Selecting DSS Evaluation Methods

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ABSTRACT

DSS evaluation is difficult because of their dynamic nature. Four methods to evaluate DSS are presented. Each method has advantages as well as disadvantages, depending on DSS characteristics and organizational objectives. In order to assess the effectiveness of the evaluation method, we define effectiveness criteria generally applicable to DSS and translate them into desirable features for DSS evaluation methods. Four DSS evaluation methods are evaluated based on seven predefined desirable features. As each method is strong on different features, combinations of the methods are suggested to complement each other.

INTRODUCTION

Decision Support Systems (DSS) are expanding their roles as important decision aids in organizations. Designed to support a wide range of organizational objectives, DSS increasingly support not only managerial control activities but also strategic decision making. DSS success is dependent on a wide variety of factors to be managed by DSS developers and IS managers [8]. Further, in order for an organization to effectively invest its resources in new DSS projects, project selection and development requires the use of suitable evaluation approaches. There are many evaluation approaches, each with strengths and weaknesses depending on DSS characteristics and other circumstances. It is important for IS and business managers to understand the pros and cons of each method and to chose wisely in assessing DSS projects for development and implementation.

Most DSS are designed to support ill-structured tasks (decisions) and user requirements cannot be specified clearly at the outset. A DSS has to evolve as users experience the system and learn to specify their needs more clearly. While traditional IS typically follow a system development life cycle (SDLC) which provide distinctive phases in the system development process, the phases are blurred in DSS development, and frequently, the processes of DSS design, implementation, and evaluation tend to proceed concurrently [29]. The DSS development process is evolutionary in the sense that DSS have to be replanned, modified, expanded and improved continuously through a prototyping process [9].

These basic differences from other systems have profound implications for DSS evaluation. First, DSS evaluation plays a crucial role for the evolution of a DSS. For a DSS to evolve in a desirable direction in a consistent manner, it requires an evaluation approach which supports such evolution and can provide a "unified framework" in this evolutionary process. Secondly, the benefits associated with ill-structured tasks are mostly qualitative and difficult to measure, calling for special evaluation methods.

In order to accommodate the unique nature of DSS, various evaluation methods have been proposed in the literature [1, 3, 15, 21, 23]. Four of the more widely known methods have been chosen for consideration in this paper: Cost/Benefit (C/B) analysis [18], the Value Analysis (VA) method [15, 16, 21], the multi-attribute utility method [11, 17], the Analytic Hierarchy Process Method [24, 25]. Combinations of different methods have also been proposed to support the more dynamic nature of DSS development [3] and to assess DSS effectiveness [10]. Each of these approaches have strengths and weaknesses, and they differ in terms of overall effectiveness for the evaluation of specific DSS projects. The ad-hoc combination of various methods can result in waste of company resources and in an inconsistent direction for DSS evolution unless the methods used complement each other in a manner to accomplish specific evaluation objectives.

While many approaches have been proposed to assess the effectiveness of a DSS, there is little research on assessing the effectiveness of the approaches themselves. The purpose of this paper is four fold. First, it develops general

DSS value assessment criteria by defining from the literature 5 important DSS characteristics which are operationalized as seven desirable features for DSS value assessment methods. Second, it briefly describes the four better established methods for DSS evaluation and discusses their general strengths and limitations. Third, it examines the effectiveness of each method along the set of desirable features. Last, since different DSS applications have different purposes and pursue different objectives, a proper match among application, effectiveness criteria, and evaluation method is also considered.

DEFINING THE DESIRABLE FEATURES OF DSS EVALUATION METHODS

In order to identify the important criteria for selecting an appropriate DSS evaluation method, it is necessary first to understand DSS characteristics pertinent to DSS evaluation. The relevant DSS characteristics can better be defined in light of their relationships with the environmental factors associated with them. A DSS should be considered as a part of a complex decision making system which consists of tasks, users, the organization, and the DSS itself [27]. In other words, a DSS is a decision aid designed to support various tasks for different user groups, and ultimately, designed to support organizational objectives. This view of the role of DSS in a decision making environment implies five important general DSS characteristics which have been recognized by various researchers [2, 14, 19, 27]. These are:

(1) DSS development is evolutionary in nature;
(2) DSS are designed to support organizational objectives;
(3) Different levels of users are involved in DSS development;
(4) Most DSS benefits are qualitative; and
(5) A DSS should be flexible in modeling the related business tasks.

