screening is thus a critical activity adopted in early product development stages to enhance the success rate of NPD projects. The manufacturing companies thus demand more intelligent and advanced tools that can advance their NPD screening decisions.

During the NPD process, companies need to develop their new products with better and safer performance, higher quality and reliability, better environmental-friendliness and in shorter time. Such multiple criteria have to be considered and assessed at early product project screening stages, which involves a group of cross-functional experts. Due to a large number of quantitative and qualitative criteria and lack of sufficient and concrete data, it is often the case that group members have to make decisions in uncertain situations. It is therefore a big challenge for product managers and experts to move from experience-based decision making to scientific NPD project screening decision making.

This paper proposes a novel methodology by integrating the Evidential Reasoning (ER) approach and Analytic Hierarchy Process (AHP), which can help manufacturers in handling uncertainties and group-based decisions in the early NPD project screening stage. A case study with an electronic consumer product manufacturer is conducted to demonstrate how the developed ER-AHP methodology can be used to support NPD project screening decisions.

Keywords - New product project screening, Evidential Reasoning (ER), Analytical Hierarchical Process (AHP), Group-based decision, Decision with uncertainties

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1. Introduction

New product development (NPD) is highly risky because of fierce competition, as well as rapid technological and market changes, which results in high rates of NPD project failure. It is reported that the NPD project failure rate, though it varies from industry to industry, is around one-third or even higher (Cooper, 1984; Cooper et. al., 2002 & 2004). A lot of research found that the majority of initial new product ideas are unsuitable for commercialization (Gidel, et. al., 2005; Carbonell et. al. 2004; Hart, et. al., 2003; Cooper, 2003 & 1992). The high mortality rate is, to some extent, accountable to the selection of wrong NPD projects. Thus, selecting a right project for commercialization is the first step to the success of NPD (Liginlal, et. al, 2006; Monhanty, et. al., 2005; Coldrick, et.al., 2005; Lin and Chen, 2004; Calantone, et. al., 1999). NPD project screening has been a critical activity adopted in early product development stages to enhance the success rate of NPD projects so as to eliminate projects that have high potential of failure. On the basis of project screening results, companies can allocate their resources to those projects that have higher potential of success. As a result, the overall NPD failure rate can be reduced and the growth of companies can be sustained.

A number of researchers have studied project screening methods (Coldrick, et. al., 2005; Gidel, et. al., 2005; Carbonell, 2004; Hart, et. al., 2003; Linton, et. al., 2002; Rangaswamy and Lilien, 1997; Rochford, 1991; Baker and Freeland, 1975). However, most of the methods, such as ranking and scoring, are rather too simple to deal with complex decision making problems. In view of the growing complexity of NPD, several researchers, including Mohanty et. al. (2005), Hsu et. al. (2003) and Calantone et al., (1999) argued that a more comprehensive management science tool is needed for improving project screening decisions. The tool must be capable of dealing with the issue of uncertainty which is the common problem of decision making in early product development stages.

In fact, the uncertainty can be induced in two ways: incomplete data, and imprecise judgments. Incomplete or lack of data is a common problem of early project screening. Many researchers (Liginlal, et. al., 2006; Mohanty, et. al., 2005; Lin and Chen, 2004; Hsu, et. al., 2003; Rochford, 1991; Cooper and Brentani, 1984) stated that generally there is insufficient information available for project screening. They also argued that at early NPD stages, little reliable information is available to make judgments against screening criteria. For example, the lack of financial and engineering data makes decision making difficult and unreliable. Another cause of uncertainty is inability of human in making reliable judgments. Some others (like Gidel, et. al., 2005; Linton, J, 2002; Haque, et. al., 2000; Cooper, 1985, etc.) criticized the screening approaches that are based on judgments of managers. It was claimed that the experience of the managers may be limited to a small number of projects, and the

managers' ability to judge the importance of screening criteria and compare potential projects may also be limited.

In addition, NPD is characterized by the involvement of multidisciplinary NPD team members in the decision making process. For instance, in the concurrent engineering approach to NPD, team members from different functional units jointly make decisions to screen and select projects (Farris, et. al., 2006; Hsu, et. al., 2003; Haque, et. al., 2000; Tummala, et al., 1999 and 1997; Winner et al., 1988). However, the members usually do not have expertise or knowledge in all the aspects of the screening criteria. In this situation, they may not be able to make accurate judgments on some aspects that are not related to their functional expertise. Thus, it is important to note that the current AHP method is not able to tackle the problem of uncertainty which may impair the reliability of the screening results. Incomplete data and human inability of making accurate judgments are common in practice, which need to be addressed for better decision making.

This paper proposes a new methodology by integrating the Evidential Reasoning (ER) approach with Analytic Hierarchy Process (AHP) method to address the problem of uncertainty and group-based decisions in NPD project screening. The proposed ER-AHP method is capable of handling both incomplete and imprecise judgments, which can effectively tackle the problem of uncertainty and in turn improve decision making quality of project screening. Moreover, as most screening activities are conducted by members of a NPD team, this paper also presents a systematic process for companies to perform the group-based NPD project screening with the ER-AHP method. This paper has seven sections. After the introduction, literature review on the past NPD project screening research is presented. The third section presents the theoretical background and details of the proposed method. The fourth section portrays the formulation of group-based project screening model and process to illustrate the application of the method in NPD project screening. A case study, with data collection procedure, calculation and results are described in the fifth section. The aggregation and analysis of evaluation results are then presented in the sixth section. It is followed by the conclusion section which presents practical implications and summarizes the research finding respectively.

2. Literature review

2.1 Past research

NPD is plagued by difficulties and uncertainties which lead to a high NPD failure rate (Cooper, 1985; Cooper et. al., 2002 & 2004). It is widely argued that good NPD project screening decision making is critical to depress the high mortality rate of NPD (Liginlal, et. al, 2006; Monhanty, et. al., 2005; Coldrick, et.al., 2005; Lin and Chen, 2004; Calantone, et. al., 1999, Ozer, 1999; Cooper and Brentani,

1984; Chenu and Wilemon; 1973). At the early stage of project development, there are usually numerous new product ideas. Some of the ideas are good, which have high probability of success. However, majority of them could be unfeasible. Thus, it is imperative to conduct project screening to eliminate the ideas that have high failure probability. Based on project screening results, companies can select the best project, which in turn enables companies to allocate their development resources to the project that has the highest potential of success (Cooper, 1985; Cooper et. al., 2002 & 2004; Lin and Chen, 2004).

Various methods are available for NPD project screening, including ranking, checklists, scoring models, and numerical weighting methods (Coldrick, et. al., 2005; Gidel, et. al., 2005; Carbonell, 2004; Hart, et. al., 2003; Linton, et. al., 2002; Ozer, 1999; Rangaswamy and Lilien, 1997; Rochford, 1991; Baker and Freeland, 1975). However, the methods are too simple to tackle complex problems. The growing complexity of NPD requires the use of more sophisticated management science decision support techniques (Mohanty et. al., 2005; Hsu et. al., 2003; Calantone et al., 1999; Rangaswamy and Lilien, 1997). Calantone et al. (1999) and Rangaswamy and Lilien (1997) argued that NewProd and AHP are the important management science tools for NPD project screening, which could provide greater potential for improving project screening decisions. As evaluated and compared with other advocacy from the literature, the authors also share the same opinion that the NewProd and AHP do lay down a good foundation for developing an advanced group-based NPD project screening decision methodology. The NewProd and AHP approaches as well as the authors' arguments are elaborated and discussed in the next sections.

2.2 NewProd

NewProd is a NPD project screening technique developed by Cooper (1985 & 1992). It was derived based on statistical analysis of the successes and failures of past NPD projects. NewProd model includes a set of screening criteria that are the predictors of project success. To use the model, evaluators rate potential projects on the model criteria using a 0 to 10 scale. Based on the inputs, NewProd can calculate the overall score to estimate the probability of project success. Although NewProd provides a logical means for companies to conduct NPD project screening, the approach has several main limitations (Calantone et al., 1999). First, NewProd is derived based on the past NPD project experience. The past experience may no longer be applicable to the current project because of rapid changes in markets and technologies, etc. Second, NewProd is based on the experience of other companies which were from different industries. As the backgrounds and practices of the companies may be different, the applicability of the tool could be limited. Third, projects are evaluated against the criteria of NewProd. The flexibility of the tool is limited since NewProd cannot be customized to cater for different companies' situations and needs. Other than the above, we propose that there is

another critical limitation. In practice, most NPD decisions are made by multidisciplinary teams that constitute members from different departments. NewProd, however, does not provide a logical mechanism to synthesize group judgments in the evaluation of projects. In general, NPD project screening is a group-based process, decision support tools must be able to address the needs of this process.

