Estudios de Administración, vol. 4, N° 2, 1997

Evaluation of Eight Project Selection Methods: the Case of Information Systems

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Extracto

La determinación de prioridades de proyectos constituye una etapa esencial del proceso de planificación. Usualmente, la escasa disponibilidad de recursos impide ejecutar simultáneamente todos los proyectos disponibles. Se han desarrollado en este respecto diversos métodos de selección, a fin de definir uno adecuado para determinar prioridades. Este artículo expone y analiza ocho de tales métodos: análisis de costo beneficio, análisis de riesgo, escalafón (*ranking*), ponderación, programación cero uno, sistemas sobre base de conocimiento, comisiones especiales y proceso de jerarquización analítica. El artículo evalúa estos métodos en función de ocho criterios, llegando a la conclusión de que ninguno satisface todos los requisitos. Una limitación importante en la mayoría de los casos es la incapacidad de dar respaldo a la adopción de decisiones colectivas, no obstante la creciente importancia de tal criterio. La conclusión obtenida es que la idoneidad de los métodos depende de las características de la situación en que se ha de adoptar una decisión. El análisis expuesto aporta pautas para escoger un método ante una situación específica.

Abstract

Determining the priorities of projects is an essential step in the planning process. Usually, the limited availability of resources prohibits the

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simultaneous execution of all proposed projects. A number of project selection methods have been developed to ensure a deliberate process of determining priorities. In this paper we describe and discuss eight of these methods: cost benefit analysis, risk analysis, ranking, scoring, zero one programming, knowledge-based systems, steering committees, and the analytic hierarchy process. We evaluate these methods based on a set of eight criteria. We conclude that none of the methods meets all requirements. An important shortcoming of most methods is the inability to support group decision-making despite the increasing importance of this criterion. As a consequence, the appropriateness of the methods depends on the characteristics of the decision situation. Our analysis provides guidelines for choosing a method in a specific situation.

Introduction

Managers frequently propose more projects than can be implemented, giving limited available resources. This implies that managers have to decide which projects to implement and in what sequence these projects will be implemented. Each project has to be evaluated in order to determine its priority. Evaluation of projects is part of any business function. Examples are the development of an advertising campaign, the purchase of production technology, the entrance of a new market, and the introduction of a new product. Giving the limited availability of resources, such as time, money, production capacity, and knowledge, not all proposed projects can be implemented simultaneously.

This situation is also often encountered in information systems planning processes, in which management has to determine which information systems the organization need, and in what sequence these have to be developed. To support the priority setting of information systems projects, several methods have been proposed. A review of literature has led us to the following eight methods: cost benefit analysis, risk analysis, ranking, scoring, zero one programming, knowledge-based systems, steering committees and the analytic hierarchy process. The objective of this paper is to enlarge our insight in the applicability of these methods. What are the relative strengths and weaknesses of each method and how can a manager determine which method is appropriate in a particular situation?

Information technology has a substantial impact on organizations (Lederer and Mendelow 1993). Information technology can be crucial to business operations, and it can provide strategic opportunities. Therefore, it is not surprising that recent research has shown that information managers consider information planning as an increasingly important topic (Brancheau and Whetherbe 1987, Earl 1993, Finnegan and Fahy 1993). Bowman et al. 1983 describe a three-stage model of the information planning process. The objective of the first stage is to create the goals and strategies of the information function. The second stage analyses the organizational information requirements and identifies the major information (sub) technology projects. In the third planning stage it is decided which projects to implement in which order. The project selection decision is affected by resource constraints and interdependencies between projects. For example, an interactive sales system is only useful when on line stock information is available to check whether certain items are available. The project selection marks the transition from the information planning stage to the implementation stage. According to Mantz et al. 1990, this transition is often difficult.

Determining priorities is not easy, because a large number of factors play a role. These factors do not only involve the financial consequences of the system, but also factors like risk and the extent to which the system contributes to the operational and strategic objectives of the firm. Usually, these factors are hard to quantify, expressing them in financial terms is often impossible (Berghout and Meertens 1992). In practice, managers have difficulty to include all of these factors in their decision process and to make the necessary trade-offs (Irsel and Swinkels 1992).

To turn the priority setting into a less subjective process, a formalized procedure can be applied to ensure that attention is paid to all relevant factors. This paper starts with a brief overview of factors that are important in priority setting. The third section describes the framework of eight criteria that is used to evaluate the various project selection methods. In the fourth section each method is evaluated, while the fifth section provides an overview of these evaluations. The paper ends with several conclusions concerning the appropriateness of the discussed methods for supporting project selection decisions and presents managerial and research implications.