The above DSS characteristics directly dictate the desirable features for an effective DSS evaluation method. These desirable features will be operationalized and used later to assess the effectiveness of DSS evaluation methods. Next, each desirable feature and its operationalization is discussed. Table 1 summarizes the discussion.

DSS Evaluation Methods Should Emphasize DSS Evolutionary Nature

Unlike traditional IS, DSS are primarily designed to support relatively ill-structured tasks whose solution procedures are not explicitly known *a priori* [14]. A complete set of system requirements cannot be identified at the outset of the DSS development process. Instead, DSS evolve continuously through an adaptive process of user/developer learning, requiring constant feedback and adaptation for their evolution [2, 7, 19]. This evolutionary nature of the DSS development process renders traditional cost/benefit analyses ineffective since total development costs and potential benefits become intangibles.

In order to support the widely known evolutionary na-

Table 1. Operationalizing the Desirable Features for DSS Evaluation Methods

Desirable Feature	Operational Feature/Effectiveness Criterion
(1) Support for DSS Evolution	• Integrated support for DSS planning and design
(2) Align DSS with Organizational Objectives	• Goal orientation
(3) Support for Multiple Evaluators/Users	• Prioritization/synthesis of viewpoints
(4) Assessment of Qualitative Benefits	• Qualitative benefits measurement • Consistent/comparable measurement • Incorporation of uncertainties
(5) Support DSS Flexibility	• Modeling Capability • Adaptabiliby of the approach

ture of a DSS, the project evaluation approach should address the iterative nature of DSS development which integrates planning and design in a prototyping mode. In other words, the evaluation method should allow DSS developers to operationalize DSS objectives and plans into the desired functions and features over the various prototype phases.

DSS Evaluation Methods Should Assess DSS Alignment With Organizational Objectives

DSS are often designed to support a set of specific tasks which support either strategic planning, managerial control, or operational control of an organization. As the DSS objectives should lead to the accomplishment of various organizational objectives, the DSS evaluation approach should be based on the degree of alignment between DSS objectives with the organizational objectives. The DSS evaluation method should shift the evaluators' attention toward an organizational perspective so that the DSS can support organizational long-term as well as short-term objectives.

DSS Evaluation Methods Should Support Different User Groups/Evaluators

The DSS projects can be initiated either by top management, user groups, or system specialists. The projects initiated can be evaluated by one of the following mechanisms: (1) Evaluation by top management, (2) evaluation by the IS department, (3) evaluation by a steering committee, or (4) evaluation by the user department. The choice of any mechanism for DSS evaluation will depend upon the culture and control policies of an organization. However, evaluation by any one of these groups can be biased in the sense that user perspectives or corporate perspectives may be neglected, or intangible benefits are ignored [6].

Different groups of DSS evaluators in an organization often expect different payoffs from the system, and it is important that their different views are integrated in the DSS evaluation process in a meaningful way. Typically top management is interested in the long-term economic value of a DSS and would regard it as a tool to accomplish organizational objectives. End-user groups are mainly interested in operational DSS capabilities which are necessary to undertake their departmental or personal tasks. The DSS capabilities, for example, may include what-if analysis, a regression model, and the graphic capability. System specialists are interested in the technical aspects of a DSS such as its machine resource efficiency and the flexibility of hardware and software. While the end-users' perspective and the related DSS features may be considered as the most important components of the DSS evaluation, the perspectives of top management and system specialists should also be incorporated. Therefore, the evaluation approach should be able to synthesize multiple viewpoints and thereby mitigate the bias inherent in a particular DSS selection group.