2.3. AHP

Several researchers, including Mohanty et al. (2005), Hsu et al. (2003) and Calantone et al., (1999) proposed the use of Analytic Hierarchy Process (AHP) to aid companies in screening and selecting NPD projects. AHP is a decision-making technique developed by Saaty (1980) to tackle the complex problems of choice and prioritization. It is a viable decision making tool developed based on firm theoretical foundations (Harker and Vargas, 1987). It has been widely recognized as a powerful approach to solve multi-criteria decision making problems in numerous diverse areas (Partovi, 2007; Liu and Hai, 2005; Wei et.al., 2005; Leung and Chin, 2004; Wasil and Golden, 2003; Chin et. al., 2002; Tummala et. al., 1997). AHP produces a ranking of potential projects using pairwise comparisons. It was shown that AHP can be very useful for gathering and processing knowledge for making screening decisions. In view of the limitations of NewProd, Calantone et al. (1999) proposed to adopt the AHP approach to NPD project screening. The use of AHP is relatively simple that NPD teams firstly identify a set of screening criteria and sub-criteria that suit their companies' situations and organize them into a hierarchical structure. Then, NPD teams conduct pairwise evaluations of alternatives (projects) at each level of the hierarchy. Finally, the importance weights (scores) of the screening criteria and sub-criteria can be computed and the overall scores of the potential projects can be obtained to indicate their priority.

Calantone et al. (1999) argued that AHP can be an alternative to NewProd, but they did not provide comprehensive discussions about the advantages of the AHP approach over NewProd. However, we believe that AHP can overcome the limitations of NewProd in several ways. First, AHP approach is not based on historical statistical data. Rather, it makes judgments on the basis of most updated information to address the current NPD problems. Second, rather than relying on other companies' judgments, AHP approach enables companies to employ their own experts to make screening decisions that best reflect their companies and industries' situations. Third, AHP is a tool of choice and prioritization. The pairwise evaluation method best suits the objective of project screening which is to select the best project. Fourth, companies can develop their own set of screening criteria according to their own situations and needs. This flexibility is very critical, which allows companies to modify the criteria when situations change. Finally, AHP facilitates a group approach to project screening decision making. This is probably the most important feature that makes AHP suitable for

project screening. NPD is a multidisciplinary process that requires the participation of a group of people from different departments in making decisions. This group approach induces a problem of judgment synthesis. Because of differences in technical backgrounds, departmental goals and constraints, group members may present different judgments about project screening decisions. The reliability of the decisions may depend on the way the diverse judgments are synthesized. AHP can provide a solution to solve this problem. AHP includes a systematic algorithm to synthesize group judgments and obtain an overall score to reflect group decisions, which is well suited to group decision making (Dyer and Forman, 1992; Saaty, 1990). In short, AHP is a useful decision support tool for companies to make NPD project screening decisions.

However, the AHP approach has two major weaknesses. One is the well-known ranking reversal problem as discussed by many researchers such as Belton and Gear (1985). The other is its limited capability in dealing with the issue of uncertainty which is the common problem of decision making in early product development stages. In fact, the uncertainty can be induced in two ways: incomplete data and imprecise judgments. Incomplete or lack of data is a common problem of early project screening. There is an obvious need to develop a new approach to support AHP and NewProd in handling the uncertainties in group-based decision process, like NPD screening process.

2.4. Research problems

Uncertainty has been a major problem of NPD project screening (Liginlal et. al., 2006; Lin and Chen, 2004; Rochford, 1991; Cooper and Brentani, 1984). In 1975, an extensive literature review conducted by Baker and Freeland (1975) revealed that inadequate treatment of uncertainty was the major limitation of project selection models. Unfortunately, three decades later, the problem has not yet been addressed. In fact, uncertainty is very common in making decisions of early product development stages. There are two causes for uncertainty. Firstly, it is due to incomplete or lack of data for making decisions. In early product development stages, there is always a lack of data for estimating the potential performance of new product projects (Lin and Chen, 2004; Rochford, 1991). It was also argued by Cooper and Brentani (1984) and Cooper et. al. (2002 & 2004) that usually little reliable information is available to make judgments against screening criteria. With limited information, NPD team makes their judgments even though they are not fully sure about the evaluations.

The second cause of uncertainty is inability of human in making reliable judgments. Most project screening approaches, such as scoring and ranking, reply on NPD team members to make their judgments about project options. Cooper (1985 & 1992) argued that these approaches are not very reliable because the experience of the NPD team members may be limited. It was believed that the members can not make accurate or precise judgments if they are inexperienced. In fact, sometimes it

is not practical to make judgments based fully on past experience or information because NPD always involves new issues including new design, new manufacturing processes, and new suppliers, etc.. As a result, it is common that the team members are not able to make accurate judgments. In other words, they are not fully confident about their judgments, indicating the existence of uncertainty. Moreover, NPD is a multi-disciplinary process in which members from different departments form a NPD team for making project screening decisions. The members usually possess very solid expertise that is related to their job functions. However, they may not have strong knowledge or expertise on other aspects that need to be considered for making screening decisions. Thus, they may not be able to make accurate judgments on those aspects that are not closely related to their functional expertise. The problem of uncertainty is an inevitable issue that can impair the reliability of NPD project screening decisions. This suggests that a better NPD project screening method is needed for improving the quality of decision making. The authors respond to this need by proposing an ER-AHP method to address the problem of uncertainty in project screening.

In fact, usually project screening decisions are made by NPD teams, rather than a single individual. However, most research studies an individual approach to project screening. The studies fail to address the need of a process to facilitate group-based decision making. Thus, the authors also propose a group-based decision making process to help companies systematically perform NPD project screening.

3. ER-AHP approach

In spite of the many excellent features of AHP, it has two crucial limitations: ranking reversal problem and inability to deal with the problem of uncertainty. The causes of the ranking reversal problem are analyzed by many researchers. They observed that the normalization of the relative values of the alternatives on each criterion is one of the causes (Belton and Gear, 1983) and the weighted additive formula for calculating the overall score of each alternative is the other (Triantaphyllou, 2000).

We believe that the root cause of the ranking reversal problem is due to the fact the AHP treats attribute weights and the performance scores of alternatives on each attribute in the same way. By nature, the importance of attributes is relative to each other. Therefore, it is logical to eliciting attribute weights by pairwise comparison. However the performance of an alternative on each attribute should normally be independent of other alternatives. Therefore, the performance should be measured by using independent standards or common scales, rather than by pairwise comparison against each other. More specifically, the measurement for a quantitative attribute should be made in

terms of the natural unit of the attribute. For a qualitative attribute, the measurement should be in pre-defined scoring standards which are linked to decision makers' preferences or utilities.

It is based on such a belief that we propose to use AHP only for eliciting the weights of attributes, not for generating the performance scores of alternatives on each attribute. The performances of each alternative will be modeled using a belief decision matrix and the attributes are aggregated by the Evidential Reasoning (ER) algorithm. Both the belief decision matrix and the ER algorithm are the two main elements of the Evidential Reasoning (ER) approach, which is briefly described below.

The ER approach is developed for handling multiple criteria decision analysis (MCDA) problems having both quantitative and qualitative information with uncertainties and subjectivity. (Zhang, Yang and Xu 1989; Yang and Singh 1994; Yang and Sen 1994; Yang 2001, Yang and Xu 2002a,b). In conventional methods, a MCDA problem is modelled using a decision matrix, with each criterion assessed at each alternative decision by a single value. In the ER approach, a MCDA problem is described using a belief decision matrix, with each criterion assessed at each alternative by a belief structure – attribute values (or assessment grades) and their associated degrees of belief. This provides a novel way to model MCDA problems and allows different types of uncertainties, such as randomness and ignorance, to be modeled in the same framework.

For example, if a new product stands a 70% chance to be successful and 30% chance unsuccessful, using a belief structure, it can be modeled as [(Successful, 0.7), (Successful, 0.3)]. In a traditional decision matrix, this may have to be approximated to a single category, which has to be Successful. From this example, it is clear that in such qualitative assessments a single number or grade is not capable of modeling uncertainty. Furthermore, it may introduce distortion to original information.

In order to produce rational and consistent assessment outcomes and reveal the combined effects of any uncertainty in the performances of an alternative, the ER approach employs the ER algorithm to aggregate belief degrees, which has been developed on the belief decision matrix, decision theory and the evidence combination rule of the Dempster-Shafer theory (1976). Where there are uncertainties, the ER algorithm can generate a lower bound and an upper bound of the performance of an alternative to indicate the sensitivity of the outcomes to uncertainties. To facilitate the applications of the ER-AHP approach, a software package called Intelligent Decision System (IDS) is developed and it is used for carrying out the case study described in the next section.