Criteria for priority setting

A large number of factors can influence the priority setting of projects, such as the costs and benefits, risk, strategic considerations, and user needs. These factors can be grouped in several ways. An important distinction is between quantitative and qualitative factors. The quantitative factors can be expressed in numbers -for example, the size of an information system can be expressed in the number of code lines or function points. Many quantitative factors are related to monetary value, such as the costs and benefits of a project. Qualitative factors cannot be expressed in numbers. Benefits like faster information, improved access to information, or better market information are hard to quantify. Nevertheless, qualitative factors play an important role in the ultimate decision concerning which information systems will be implemented.

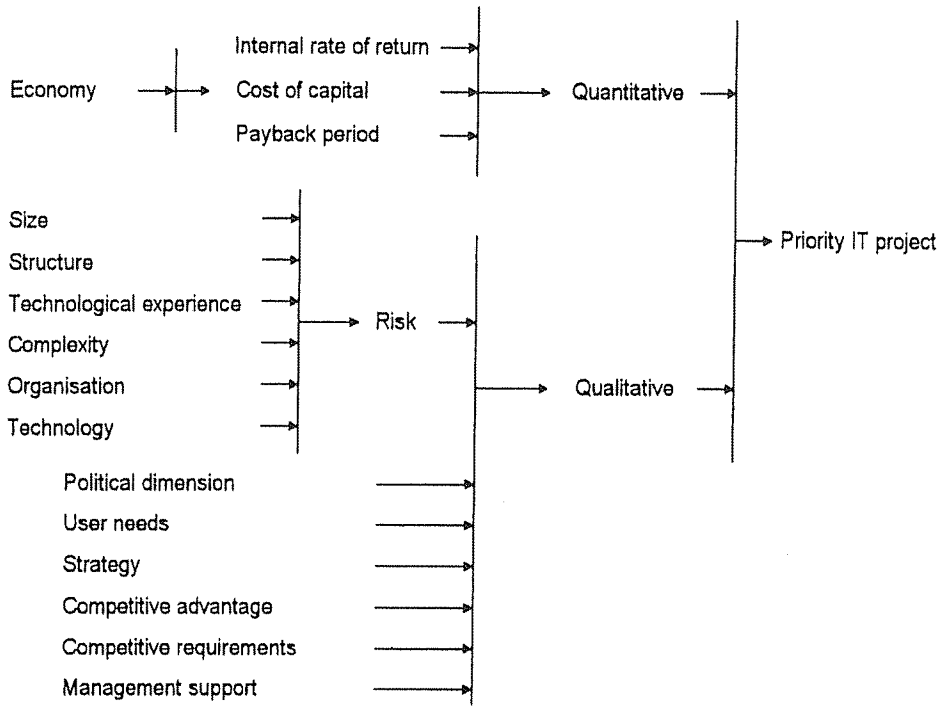
According to Mehrez et al. 1993, there is no uniform collection of criteria for project selection that can be applied in any situation for any organization. Figure 1 contains an overview of criteria that are often used to determine the priorities of projects (based on Agarwal et al. 1992, Parker et al. 1988, McFarlan 1981). Each organization or manager has to decide which of these criteria are relevant in a particular situation. One factor influencing this decision is the type of information system. When manual processes are replaced by computerized information systems, classical investment analysis can be applied because the main effects of the new system are cost savings. If, on the other hand, the information system is aimed at strategic objectives or management support, qualitative factors and risk become more important (Irsel and Swinkels 1992). Classical investment analysis provides less possibilities to include these factors. In these instances management has to search for different methods to support the priority setting of projects.

Criteria for comparing project selection methods

Over the years, a number of methods and techniques have been developed to support priority setting of projects. To evaluate these kind of methods, various criteria have been proposed in literature. Sowder 1972 and Santhanam et al. 1989 discuss the following criteria: a realistic description of the selection problem, analyzing alternatives and the comprehensibility and applicability of the method. Muralidhar et al. 1990 add the incorporation of both quantitative and qualitative factors and the relative importance of factors.