DSS Evaluation Methods Should Facilitate Assessment of DSS Qualitative Benefits.

While there are some DSS designed for structured tasks [21], most DSS are designed to support relatively ill-structured tasks whose benefits are often very difficult to measure. The difficulties in estimating DSS benefits are more thoroughly discussed elsewhere [3, 5, 13]. In summary, the difficulties are: the quantification of some benefits is highly subjective and subject to great uncertainty; the natural unit of measurement may not be comparable across all benefits; the estimation depends upon the operating environment and may change over the life of the system [5].

In order to facilitate the measurement of intangible benefits, a DSS evaluation approach should provide for consistent measures, e.g. indexing scheme for benefit estimation as discussed by Cooper [4], in developing benefit value estimation. Moreover, the measures should be comparable along all dimensions and should provide a way for incorporating uncertainties associated with the estimation process.

DSS Evaluation Methods Should Account for DSS Flexibility in Modeling Business Tasks

The business environment is increasingly volatile, changing quickly due to new business opportunities, problems and government regulations. To continue to be effective DSS applications must also change continuously to reflect new user knowledge and information requirements, technology, and other internal/external company environmental factors. Therefore, DSS should be flexible to support different/changing problem domains and different/changing problem solving environments. The DSS evaluation method needs to account for DSS ability to adapt to changing business problems and environments. The DSS selection method itself needs to be adaptable across DSS in the sense that changes in the environment (changes in DSS purposes, types of projects, objectives, and perspectives) should be easily incorporated into the evaluation model. In other words, the need to assess DSS with new objectives and new perspectives should not require revision of the whole evaluation process. Further, the method should be adaptable to complex and political environments where each group or division competes for resources [5].

Table 1 shows the desirable features of DSS evaluation methods and how these features are operationalized. The following section contains a description of the four DSS evaluation methods considered in this paper.

FOUR MAJOR METHODS FOR DSS EVALUATION

While there are other evaluation methods available, the four evaluation methods discussed in this paper were selected because of their distinctive characteristics and their widespread recognition in the literature. Included are: Cost/Benefit Analysis, Value Analysis, Multi-attribute Utility approach, and Analytic Hierarchy Process method.

Cost/Benefit Analysis

Cost/Benefit analysis (C/B) is based on well-developed financial economic theory and can therefore provide the most meaningful results to management. The basic technique involves comparing costs and benefits of undertaking a DSS project. The C/B analysis can be utilized successfully for DSS that support highly structured tasks in a fairly certain environment [22, 28]. Unfortunately, as discussed earlier, DSS benefits are frequently very difficult to quantify. Further, these qualitative benefits are the primary impetus for development of the system and therefore should be a major concern to the host organization [13]. Although a few methods are suggested to incorporate qualitative benefits into C/B analysis [18], the authors conclude that intangible benefits should not be used in the equations of the analysis itself. Instead, they should be considered separately. Ginzberg discusses the choice of an appropriate discount rate to reflect uncertainties involved in the project. The discount rates should directly reflect the degree of uncertainty associated with the intangible benefits [5].

Value Analysis

Emphasizing that C/B analysis is not appropriate for DSS projects whose benefits are mostly qualitative, Keen [15] proposes a value analysis. Since the essential issue in this approach is assessing the perceived value of qualitative benefits, benefits are emphasized while costs are maintained within some acceptable limit. Keen's method emphasizes robustness and simplicity in the assessment process, which is very important in the sense that as a consequence decision makers do not have to provide precise estimates of uncertain future variables. This method evaluates a DSS as a research-and-development (R&D) project rather than as a capital investment one, in a way that encourages innovation rather than immediate return-on-investment. The sequence of value analysis process can be described in a series of steps. In brief, these steps are: An operational list of required benefits is first defined and the cost threshold, which is the maximum cost for the given benefits, is determined. A prototype DSS is developed, and the benefits and costs are assessed. This approach is useful because it is simple, intuitive, and easy to install due to the prototyping approach to development. Compared to C/B analysis, this method also considers benefits and costs, but the means of assessing benefits in this case is more subjective and heuristic, and calls for a less rigorous estimation process.