4. Model and process for NPD project screening

4.1. NPD project screening model

Past research has developed a number of models which comprise criteria for making NPD project screening decisions (Chenu and Wilemon, 1973; Cooper and Brentani, 1984; Rochford, 1991). The criteria include a set of factors affecting the success of new product commercialization, viz. marketing competencies, product features, financial risk, and company capabilities. Calantone, et al. (1999) developed a model which comprises comprehensive criteria for making NPD project screening decisions. However, since the screening criteria were developed by a group of experts of a company, not all the criteria may suit the needs of most companies. To enhance the applicability of the model, we revised some of the criteria to generate a generic NPD project screening model which could more likely be adopted by industries.

As depicted in Figure 1, the NPD project screening model has five criteria, namely Fit with firm’s core marketing competencies (MKTFIT), Fit with firm’s core manufacturing competencies (MANUFIT), Fit with customer’s requirements (CUSTFIT), Financial risk of projects (FINRISK), and Uncertainty about project’s outcomes (UNCERT). The criteria are organized into a hierarchical structure which has two levels. The first level shows the five criteria, while the second level consists of the sub-criteria. Definitions of the criteria and sub-criteria are displayed in Table 1. Although this model covers the essential criteria of project screening, companies may adjust the model by changing the criteria according to specific companies’ needs.

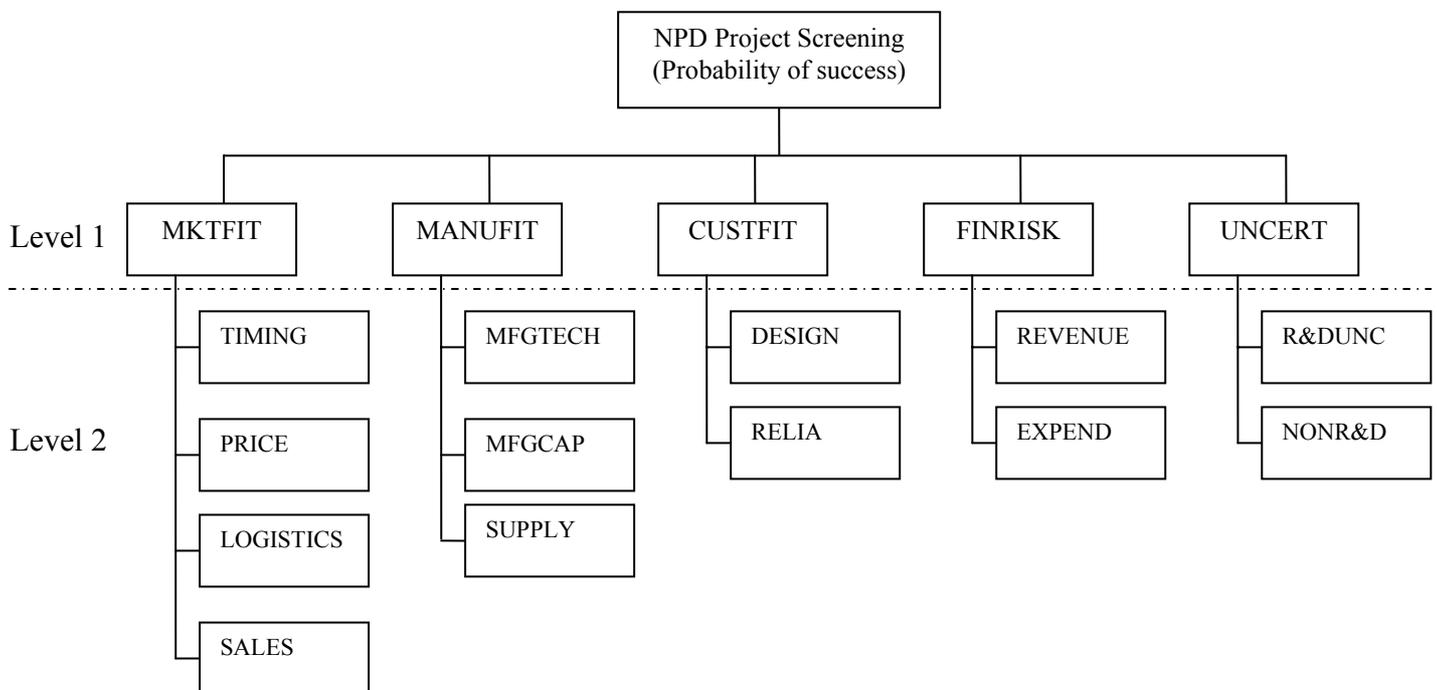


Figure 1. NPD project screening model

1. MKTFIT	Fit with firm's core marketing competencies
1.1 TIMING	The product matches the target launch timing needed by our target segment
1.2 PRICE	The product matches the target price level for our target segment
1.3 LOGISTICS	The product fits with our logistics and distribution strengths
1.4 SALES	The product fits with our salesforce coverage and strengths
2. MANUFIT	Fit with firm's core manufacturing competencies
2.1 MFGTECH	The product fits with our manufacturing technology
2.2 MFGCAP	The manufacturing capacity matches demands
2.3 SUPPLY	The product allows us to use our good suppliers
3. CUSTFIT	Fit with customer's requirements
3.1 DESIGN	The product is designed for the requirements needed by the customer
3.2 RELIA	The product meets the target reliability level
4. FINRISK	Financial risk of projects
4.1 REVENUE	Expected revenue
4.2 EXPEND	Expected expenditure
5. UNCERT	Uncertainty about project's outcomes
5.1 R&DUNC	Technological uncertainties in research and product design.
5.2 NONR&D	Uncertainties which are not related to research and product design (e.g. changes in government's regulations and markets)

Table 1. Definitions of the screening criteria and sub-criteria

4.2. Evaluation process for NPD project screening

New product development (NPD) is a cross-functional task, which normally involves contributions from marketing, engineering, and manufacturing functions. A group based decision making system is thus essential for NPD project evaluation in early design stages. However, the contribution (weight) of an individual function to a particular evaluation criterion is varying. The proposed evaluation process has four steps. Steps 1 to 3 are to formulate the evaluation model, while step 4 is to evaluate NPD projects with the determination of probability of success.

Step 1. Top management assigns the weight of each product development team member (Marketing, Engineering, and Manufacturing) for the level 1 criteria of the evaluation model.

Step 2. Top management evaluates the importance weights of the level 1 criteria of the evaluation model using AHP*.

Step 3. NPD team members evaluate the importance weights of the model elements (whole model) respectively using AHP*.

Step 4. NPD team members evaluate NPD projects using the evaluation model and developed methodologies#.

* Referring to the NPD project screening model shown in Figure 1, the resulting importance weights of the level 1 criteria should be calculated by taking into consideration both the judgments of the top management and the product development team members, of which the ratio of the two groups of judgments is 1:1 (Top management 0.5, marketing 0.167, engineering 0.167, manufacturing 0.167). For level 2 criteria, only the judgments of the product development team members are considered. The weight of each team member (i.e. marketing, engineering, and manufacturing) is based on the weights obtained in step 1.

The evaluation results should be obtained by synthesizing the judgments of the product development team members, of which the ratio is based on the weights obtained in step 1.

5. Case study

5.1 Background of the company

This section presents a case study to demonstrate the application of the proposed Group-based ER-AHP approach to NPD project screening. The studied company is a manufacturer headquartered in Hong Kong, which manufactures a wide range of electronic entertainment products in its factory in southern China. Other than manufacturing, the company also markets its products in various countries including United States, the United Kingdom, Canada and Hong Kong. Every year, the company identifies market requirements and comes up a list of potential NPD projects. Selection of right projects is one of the key factors that determine company's success. Thus, it is imperative to have a reliable system to evaluate the potential projects.

5.2 Description of projects for evaluation

There are two projects selected for the study, namely, an interactive baseball TV game and a handheld fishing game. The NPD team of the company generated the product ideas of an interactive baseball TV game and a handheld fishing game. Because of resource constraints, only one of them could be selected for commercialization. The details of the two projects are presented below.

The Interactive Baseball TV Game is an interactive game with which customers can play a virtual baseball game against a friend or computer using a wireless bat. This is a brand new product that has very high market potential. However, the product development project is highly risky because of high product price, uncertain distribution channel, high technological risk, and uncertainty of material/part availability.

The Handheld Fishing Game is a virtual fishing game that enables customers to feel the excitement of real fishing. With the product, customers can cast, feel the fish bite, set the hook with a jerk, and reel in the fish with a real handle. The product is an extension of the existing product lines. The market is very mature and stable and there are limited risks in R&D, manufacturing and distribution. However, the expected profit is not high.



Figure 2: Interactive baseball TV game



Figure 3: Handheld fishing game

5.3 Data collection and calculation

5.3.1. Formulation of the group-AHP evaluation model

1. Based on the evaluation model and process mentioned in section 4, the following data were collected to formulate the company's evaluation model on NPD project screening. The weight of the NPD team members for each of the level 1 criteria, which is determined by the top management (Appendix 1)
2. The importance weights of the level 1 criteria of the evaluation model, which are determined by the top management (Appendix 2)
3. The importance weights of the model elements, which are determined by the NPD team members (Appendix 3)

The resulting importance weights of the level 1 criteria are calculated by taking into consideration both the judgments of the top management and the product development team members, of which the ratio of the two groups of judgments is 1:1 (Top management 0.5, marketing 0.167, engineering 0.167, manufacturing 0.167).