Figure 1

Criteria affecting the priority of IT *projects*



To these criteria we will add the criteria of supporting group decision-making and structuring the decision process. Several paradigms refer to the way decisions are made in organizations. The holistic paradigm treats organizations as single decision makers (Bosman 1977, Cyert and March 1963, Tirole 1989). In practice, however, a number of people with different preferences and different expectations are involved in the project selection process. Abandoning the holistic paradigm and accepting the model of an organization as a group of participants working together in order to reach certain goals has consequences for the decision-making process. Project selection decisions involve many people from different departments with different needs and goals. Therefore project selection should be able to support group decision-making. Due to several changes in technology and business environment project selection decisions are becoming increasingly complex. These developments include increasing user involvement, the development of integrated information systems spanning multiple departments and the fact that information technology decisions are less and less left to information managers alone (functional managers and/or top managers play an increasingly important role). The complexity of the decision requires a phased solution of the problem and therefore methods should structure the decision-making process. The resulting eight criteria are listed in table 1. Each criterion will be briefly described.

Table 1

Criteria for evaluating project selection methods

	CRITERIA
1	Providing a realistic description of the selection problem
2	Supporting group decision-making
3	Structuring the decision-making process
4	Incorporating both quantitative and qualitative factors
5	Expressing the relative importance of factors
6	Analyzing alternatives
7	Comprehensibility of the method
8	Applicability of the method

1. Providing a realistic description of the selection problem
   The project selection problem is characterized by multiple goals, constraints and risks. A method should incorporate all of these aspects in order to be realistic.
2. Supporting group decision-making
   Project selection is a problem that involves a large number of people from both the information department and the user departments. A method is able to support group decision-making if differences in opinion among group members can be stated and evaluated explicitly.
3. Structuring the decision-making process
   The method should structure the decision-making process by prescribing which steps should be taken to reach a solution. Structuring can refer to the construction of the model as well as to the application of this model.

4. Incorporating both quantitative and qualitative factors
   As discussed in the previous section, a large number of factors play a role in project selection. Some of these factors are quantitative (such as the costs of the system), others are qualitative (such as the risk of a system). A method should be able to incorporate both qualitative and quantitative factors.
5. Expressing the relative importance of factors
   Because many factors are involved, decision makers should be able to state differences in the relative importance of the factors. All factors do not necessarily have the same importance.
6. Analyzing alternatives
   The method should provide decision makers with the opportunity to perform a number of analyses. Sensitivity analyses and what-if analyses show the consequences of changes in, for example, the importance of factors. Confidence in the outcome of the model will increase if small changes in the relative importance of factors do not have much impact on the overall priority setting
7. Comprehensibility of the method
   The method should be easy to understand. Managers have to understand how the method derives the priorities. This does not necessarily mean that the methodology is easy to use. Comparing the costs and benefits of a system is easy to understand; quantifying these costs and benefits, however, can be hard.
8. Applicability of the method
   This criterion refers to two aspects. First, the costs of developing and using the model should be limited. Second, the method should be easy to use without elaborate training.

Evaluation of project selection methods

Literature review has led us to a number of methods that have been developed to support the selection of projects. Each method assumes that a list of proposed projects is available. In this section we describe eight of these methods (table 2). Their strengths and weaknesses are determined by applying the eight criteria described in the previous section.

Table 2

Methods for the selection of projects

	METHOD
1	Cost benefit analysis
2	Risk analysis
3	Ranking
4	Scoring models
5	Zero one programming
6	Knowledge-based systems
7	Steering committee
8	Analytic hierarchy process

1. Cost benefit analysis

   Cost benefit analysis requires the identification and specification of the costs and benefits of each project. All factors should be expressed in monetary terms. To facilitate the identification of costs and benefits, King and Schrem 1978 have established a list of potential costs and benefits. After specifying the costs and benefits, the projects must be evaluated according to a financial statistic such as the internal rate of return, the payback period or the net present value. Cost benefit analysis considers the project selection problem as an investment decision. It recognizes that a new information system is an investment that should contribute to the bottom line performance of an organization.

   This method has a few serious weaknesses. The assumption that all factors can be expressed in monetary terms is not realistic. Groenendijk and De Groot 1992 state that when all factors are forced into one unity, this unity can lose its meaning, at the cost of the organizational goals. Another problem is not incorporating the risks of the various projects. Although the method is easy to understand, quantifying the costs and benefits can be very tedious. This seriously limits the ease of use of the method. Finally, according to Sebus 1992, indirect costs are often neglected.