Multi-Attribute Utility Value Approach

The utility value approach [11, 17] involves measuring the users' perception of the overall value (util) of a DSS. There are many different types of models, functions, and instruments which can be used in the utility value approach. The multi-attribute value function $V(x_1, x_2, \ldots, x_n)$ can be expressed in an additive form as shown in equation (1):

$$V(x_1, x_2, \ldots, x_n) = \Sigma_i w_i \cdot v_i(x_i) \qquad (1)$$

where V and v_i are value functions and w_i is the relative importance (or weight) of the attribute i. Different utility methods, such as lexicographical ordering, efficient frontier, additive utility models, and multiplicative utility models, are discussed by Keeney & Raifa [17] and by Huber [11]. The selection of the most appropriate method will depend upon the specific characteristics of the problem. A scoring model is a practical instrument often used to assess util of alternative DSS projects by examining various aspects associated with DSS development [20]. In the scoring model, quantitative as well as qualitative criteria are included, the weight of each criterion is determined, and the expected performance of alternative DSS projects along each criterion is measured either in terms of natural units or on artificial scales. Other instruments, including semantic differential technique [30] and questionnaires [12], can also be used to evaluate user satisfaction with alternative DSS projects over various dimensions. While cost factors can also be included along with other criteria in this approach, sometimes it may be necessary to conduct a separate analysis for the DSS project costs, especially if significant differences exist among the DSS projects in terms of cost items. In this case, cost and other factors may have to be reevaluated using the efficient frontier technique [17, 22] or a marginal analysis of benefits [18].

The Analytic Hierarchy Process Method

The Analytic Hierarchy Process (AHP) method, developed by Saaty [24, 25], can be used to evaluate DSS. The AHP method structures any complex, multi-criterion, multi-evaluator, and multi-period problem into a hierarchical model. The elements at the higher levels of the hierarchy represent more general issues such as overall DSS objectives while the elements at the lower level indicate more detailed issues such as specific DSS selection criteria. On each level of the hierarchy, each pair of elements is compared in terms of their relative importance in accomplishing a higher-level objective. Through this process, alternative DSS and DSS attributes can be evaluated in terms of how well they help to accomplish organizational objectives. Thus the method allows us to

Table 2. Performance of Evaluation Methods on Each Effectiveness Criterion

Effectiveness Criterion	Evaluation Method			
	C/B	Value Analysis	Multi-Attribute	AHP
(1) Integrated Support for DSS planning/design	LOW	HIGH	MEDIUM	HIGH
(2) Goal-Oriented	MEDIUM	LOW	LOW	HIGH
(3) Prioritization/Synthesis of Viewpoints	LOW	MEDIUM	MEDIUM	HIGH
(4) Qualitative Benefits Measurement	LOW	HIGH	MEDIUM	MEDIUM
(5) Measurement (OBJ = Objective SUB = Subjective ABS = Absolute REL = Relative)	OBJ/ABS	SUB	REL	REL
(6) Uncertainties	LOW	MEDIUM	MEDIUM	MEDIUM
(7) Modeling Capabilities	LOW	LOW	MEDIUM	MEDIUM
(8) Adaptability	LOW	LOW	MEDIUM	HIGH