5.3.2. Evaluation scales and guidelines

In addition to the weightings, two general evaluation scales and guidelines of NPD projects screening are developed. One is for evaluating items with a target value, while another one is for items without specific target values.

Type 1: 1-7 scale – for an evaluation with a target value (5) which is predetermined according to companies or industries situations, exceeding the value (6-7) could make additional contributions.

Scale	1 [#]	2	3	4	5	6	7
Definition	Not meet target	Marginally meet target	Fairly meet target	Mostly meet target	Meet target	Exceed target	Well exceed target

[#]A warning symbol to indicate that the project is disqualified because the criterion cannot be met.

Type 2: 1-5 scale – for an evaluation with no target values specified. The highest value (5) indicates a perfect situation, exceeding the highest value does not make additional contributions.

Scale	1 [#]	2	3	4	5
Definition 1	Not fit	Marginally fit	Fairly fit	Mostly fit	Perfectly fit
Definition 2	Not match	Marginally match	Fairly match	Mostly match	Perfectly match
Definition 3	Not acceptable	Marginally acceptable	Fair	Satisfactory	Perfect

[#]A warning symbol to indicate that the project is disqualified because the criterion cannot be met.

According to these two general guidelines, the specific evaluation scales for each criteria of the selected two NPD projects in this case study are developed as shown in Appendix 4. The following is an example of the evaluation scale of “Supply”.

Evaluation scale of “SUPPLY” – in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	≤60%	70%	80%	90%	100%

Notes : 100% indicates that the product perfectly fits with the current supply base. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

It is noted that screening decisions can be made based on the number of warning symbols and the total evaluation score. Companies need to take actions to remove the warning symbols; otherwise a project should not be commercialized. To calculate the total evaluation score of each proposed NDP project, a utility function needs to be defined for each evaluation scale.

A utility function represents the preferences of decision makers towards each point in the evaluation scale. The utility of each point is normally a number between 0 and 1, with 0 corresponding to the least favorable point and 1 the most favorable one. The utilities of the other points are normally monotonically distributed between 0 and 1. More details on utility theory can be found in many references such as Keeney and Raiffa (1976) and French (1986).

Using utilities as a common scale, the performances of different NPD projects on different criteria can be measured and compared. The equivalence relationships among different evaluation scales can also be established based on such a common scale. For the two evaluation scales used in the case study, it is agreed by the decision makers, the NPD team members, that their utility functions are linear. That is, for the 7 point scale, the utilities for the points are 0, 0.167, 0.333, ..., and 1, respectively, and for the 5 point scale, they are 0, 0.25, 0.5..., and 1, respectively. An assessment made using the 7 point scale can be equivalently (in terms of utility) transformed into a 5-point one using a belief structure.

For example, if a project is assessed to be “*Fairly meet target*”, the 3rd point in the 7 point scale with a utility of 0.333, the assessment can be transformed into the following equivalent assessment based on the 5 point scale: The project is “*Marginally acceptable*” to a degree of 66.7% and “*Fair*” to a degree of 33.3%. Because the utilities of “*Marginally acceptable*” and “*Fair*”, the 2nd and 3rd points in the 5 point scale, are 0.25 and 0.5 respectively, the utility of [(66.7%, *Marginally acceptable*), (33.3%, *Fair*)] is $66.7\% \times 0.25 + 33.3\% \times 0.5 = 0.333$, which is the same as the one based on the 7 point scale.

5.3.3. Evaluations of two NPD projects by NPD team members

After formulating the evaluation model in terms of criteria, weights and evaluation scales, data and expert judgments for the two NPD projects on each criterion were collected from the NPD team members of the company. The judgments are associated with uncertainties that can be presented in interval values, or in a belief structure, or even unknown. For instance, for the evaluation of the “Supply” criterion (how the new product allows the company to use their existing good suppliers), the team members can reply in the following format:

With respect to SUPPLY - The product allows us to use our good suppliers

	Evaluation
Interactive Baseball TV Game Project	2 (marginally fit) – 3 (fairly fit) : 20% 4 (mostly fit) – 5 (perfectly fit) : 60% unknown : 20%
Handheld Fishing Game Project	5 (perfectly fit) : 100%

Comparatively, more uncertainties are noticed in the evaluation of the Interactive Baseball TV Game Project than the Handheld Fishing Game Project as the company does not have the experience with the novel Interactive TV Game as much as the Fishing Game. The evaluations of the two NPD projects by the NPD team members are shown in Appendix 5.

6. Evaluation with Aggregated Information

To facilitate the evaluation process, a software system is developed on the basis of a software shell called IDS (Intelligent Decision System) which is developed by the authors, Prof. JianBo Yang and Dr. Dongling Xu, of The University of Manchester. The calculated results and graphs generated by using the IDS are presented and discussed as follows.

6.1 Hierarchy structure of calculation

For calculation purpose, one more layer is added between the original Level 1 and Level 2 attributes of the NPD project screening model, as Level 1A. In this new hierarchy, as shown in Figure 4, Level 1 attributes are the 5 main areas given previously. Level 1A attributes are the three departmental experts in the NPD team. As indicated in Appendix 1, for each area represented by a Level 1 attribute, the opinions of the three departments carry different weights to reflect the levels of expertise of the departments in the area. Also from Appendix 5, we can see that the performance of a NPD project in each area is assessed by the three departmental experts. To aggregate the assessment information from different experts, we can use the weights given in Appendix 1 to reflect the importance (or credibility) of their opinions in each area. For example, in the MKFIT area, Marketing Department has significantly more knowledge and experience than the other two departments, and therefore a heavier weight to its assessment information. Such logic is accomplished through the adding of the new Level 1A attributes. Level 2 attributes are the various elements associated with the NPD projects and are assessed by each of the three departments in the NPD team.

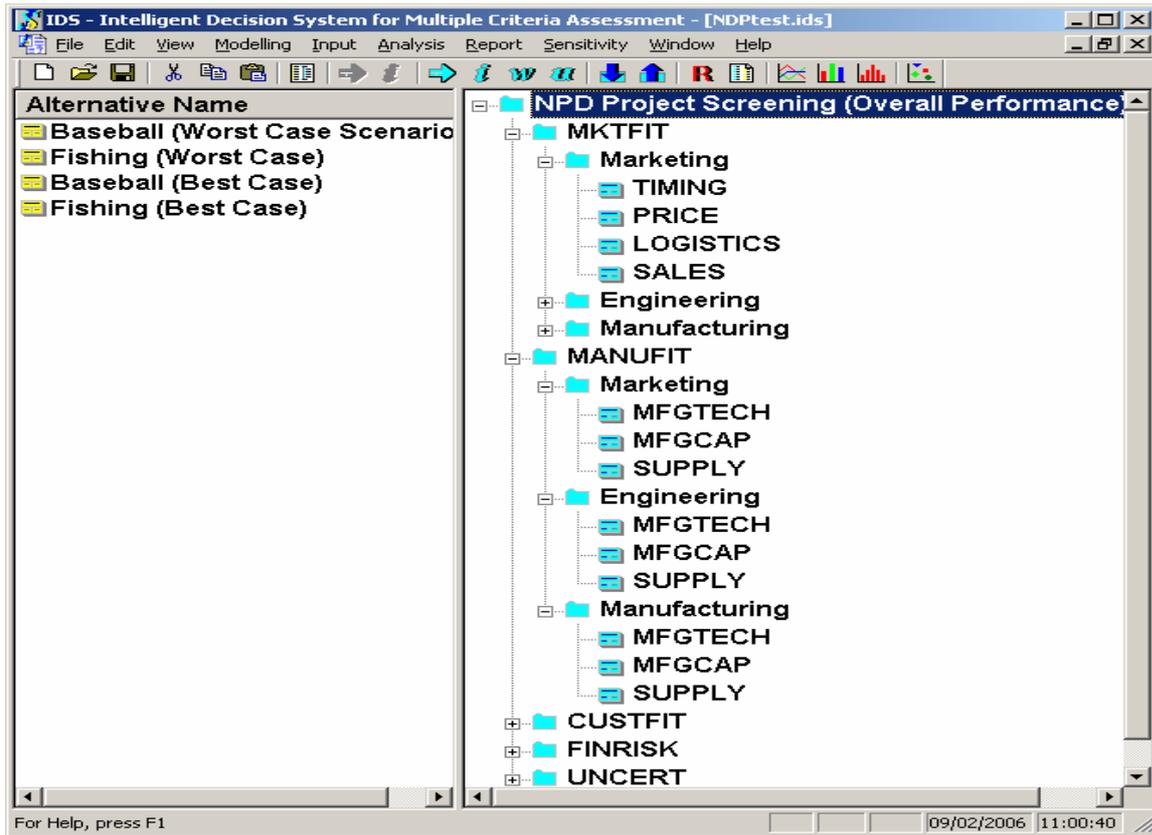


Figure4 : Hierarchical structure of the IDS based calculation

6.2 Calculated weights of attributes

Level 1 attribute weights are calculated as presented in Table 2 as Synthesized AHP results. Level 1A attribute weights are assigned by top management as given in Appendix 1. The weights for Level 2 attributes are calculated from the pairwise comparison matrices shown in Appendix 3. Hence, the weightings of all criteria in all levels are calculated as shown in Table 3.