2. Risk analysis

   McFarlan 1981 has developed a method that takes the risk of projects into account. According to McFarlan, many projects fail because the risks of individual projects and portfolios of projects are not properly assessed.

The risk of a proposed project depends, among others, on the use of new technology (hardware, software, or databases), or the experience and knowledge of the system developers. McFarlan argues that one should select a portfolio of projects with different risk levels. The ratio of low- to high-risk projects depends on the organizational environment and the goals of the organization. Information technology used as a strategic weapon requires more high-risk projects than information technology supporting the operational activities of an organization. Management should balance the risk of projects and the benefits of these projects.

A drawback of this method is that it focuses entirely on risk, while other factors are only dealt with indirectly. As a consequence, the method is not very realistic. Risk analyses can be partly structured by using a standardized questionnaire. An advantage of such a questionnaire is that the multidimensional construct 'risk' is measured in a uniform way, which increases the validity and reliability of the measurement. The vagueness of the concept risk, however, limits the comprehensibility of the method. Risk can be defined in many ways, which can lead to different interpretation by managers. The use of the standard questionnaire increases the applicability of the method, although some of the questions as described by McFarlan 1981 are difficult to answer.

3. Ranking

The ranking method involves the ranking of projects for each factor, such as pay back period and complexity (Buss 1983, Muralidhar et al. 1990, Earl 1993). The project that best fulfills a factor gets score one, the project that comes second score two, etc. Subsequently, the ranks for the different factors are added up for each individual project. This total score reflects the priority of a project. A project with the lowest total score has the highest priority.

An advantage of this method is that both quantitative and qualitative factors are dealt with. Also, factors can compensate each other. A project with a lower profit and a lower risk can be preferred to a project with a higher profit and a high risk. The method is easy to apply, the projects only have to be ranked for each factor. The method is also easy to understand. A disadvantage of this method is that all factors are considered to be equally important. A conceptual problem is the fact that the ordinal rankings are used as interval ratings.

4. Scoring models

Scoring models require the decision maker to assign a score to each project on each factor. This score represents the extent to which a project fulfills a certain factor (Melone and Wharton 1984, Muralidhar et al. 1990). Besides providing a score for each project, the factors are scored to represent the relative importance of the factors. The overall priority of a project is calculated by multiplying the relative importance of a factor and the score of a project on that factor, aggregated for all factors.

A major advantage of this method is the opportunity to specify the relative importance of factors. If risk is more important than complexity one can assign a higher score to risk. Scoring models are easy to understand. The overall priority of a project is based on the extent to which a project fulfills the various factors. Scoring models implicitly assume that all factors are measured in the same unit (not necessarily money, but for example 'utility'). If the factors cannot be measured in the same unit, the necessary aggregation to an overall score is not allowed. Despite the fact that the method is easy to understand, the applicability is somewhat limited. It may be hard to specify in precise units what a project scores on a factor or the relative importance of the factor. Determining the factor weights can be a time-consuming process and it is questionable whether the weights are a valid measurement of the real importance of the factors.

5. Zero one programming

Santhanam et al. 1989 state that none of the previous methods account for resource limitations. To solve this problem, they have developed a model to select projects in a situation of limited resource availability. The model distinguishes goals (the model tries to maximize the achievement of these goals), resource constraints (the solution should fulfill these constraints) and an objective function which tries to minimize deviations from the goals. Zero one programming is used to solve the model.

An advantage of this method is that it does not only result in a determination of the priorities of projects, but it also results in the determination of an optimal portfolio of projects. By explicitly incorporating the availability of resources the feasibility of the solution is guaranteed. In this way the method is realistic. One problem, however, is the requirement to express all goals and constraints in one overall objective function. The intangible benefits must be ranked or scored in order to specify this function. A practical problem is that the method requires a lot of input data that might be difficult to specify. The authors partly solve this problem by developing a model management system to support the specification of the model (Santhanam and Schniederjans, 1993).. The comprehensibility and the ease of use of the model is limited. Applying this method requires a solid knowledge of zero one programming.

6. Knowledge-based systems

Agarwal et al. 1992 argue that knowledge-based systems provide the opportunity to combine both qualitative and quantitative factors. Their system combines financial statistics, such as the net present value and the internal rate of return on the one hand, and knowledge and experience elicited from human experts on the other. Agarwal et al. have specified an interrelated set of factors, and heuristic rules are used to classify the projects based on these factors. Firstly, the projects are classified according to the quantitative and qualitative factors separately. Secondly, heuristic rules are used to combine these classifications into one overall ranking. For example, a rule may state that if the project involves new technologies, is highly complex, and incorporates conflicting goals, the project is categorized as 'high risk'. Next, the risk is combined with the political dimension, the strategic dimension, and the number of users, ultimately resulting in an overall qualitative ranking.