examine systematically the overall impact of the DSS on the organization involved (see Saaty [25] for details). The AHP method can be considered as a type of multi-attribute value function. However, there are some differences as well as advantages to using this method. First, the AHP method uses the systems approach, and the problem is evaluated in the context of the degree to which the higher level objectives have been accomplished. Second, the method can represent different viewpoints and different dimensions of DSS evaluation through different layers of the hierarchical model and different criteria. Uncertainties and risks can be included as one dimension of the model. A third major advantage stems from the AHP method's qualitative criteria for assessing DSS value. The method induces users to make comparable measures through pair-wise comparisons, instead of forcing them to assign weights directly. Fourth, the AHP method checks the consistency of judgments; if the decision-maker's judgment is not consistent throughout the procedure, the decision-maker can evaluate the process again. According to Saaty, a consistency ratio of 10% or less is considered acceptable. When the degree of consistency is poor, it is necessary to get more information about the comparisons of the selection criteria involved. Such action typically calls for the collection of data from another round of judgments. For a more detailed discussion of the AHP process, see [24, 25]. Fifth, the model behind the AHP evaluation method is both stable and flexible. It is stable because small changes in a local area of the model do not affect the entire model [24, 25]. It is flexible in the sense that different objectives and scenarios can be easily incorporated into the model. Last, the method is useful in a political environment because it facilitates group discussion of the decision making process.

RATING EVALUATION METHODS ALONG THEIR DESIRABLE FEATURES

Each of the evaluation methods discussed is strong in some aspects and weak on others. As shown in Table 2, we use a scale of LOW, MEDIUM, and HIGH to subjectively express the extent to which the evaluation method satisfies each of desirable features. The effectiveness of each DSS evaluation method along each desirable feature is discussed below.

Feature 1: Integrated Support for DSS Planning and Design

For integrated support for DSS planning and DSS design, the C/B does not provide any insight into DSS design or its evolution because the outcome of the method is in terms of a priori development dollar figures. The VA does provide high level of support for iterative DSS planning and design by allowing users to define the qualitative benefits criteria for a given DSS prototype phase where its qualitative benefits can easily be associated with specific prototype features and development costs. MA provides only a medium level of support for iterative planning and design; it will be difficult to derive a complete set of system capabilities from the criteria used to evaluate a particular prototype phase because of the *ad hoc* nature of the criteria. The method does not provide a mechanism to associate system characteristics with organizational objectives and nature of the criteria. The method does not provide a mechanism to associate system characteristics with organizational objectives and plans, and therefore, does not support the evolution of a DSS over time. The AHP allows the incorporation of alternative projects as well as their desired capabilities through the insertion of different layers into the hierarchical evaluation model. Thus, the AHP can support the iterative DSS planning and design process well, making it suitable for the process of DSS evolution.

Feature 2: Organizational Goal Orientation

The C/B method's goal-orientation is limited to economic goals. In the VA method, the qualitative benefits perceived by users are considered but organizational objectives may not be specified. In the MA method, criteria could be goal-related, but organizational objectives may not be particularly emphasized. In the AHP, objectives must be specified because of the systemic nature of the model.

Feature 3: Synthesis of Multiple Viewpoints

In incorporating different viewpoints, the C/B analysis incorporates only the economic measures in dollar terms. While this measure represents the perspectives of top management, it cannot represent other perspectives such as user satisfaction, and system design quality. The VA can incorporate multiple viewpoints of users and system specialists; however, it does not suggest the explicit mechanism to prioritize or to synthesize these viewpoints. MA can incorporate multiple viewpoints through the inclusion of different criteria. Prioritization and synthesis is accomplished through the assignment of different weights and the computation of the total score. The AHP can incorporate multiple viewpoints in terms of objectives, scenarios, attributes, and other dimensions if necessary. The prioritization and the synthesis is achieved by computing the weights of each element.

Feature 4: Measuring Qualitative Benefits

In developing the criteria of qualitative benefits, the appropriateness of C/B analysis is low since the estimates of qualitative benefits should not be incorporated in the equation. The level of VA is high since the emphasis of the VA is on developing and assessing qualitative benefits. The AHP methods encourages group decision making, and the hierarchical structure of the methods facilitates the incorporation of different scenarios, objectives, and attributes. The prioritization and the synthesis is achieved by computing the weights of each element. The appropriateness of the MA and the AHP is medium because these methods can incorporate various qualitative benefits criteria, but not in dollar terms. In terms of the objectivity of the measures, the C/B method encourages objective and absolute measures in dollar terms. The VA provides subjective dollar measures, and the estimates may vary from one person to the other. The MA and the AHP provide relative measures in terms of weights.