	Market	Manu	Eng	TopMan	Synthesized (0.5*Topmgt+0.16667*(Market+Manu+Eng))
MKFIT	0.3198	0.2226	0.2439	0.3139	0.288
MANUFIT	0.0408	0.1523	0.0334	0.1354	0.10545
CUSTFIT	0.3197	0.2002	0.2827	0.1054	0.186467
FINRISK	0.1517	0.2318	0.1961	0.1602	0.1767
UNCERT	0.168	0.1931	0.2439	0.2851	0.243383

Table 2: Calculation of synthesized AHP results in Level 1

LEVEL 1 (Table 2)	LEVEL 1A Attribute Weights (From Appendix 1)	LEVEL 2 Attribute Weights (calculated)
MKTFIT=0.288	Marketing=0.6	TIMING=0.3383 PRICE=0.2879 LOGISTICS=0.2046 SALES=0.1692
	Engineering=0.3	TIMING=0.3383 PRICE=0.2879 LOGISTICS=0.1692 SALES=0.2046
	Manufacturing =0.1	TIMING=0.2463 PRICE=0.3465 LOGISTICS=0.2036 SALES=0.2036
MANUFIT=0.105	Marketing=0.1	MFGTECH=0.4 MFGCAP=0.4 SUPPLY=0.2
	Engineering=0.4	MFGTECH=0.4126 MFGCAP=0.2599 SUPPLY=0.3275
	Manufacturing=0.5	MFGTECH=0.3333 MFGCAP=0.3333 SUPPLY=0.3333
CUSTFIT=0.186	Marketing=0.7	DESIGN=0.5 RELIA=0.5
	Engineering=0.3	DESIGN=0.5 RELIA=0.5
	Manufacturing=0	DESIGN=0.5 RELIA=0.5
FINRISK=0.177	Marketing=0.7	REVENUE=0.5 EXPEND=0.5
	Engineering=0.3	REVENUE=0.5 EXPEND=0.5
	Manufacturing=0	REVENUE=0.5 EXPEND=0.5
UNCERT=0.243	Marketing=0.5	R&DUNC=0.75 NONR&D=0.25
	Engineering=0.4	R&DUNC=0.8333 NONR&D=0.1667
	Manufacturing =0.1	R&DUNC=0.8333 NONR&D=0.1667

Table 3: Calculated synthesized AHP results in Level 2

6.3 Utility of Evaluation Scales

Utility is a value between 0 and 1 used to represent the preferences of decision makers towards the points in the evaluation scales, with 0 representing the most undesirable and 1 the most desirable.

From the description given in Appendix 4, it is reasonable to assume that the points of evaluation scales and their corresponding utilities are in linear relationship. For the 5 and 7 point scales given in Appendix 4, the utility of each point is assumed to be as shown as follows.

Scale	1 [#]	2	3	4	5
Utility	0	0.25	0.5	0.75	1

Scale	1 [#]	2	3	4	5	6	7
Utility	0	0.167	0.333	0.5	0.667	0.833	1

6.3 Handling of Assessment Information

For the case study, the two competitive NPD projects are the Interactive Baseball TV Game and the Fishing Game. The assessment information provided by the three NPD project team members is shown in Appendix 5. There are various types of uncertainties in the assessment data: Probability, unknown (global ignorance), and grade intervals (local ignorance or local unknown).

To aggregate the assessment information, the IDS software is employed. To identify the effects of the uncertainties on the aggregated outcomes, the best and worst possible performances of each NPD project are analyzed.

To identify the best possible performance of a project, it is assumed that the unknown information (both locally and globally) in each assessment turns out to be favorable. For example, if Baseball project is assessed on Revenue to be $\{(3-5, 70\%); (\text{unknown}, 30\%)\}$, the best case scenario is that the 30% of unknown turns out to be in grade 5 and the 70% of grade 3-5 performance turns out to be all in grade 5. Therefore the performance of the Baseball project in the best case scenario is calculated by assuming that the assessment is $\{(5, 70\%); (5, 30\%)\} = \{(5, 100\%)\}$.

Similarly, the worst case scenario would be that all the local and global unknown information turns out to be unfavorable. For example, the assessment $\{(3-5, 70\%); (\text{unknown}, 30\%)\}$ would be assumed to be $\{(3, 70\%); (1, 30\%)\}$.

To record the best and worst case scenarios for each project, 4 alternatives are created using the IDS software: Baseball (Best Case Scenario), Baseball (Worst Case), Fishing (Best Case) and Fishing (Worst Case). The 4 alternatives are denoted by BW (Baseball Worst), BB, FW and FB respectively.

6.4 Overall Project Performances

6.4.1 Performance Scores

The overall performance scores of the 4 alternatives, as shown in Figure 5, are given by:

$$U(BW) = 0.54$$

$$U(BB) = 0.85$$

$$U(FW) = 0.77$$

$$U(FB) = 0.90$$

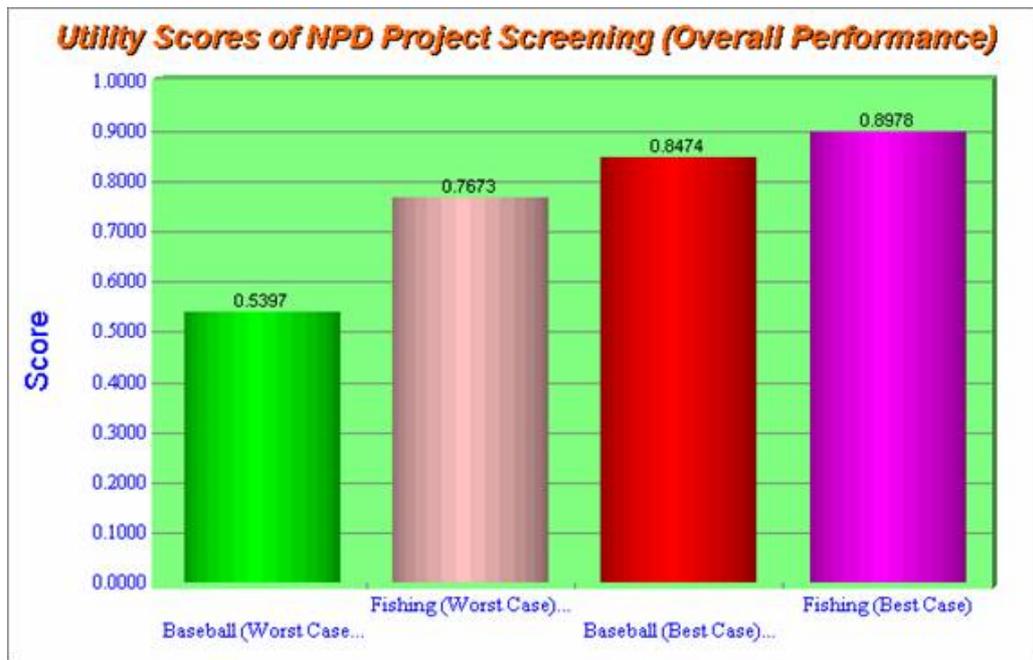


Figure 5: Performance Scores of the 2 Projects in Their Best and Worst Case Scenarios

From Fig. 5, we can see that the Fishing Game project may outperform the Baseball project because the former has higher scores than the latter in both worst and best cases respectively. However, as the score of Fishing in the worst case is lower than the score of Baseball in the best case, there is still a potential that Baseball Game project may outperform the Fishing Game project.

We can also see from Fig. 5 that there is more uncertainty in the Baseball project than that in Fishing, because $U(BB) - U(BW) = 0.31 > U(FB) - U(FW) = 0.13$.

6.4.2 Performance Distributions

Performance distributions reveal the composition (represented by belief degrees) of strengths (represented by preferred grades or points in a scale) and weaknesses (represented by undesirable

grades or points in a scale) of each project. The distributions of the 4 alternatives are shown in Fig. 6. It shows that the Fishing Game project (whether in its best or worst cases) has more “Best” components than the Baseball Game project, while Baseball Game project has more “Good” components than Fishing Game project.