Incorporating both quantitative and qualitative factors is an important advantage of this method. The heuristic rules contain the relative importance of the various factors, while the use of an expert system structures the process. The knowledge of a human expert is modeled in production rules. The inference engine of the expert system subsequently determines the reasoning process. The use of an expert system with explanation facilities also increases comprehensibility. If these facilities are available, questions and reasoning steps can be clarified for the decision maker.

Concerning the applicability of the method, the use of the system should be clearly distinguished from the construction of the system. The use of the system is relatively easy, the development of the system is certainly not. One has to find human experts in order to make the reasoning process explicit. It is questionable whether the same knowledge-based system can be applied to different organizations, or whether each organization should develop its own system to reflect the specific characteristics of that organization.

7. Steering committee

Lederer and Mendelow 1993 describe the steering committee as an important instrument for determining the priorities of projects. A committee consists of a group of senior business executives, who determine the priorities of the different projects. These priorities are established in one or more negotiations. In discussing the steering committee we will forgo the possibility of using one of the other methods within the steering committee.

A major advantage of this method is the increased acceptance of the decisions reached by consensus. The method is realistic, because all of the relevant aspects can be discussed. There is no guarantee, however, that consensus will be reached and it can take a long time to reach consensus. A special problem is the existence of group effects such as the dominance of one of the members. The steering committee aims at reaching consensus rather than at objectively comparing alternatives.

McKeen and Guimaraes 1985 argue that steering committees will result in a portfolio of projects with distinctive characteristics. Project proposals should be supported by different departments in order to get the proposal accepted. Therefore, projects with positive effects on more than one department have a higher chance of being accepted. McKeen and Guimaraes 1985 conclude that steering committees tend to select projects that: are large (number of users and development time), have little vertical integration, are aimed at the lower levels of the organization, are formally proposed with a written cost benefit analysis, and provide both quantitative and qualitative advantages.

8. Analytic hierarchy process (AHP)

AHP (Saaty 1977, 1980) requires the explicit specification of the goal, the factors and the projects in a decision hierarchy. Subsequently, the decision maker has to make pairwise comparisons of the projects for each factor. For example, a decision maker can specify that project A is moderately to strongly preferable to project B with regard to factor risk. All pairs of projects must be compared for all factors. The factors are pairwise compared in order to establish the relative importance of the factors. The overall priority of a project can be calculated by multiplying the relative importance of a factor and the preference of a project on that factor, aggregated over all factors.

An advantage of AHP is that it deals with both quantitative and qualitative factors. Furthermore, it enables the specification of the relative importance of factors by making pairwise comparisons of these factors. The requirement to explicitly specify the goals, factors and projects and the subsequent pairwise comparisons greatly structures the decision-making process. This also contributes to the comprehensibility of the method. The computations to determine the preferences of the projects and the relative importances of the factors using eigenvectors require a good understanding of matrix algebra. Special AHP-software (Buede 1992) reduces the importance of this disadvantage. These software packages also support different kinds of sensitivity analyses. A practical problem is that the number of pairwise comparisons that have to be made can become quite large. Finally, the AHP can support group decision-making by adding a level in the decision hierarchy that represents the various decision makers.

Overview of evaluation

Table 3 presents an overview of the evaluation of the eight project selection methods. As a supplement to the discussion of the individual methods in the previous section, we will discuss some general findings.

Table 3

An evaluation of project selection methods

Criteria \ Method	Cost benefit	Risk	Ranking models	Scoring models	Zero one progr.	Knowledge-based system	Steering committee	AHP
Realistic	-	-	+	+	+	+	+	+
Group decisions	-	-	-	-	-	-	+	+
Structure process	□	□	□	□	□	-/+	-	+
Quant./qualit.	-	-	+	+	+	+	+	+
Importance factors	-	-	-	+	+	+	+	+
Analyses	+	□	+	+	+	+	-	+
Comprehensibility	+	□	+	+	-	+	+	□
Applicability	□	-	+	□	-	-/+	□	□

+ = strong, - = weak, -/+ = strong and weak elements, □ = neutral

Most methods are realistic in the sense that they are able to deal with multiple goals and constraints. However, a number of methods assume that the different factors can be expressed in the same unit, cost benefit analysis expresses the factors in money, risk analysis in risk, ranking and scoring models use a rather undefined unit, for example 'utility'.