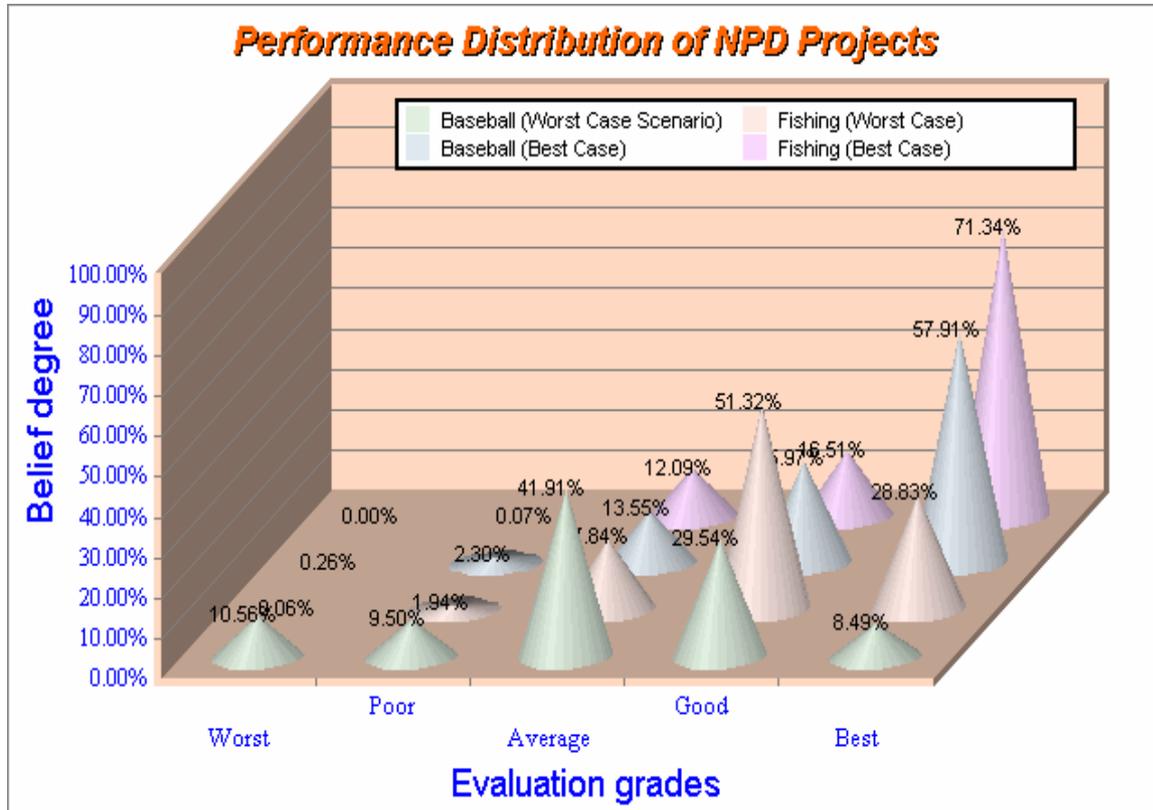


Figure 6: Project Performance Distributions

6.5 Project Performances in Sub Areas

6.5.1 Performance Scores

The performance scores in sub areas reveal the winner and loser in each of the sub areas. We can see from Fig 7 that the Fishing Game project outperforms the Baseball Game project in MKFIT, MANFIT, while the Baseball Game project performs well in CUSTFIT.

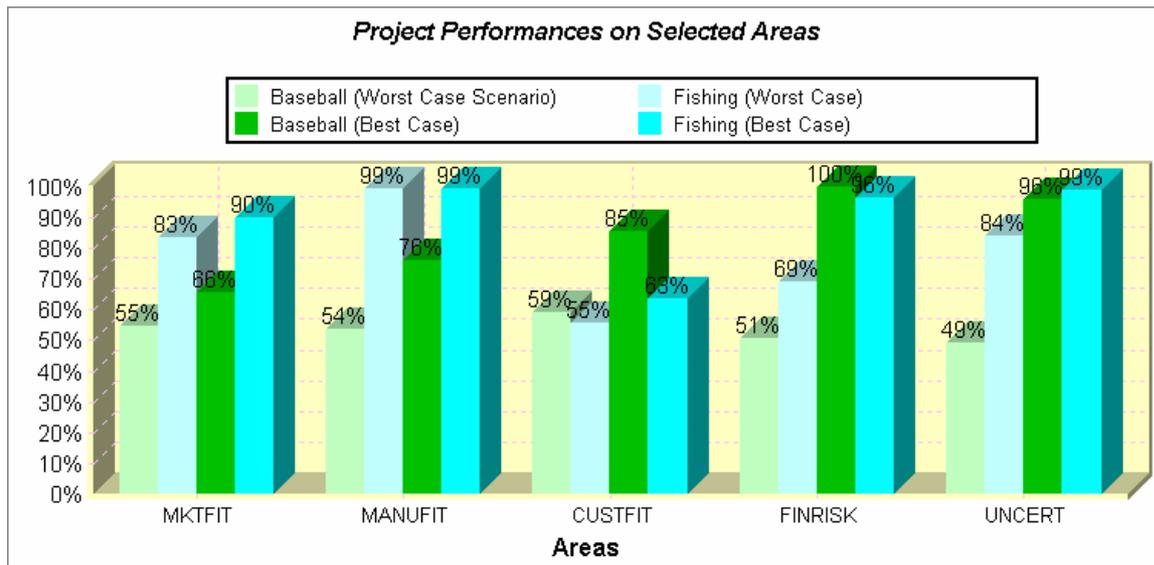


Figure 7: Performance Scores of Projects in Sub Areas

6.5.2 Performance Distributions

Performance distributions can also be generated for each of the sub areas if necessary. Fig. 7 shows the distributions in the UNCERT area. It tells us that the Fishing Game project performs consistently well in this area.

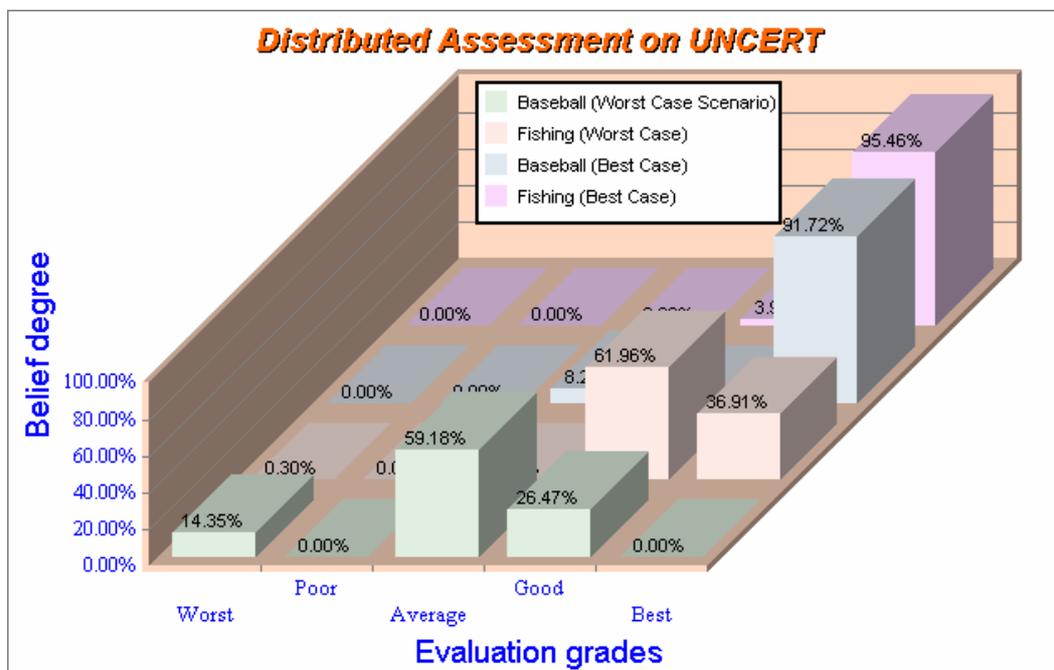


Figure 7: Performance Distributions of Projects in UNCERT Area

6.6. Overall evaluation result

As the outcomes as discussed in the previous sections are not so conclusive in this case study, generally the following are suggested:

- 1) Gather more information to reduce uncertainties
- 2) Reconsider the attribute weights
- 3) Make a decision based on the available information and analysis

The 1st option requires more time and efforts in data collection and the subsequent analysis. It depends on the availability of more data and information of higher certainty. External experts and consultants may sometimes be required. The 2nd option also either needs the involvement of project team members, maybe with more other internal/external experts, to re-evaluate the attribute weights.

The 3rd option may have to be taken when options 1 and 2 are not justifiable or can not offer further information to distinguish the performances of different alternatives. The average performance score of the best and worst case of each project is a good indicator for ranking purposes. Based on such an indicator, in this case study, the Fishing Game project is a preferred project.

7. Conclusions

There is a need to tackle the problem of uncertainty which may impair the reliability of the NPD project screening results. Incomplete data and human inability of making accurate judgments are common in practice, which need to be addressed for better decision making. The Group based ER-AHP method presented in previous sections can be used to address the problem of uncertainty in project screening. The proposed method is capable of handling both incomplete and imprecise judgments, which can effectively tackle the problem of uncertainty and in turn improve decision making quality of project screening. It also facilitates the group-based decision making in the project screening process. A case study, with data collection procedure, calculations and results, is introduced to illustrate the application of the method to project screening.

The authors extend the basic AHP algorithm to consider uncertainties caused by interval-valued evaluations, which always happen in NPD project screening problem. The developed ER-AHP methodology could improve the decision analysis on the basis of taking into account two kinds of interval-valued evaluations, interval grades and interval assessment in possibilities. As shown in the case study, the industrial experts' judgments are associated with uncertainties that are a combination of qualitative, quantitative and vague information in various forms. The typical formats of data and

information employed in the industry are described in a precise number, an interval value, and a belief structure. The ER-AHP methodology is able to deal with these uncertain data and information with intervals, probabilities, and unknown embedded, etc.

To illustrate the contribution of this research to the practice, the authors formulated a NPD project screening evaluation framework incorporated with the ER-AHP methodology for the implementation through a case study. A hierarchal project screening evaluation model is proposed, which constitutes five categories of criteria, namely marketing competencies, manufacturing competencies, customers' requirements, financial risks, and uncertainties of project outcomes. The model consists of thirteen evaluation criteria in 2 levels. The AHP method is used to determine the weightings of individual criteria. In addition, a group-based approach is suggested to facilitate the group-based decision making in the project screening process. This provides a way of implementing the Group ER-AHP evaluation methodology.

The development of this group based ER-AHP new product project screening methodology is motivated by practicing product managers trying to make decisions about choices of alternative new product concepts. The authors have demonstrated the applicability of the methodology through a case study. This case study, however, is not the full validation of the methodology, as it only demonstrates its applicability in one company. Therefore, for future work, the methodology will be validated in more companies and even in different industries.

Appendix 1: The weights of the NPD team members for each of the level 1 criteria (determined by the top management)

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
Marketing	0.6	0.1	0.7	0.7	0.5
Engineering	0.3	0.4	0.3	0.3	0.4
Manufacturing	0.1	0.5	0	0	0.1

Appendix 2: The importance weights of the level 1 criteria of the evaluation model (determined by the top management with AHP approach)

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
MKTFIT		1	3	4	1
MANUFIT			1	1/2	1/3
CUSTFIT				1/2	1/2
FINRISK					1/2
UNCERT					
Weights **	0.3139	0.1354	0.1054	0.1602	0.2851

Table 1 Level 1 Overall model

CR=0.1

** Weights are calculated using the Eigenvector (AHP) method in the IDS software

Appendix 3: The importance weights of the model elements (determined by the NPD team members by AHP)

Marketing

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
MKTFIT		8	1	2	2
MANUFIT			1/8	1/3	1/5
CUSTFIT				2	2
FINRISK					1
UNCERT					
Weights **	0.3198	0.0408	0.3197	0.1517	0.1680

Table 1 Level 1 Overall model
CR=0.01

	TIMING	PRICE	LOGISTICS	SALES
TIMING		1	2	2
PRICE			1	2
LOGISTICS				1
SALES				
Weights **	0.3383	0.2879	0.2046	0.1692

Table 2 Level 2 MKTFIT - Fit with firm's core marketing competencies
CR=0.02

	MFGTECH	MFGCAP	SUPPLY
MFGTECH		1	2
MFGCAP			2
SUPPLY			
Weights **	0.4	0.4	0.2

Table 3 Level 2 MANUFIT - Fit with firm's core manufacturing competencies

CR=0

	DESIGN	RELIA
DESIGN		1
RELIA		
Weights **	0.5	0.5

Table 4 Level 2 CUSTFIT - Fit with customer' requirements

	REVENUE	EXPEND
REVENUE		1
EXPEND		
Weights **	0.5	0.5

Table 5 Level 2 FINRISK - Total dollar risk profile of the project

	R&DUNC	NONR&D
R&DUNC		3
NONR&D		
Weights **	0.75	0.25

Table 6 Level 2 UNCERT - Uncertainty about project's outcomes

Engineering

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
MKTFIT		8	1	1	1
MANUFIT			1/8	1/5	1/8
CUSTFIT				2	1
FINRISK					1
UNCERT					
Weights **	0.2439	0.0334	0.2827	0.1961	0.2439

Table 1 Level 1 Overall model
CR=0.015

	TIMING	PRICE	LOGISTICS	SALES
TIMING		1	2	2
PRICE			2	1
LOGISTICS				1
SALES				
Weights **	0.3383	0.2879	0.1692	0.2046

Table 2 Level 2 MKTFIT - Fit with firm's core marketing competencies
CR=0.02

	MFGTECH	MFGCAP	SUPPLY
MFGTECH		2	1
MFGCAP			1
SUPPLY			
Weights **	0.4126	0.2599	0.3275

Table 3 Level 2 MANUFIT - Fit with firm's core manufacturing competencies

CR=0.027

	DESIGN	RELIA
DESIGN		1
RELIA		
Weights **	0.5	0.5

Table 4 Level 2 CUSTFIT - Fit with customer' requirements

	REVENUE	EXPEND
REVENUE		1
EXPEND		
Weights **	0.5	0.5

Table 5 Level 2 FINRISK - Total dollar risk profile of the project

	R&DUNC	NONR&D
R&DUNC		5
NONR&D		
Weights **	0.8333	0.1667

Table 6 Level 2 UNCERT - Uncertainty about project's outcomes

Manufacturing

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
MKTFIT		2	1	1	1
MANUFIT			1/2	1	1
CUSTFIT				1/2	1
FINRISK					1
UNCERT					
Weights **	0.2226	0.1523	0.2002	0.2318	0.1931

Table 1 Level 1 Overall model
CR=0.04

	TIMING	PRICE	LOGISTICS	SALES
TIMING		1	1	1
PRICE			2	2
LOGISTICS				1
SALES				
Weights **	0.2463	0.3465	0.2036	0.2036

Table 2 Level 2 MKTFIT - Fit with firm's core marketing competencies
CR=0.02

	MFGTECH	MFGCAP	SUPPLY
MFGTECH		1	1
MFGCAP			1
SUPPLY			
Weights **	0.3333	0.3333	0.3333

Table 3 Level 2 MANUFIT - Fit with firm's core manufacturing competencies

CR=0

	DESIGN	RELIA
DESIGN		1
RELIA		
Weights **	0.5	0.5

Table 4 Level 2 CUSTFIT - Fit with customer' requirements

	REVENUE	EXPEND
REVENUE		1
EXPEND		
Weights **	0.5	0.5

Table 5 Level 2 FINRISK - Total dollar risk profile of the project

	R&DUNC	NONR&D
R&DUNC		5
NONR&D		
Weights **	0.8333	0.1667

Table 6 Level 2 UNCERT - Uncertainty about project's outcomes

Appendix 4: The specific evaluation scales and guidelines for each model criteria of NPD projects of this case study

1.1 TIMING – in terms of delivery time for Christmas sales

Scale	1	2	3	4	5	6	7
Value	Beyond Nov	End Nov	Mid Nov	Early Nov	End Oct	Mid Oct	Before Early Oct

Explanation: The target launch time of the product is set to match the Christmas sales in overseas markets. Thus, it is targeted to deliver the products in End Oct. Earlier delivery, Before End Oct, is preferable. Some degree of late delivery is tolerable. However, it is extremely unacceptable if it is delivered Beyond Nov because the peak sales period will be over when the products arrive at the market.

1.2 PRICING – in terms of percentage of deviation from the target price level

Scale	1	2	3	4	5	6	7
Value	$\geq +20\%$	+15%	+10%	+5%	0%	-5%	$\leq -10\%$

Explanation: A target price level is predetermined based on market situations. It is satisfactory to meet the target, which means zero deviation from the target. However, it is undesirable if the price is higher the target. The limit is 20% of the deviation. It is extremely unacceptable if the price is more than 20% of the target. On the other hand, if the products can be launched at a cheaper price, it is preferable because of marketing advantages

1.3 LOGISTICS – in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	$\leq 60\%$	70%	80%	90%	100%

Explanation: 100% indicates that the product perfectly fits with the logistics and distribution channel. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

1.4 SALESFORCE - in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	$\leq 60\%$	70%	80%	90%	100%

Explanation: 100% indicates that the product perfectly fits with the salesforce coverage and strengths. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

2.1 MFGTECH – in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	$\leq 60\%$	70%	80%	90%	100%

Explanation: 100% indicates that the product perfectly fits with the manufacturing technology. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

2.2 MFGCAP – in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	$\leq 60\%$	70%	80%	90%	100%

Explanation: 100% indicates that the product perfectly fits with the manufacturing capacity. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

2.3 SUPPLY – in terms of confidence level about the fit

Scale	1	2	3	4	5
Value	$\leq 60\%$	70%	80%	90%	100%

Explanation: 100% indicates that the product perfectly fits with the current supply base. A decrease of the fit is undesirable and the limit is 60% which is extremely unacceptable.