While usually a number of departments are involved in the project selection decision, only one method, the steering committee, explicitly supports group decision-making. Extensions to AHP also facilitate group decision-making. Without these extensions, the other methods only provide the opportunity to generate the input data within a group.

Most methods concentrate on the use of a model instead of the process of reaching a decision. The structuring of the decision-making process is limited, therefore, to the construction and use of the decision model. This means: identify the variables, assign a value to each variable or parameter, compute the outcome, and perform what-if and sensitivity analyses. Knowledge-based systems provide some structure because determining the priorities is structured by the inference engine. In contrast, the development of a knowledge-based system is less structured. Although the AHP is also primarily aimed at constructing and using a model, there have been efforts to structure decision-making with AHP (Dyer and Forman 1991, Huizingh and Vrolijk 1993). Probably, decision-making by means of one of the other methods can be structured in a similar way.

In theory, most methods enable the specification of quantitative and qualitative factors, and also provide the possibility of assigning relative importances to factors. Implementing both concepts is often not easy. Scoring models and AHP are most adequate in dealing with relative importances.

With the exception of steering committees, all methods use an explicit model to calculate priorities. This enables the alternatives to be analyzed when the appropriate software is used (often a spreadsheet). Table 3 reveals the distinction between the comprehensibility and applicability of the method. Several methods, e.g. cost benefit analysis, risk analysis and knowledge-based systems, are easy to understand but difficult to implement. The structuring and applicability of knowledge-based systems is described as -/+ because of the distinction between building and using the system. Using a system is easy and highly structured, developing such a system is difficult and much less structured.

Conclusion

It is not an unusual situation in organizations that managers propose more projects than can be implemented, due to the limited availability of resources. In these cases, management has to determine the priority of each project. An example is the priority setting of proposed information system projects at the end of the information systems planning process. This decision involves a large number of factors and participants. Some of the factors are quantitative, such as the pay back period and the internal rate of return, others are qualitative, such as contribution to the goals of the organization and better access to information. Carefully determining the priorities of projects requires the consideration of all of these factors. In this paper we have described the following eight methods to support project selection decisions: cost benefit analysis, risk analysis, ranking, scoring, zero one programming, knowledge-based systems, steering committees, and the analytic hierarchy process.

These methods have been evaluated by means of a framework consisting of eight criteria that influence the appropriateness of a method. Each method has some strengths and weaknesses, making them appropriate for different situations. Cost benefit analysis is especially applicable in the case of operational systems, such as payroll systems, and less applicable in the case of strategic systems, because the costs and benefits of such systems are hard to quantify. Risk analysis as described by McFarlan 1981 is more appropriate for selecting a portfolio of projects than selecting one project. The steering committee ensures that all interested parties are involved in the determination of priorities, but provides almost no guidance for the decision-making process. Scoring models, often proposed in information systems literature (Alter 1992, Kendall and Kendall 1992, Hicks 1993), have some clear strengths, but provide no opportunities to support group decision-making and its applicability declines with a rising number of projects and factors. A knowledge-based system can be built only if several similar project selection decisions have to be made and an expert is available. Analytic hierarchy process meets most criteria but might require making a large number of pairwise comparisons. These findings support the conclusion that none of the methods is dominant and that the appropriateness of a method depends upon the characteristics of the decision situation. In a specific situation our framework of criteria can be used to choose the most appropriate project selection method.

The most important shortcomings of the methods discussed are the lack of support for group decision-making and process structuring. Despite the increasing importance of group decision-making most methods do not adequately support this kind of decision-making. One way to solve this problem is to develop completely new methods which do take group decision-making considerations into account. Another solution is to adjust or to extend the existing methods. The knowledge gathered in the research fields of group decision-making (Sotirov and Krasteva 1994, Basak and Saaty 1993) and group decision support systems (Teng and Ramamurthy 1993, Nour and Yen 1992) can lead to useful extensions. Also, most methods provide little support to structure the decision-making process. Our experiences with structuring decision-making processes using AHP (Huizingh and Vrolijk 1993) suggest that comparable extensions can be developed for other methods. Future research should be directed to extensions of the methods discussed in order to solve these weaknesses.

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