3.1 DESIGN – in terms of extent to which the requirements are met

Scale	1	2	3	4	5	6	7
Value	≤80% meet	85% meet	90% meet	95% meet	100% meet	10% additional features	20% additional features

Explanation: It is desirable that all the customer requirements are met. It is very important to meet the requirements. It is extremely unacceptable if only 80% or less of the requirements can be met. On the other hand, it is preferable if the product can deliver additional features that are required by customers, but not yet voiced out.

3.2 RELIA – in terms of percentage of deviation from the target reliability level

Scale	1	2	3	4	5	6	7
Value	≤20%)	-15%	-10%	-5%	0%	+5%	≥+10%

Explanation: A reliability level is. It is satisfactory to meet the target, which means zero deviation from the target. However, it is undesirable if the estimated reliability is lower the target. The limit is 20% of the deviation. It is extremely unacceptable if the reliability is lower than the target. On the other hand, reliability that is higher than the target is preferable as it will lead to higher customer satisfaction.

4.1 REVENUE – in terms of probability of meeting the target revenue level

Scale	1	2	3	4	5
Value	≤80%	85%	90%	95%	100%

Explanation: 100% indicates that the product perfectly meets the target revenue level. A decrease of the value is undesirable and the limit is 80% which is extremely unacceptable.

4.2 EXPEND – in terms of probability of meeting the target expenditure level

Scale	1	2	3	4	5
Value	≤80%	85%	90%	95%	100%

Explanation: 100% indicates that the product perfectly meets the target expenditure level. A decrease of the value is undesirable and the limit is 80% which is extremely unacceptable.

5.1. R&DUNC – in terms of the uncertainty

Scale	1	2	3	4	5
Value	≥20%	15%	10%	5%	0%

Explanation: 0% indicates a perfect situation that there is no technological uncertainty. An increase of the uncertainty is undesirable and the limit is 20% which is extremely unacceptable.

5.2. NONR&D – in terms of the uncertainty

Scale	1	2	3	4	5
Value	≥20%	15%	10%	5%	0%

Explanation: 0% indicates a perfect situation that there is no uncertainty that are not related to research and product design. An increase of the uncertainty is undesirable and the limit is 20% which is extremely unacceptable.

Appendix 5: The evaluations of NPD projects by the NPD team members for this case study

The weights of the NPD team members for each of the level 1 criterion

	MKTFIT	MANUFIT	CUSTFIT	FINRISK	UNCERT
Marketing	0.6	0.1	0.7	0.7	0.5
Engineering	0.3	0.4	0.3	0.3	0.4
Manufacturing	0.1	0.5	0	0	0.1

Marketing

With respect to TIMING - The product matches the desired launch timing needed by our target segment

	Evaluation
Baseball	2:10% 3-4:30% 5:60%
Fishing	6-7:80% 5:20%

With respect to PRICE - The product matches the desired price level for our target segment

	Evaluation
Baseball	3:10% 4:20% 5:70%
Fishing	4:10% 5:80% 6:10%

With respect to LOGISTICS - The product fits with our logistics and distribution strengths

	Evaluation
Baseball	2:30% 3-4:70%
Fishing	4:10% 5:90%

With respect to SALES - The product fits with our salesforce coverage and strengths

	Evaluation
Baseball	3-4:100%
Fishing	4:10% 5:90%

With respect to MFGTECH - The product fits with our manufacturing technology

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	5:100%

With respect to MFGCAP - The manufacturing capacity matches demands

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	5:100%

With respect to SUPPLY - The product allows us to use our good suppliers

	Evaluation
Baseball	4-5:70% unknown:30%
Fishing	5:100%

With respect to DESIGN - The product is designed for the requirements needed by the customer

	Evaluation
Baseball	6:20% 7:80%
Fishing	3-4:20% 4-5:80%

With respect to RELIA - The product meets the target reliability level

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	5:100%

With respect to REVENUE – Expected revenue

	Evaluation
Baseball	4-5:70% unknown:30%
Fishing	2-3:30% 4-5:70%

With respect to EXPEND – Expected expenditure

	Evaluation
Baseball	3-5:80% unknown:20%
Fishing	4-5:100%

With respect to R&DUNC - Technological uncertainties in research and product design

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	4-5:100%

With respect to NONR&D- Uncertainties which are not related to research and product design

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	3:20% 4-5:80%

Engineering

With respect to TIMING - The product matches the desired launch timing needed by our target segment

	Evaluation
Baseball	2:10% 3-4:40% 5:50%
Fishing	5:20% 6-7:80%

With respect to PRICE - The product matches the desired price level for our target segment

	Evaluation
Baseball	2-3:10% 4:30% 5:60%
Fishing	4:10% 5:80% 6:10%

With respect to LOGISTICS - The product fits with our logistics and distribution strengths

	Evaluation
Baseball	4:80% unknown:20%
Fishing	5:100%

With respect to SALES - The product fits with our salesforce coverage and strengths

	Evaluation
Baseball	4-5:80% unknown:20%
Fishing	5:100%

With respect to MFGTECH - The product fits with our manufacturing technology

	Evaluation
Baseball	3:20% 4:80%
Fishing	4:5% 5:95%

With respect to MFGCAP - The manufacturing capacity matches demands

	Evaluation
Baseball	3:20% 4:80%
Fishing	5:100%

With respect to SUPPLY - The product allows us to use our good suppliers

	Evaluation
Baseball	2-3:30% 4-5:70%
Fishing	5:100%

With respect to DESIGN- The product is designed for the requirements needed by the customer

	Evaluation
Baseball	6-7: 80% unknown:20%
Fishing	3:10% 4:90%

With respect to RELIA - The product meets the target reliability level

	Evaluation
Baseball	3-4:40% 4-5:60%
Fishing	4:5% 5:95%

With respect to REVENUE – Expected revenue

	Evaluation
Baseball	4-5:80% unknown:20%
Fishing	3-5:100%

With respect to EXPEND – Expected expenditure

	Evaluation
Baseball	3:20% 4-5:80%
Fishing	4-5:100%

With respect to R&DUNC - Technological uncertainties in research and product design

	Evaluation
Baseball	3:30% 4-5:70%
Fishing	4:10% 5:90%

With respect to NONR&D- Uncertainties which are not related to research and product design

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	4-5:80% unknown:20%

Manufacturing

With respect to TIMING - The product matches the desired launch timing needed by our target segment

	Evaluation
Baseball	1:10% 2-4:50% 5:40%
Fishing	5:20% 6-7:80%

With respect to PRICE - The product matches the desired price level for our target segment

	Evaluation
Baseball	2-3:20% 4:30% 5:50%
Fishing	4:20% 5:80%

With respect to LOGISTICS - The product fits with our logistics and distribution strengths

	Evaluation
Baseball	4:80% unknown:20%
Fishing	5:100%

With respect to SALES - The product fits with our salesforce coverage and strengths

	Evaluation
Baseball	4-5:80% unknown:20%
Fishing	5:100%

With respect to MFGTECH - The product fits with our manufacturing technology

	Evaluation
Baseball	2:20% 3-4:70% unknown:10%
Fishing	4:10% 5:90%

With respect to MFGCAP - The manufacturing capacity matches demands

	Evaluation
Baseball	2:30% 3-4:70%
Fishing	4:10% 5:90%

With respect to SUPPLY - The product allows us to use our good suppliers

	Evaluation
Baseball	2-3:20% 4-5:60% unknown:20%
Fishing	5:100%

With respect to DESIGN - The product is designed for the requirements needed by the customer

	Evaluation
Baseball	6-7:60% unknown:40%
Fishing	3:10% 4:90%

With respect to RELIA - The product meets the target reliability level

	Evaluation
Baseball	3-4:30% 4-5:50% unknown:20%
Fishing	4:5% 5:95%

With respect to REVENUE – Expected revenue

	Evaluation
Baseball	4-5:80% unknown:20%
Fishing	3-5:100%

With respect to EXPEND – Expected expenditure

	Evaluation
Baseball	3:20% 4-5:70% unknown:10%
Fishing	4-5:100%

With respect to R&DUNC - Technological uncertainties in research and product design

	Evaluation
Baseball	3:30% 4-5:70%
Fishing	4:10% 5:90%

With respect to NONR&D- Uncertainties which are not related to research and product design

	Evaluation
Baseball	3-5:70% unknown:30%
Fishing	4-5:80% unknown:20%

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