Feature 5: Handling Uncertainties

Although various techniques are suggested to handle the uncertainties in the C/B method, this technique is not an explicit part of the equation; therefore, on this criterion, the C/B method's effectiveness level is low. In VA, uncertainties are reduced somewhat by making the scope of the prototype small; therefore, the VA method's score on this criterion is medium. The MA approach can incorporate uncertainties in the assessment process. The uncertainties related to a criterion can be represented as an uncertainty factor which is multiplied by the assessed value (scores) of that criterion [26]. In the AHP method, the uncertainties can be represented as one evaluation criterion of the model. As both methods allow the estimation of uncertainties as a component of the model, the level of effectiveness for this criterion for the MA and AHP methods is medium.

Feature 6: Decision Modeling Capability

In order to support a flexible DSS which deals with different problem domains and complex environments, the

evaluation method should be able to model the requirements from such complex environments. In terms of decision modeling capability, the C/B analysis is inadequate to model complex factors related to DSS evaluation. The VA method is heuristic in nature and is also weak in modeling. The MA can incorporate various factors, but interaction among the factors cannot be examined; therefore, the modeling capability of the MA is considered medium. The AHP can examine the factors as well as their interactions in a systemic view; however, the method applies mainly to hierarchical models. Thus the rating is medium.

Feature 7: Adaptability to Wide Variety of DSS Projects

In terms of its ability to adapt to the variety of DSS projects which may differ in terms of objectives, the evaluation methods differ considerably. The C/B method may require completely different procedures and criteria for evaluating different DSS. Therefore, its rating is low. In the VA method, different projects, with different purposes, will require different criteria and estimations. The method may be very difficult to apply in a political situation because it does not facilitate the consolidation of the conflicting viewpoints (Rating: low). The MA method may require partial revision in the procedures for different projects and purposes (Rating: medium). The AHP model is more flexible because of the hierarchical structural advantage of the model. The AHP model is relatively comprehensive, and the addition of the objectives and criteria does not require a whole revision in the model or in the procedure (Rating: high). A summary of the evaluation methods' effectiveness along each desirable feature is shown in Table 2. Each cell in the table indicates the strength/weakness of the evaluation method with respect to the specific feature.

FURTHER COMMENTS ON WHEN TO USE THE METHODS

While all effectiveness criteria are necessary dimensions for the evaluation of all DSS applications, a specific application may call for a specific method because of its unique nature. It is because that one or two criteria are more critical than the others for that specific application. However, other effectiveness criteria should also be satisfied, and the method chosen may be weak in those other areas. Therefore, we suggest combinations of the methods in such a way that they complement each other.

Table 3. Relating Application Characteristics, Effectiveness Criteria, and DSS Evaluation Methods

Application Characteristic	Main Method	Effectiveness Criterion (*)	Complimentary Method
Strategic Impact	C/B	• Measurement (M) • DSS Planning/Design (C) * Synthesis of Multiple Viewpoints (C)	AHP
Qualitative Benefits	VA	• DSS Planning/Design (C) • Uncertainties (M) • Goal Orientation (C) • Measurement (M)	AHP
Many Users	MA	• Goal Orientation (C) • Synthesis of Multiple Viewpoints (M)	AHP
Many Functional Areas	AHP	• DSS Planning/Design (M) • Synthesis of Multiple Viewpoints (M) • Goal Orientation (M) • Measurement (C)	C/B or VA
Multi Tasks	MA or AHP	• Synthesis of Multiple Viewpoints (C) • DSS Planning/Design (M) • Measurement (C)	C/B or VA

There are certain types of DSS applications which call for specific methods (or method combinations) to properly assess their value. We can identify four different general types of DSS applications: (1) DSS applications which have strong strategic impact; (2) DSS applications which will be used in many functional areas; (3) DSS applications which will be used by many users; (4) DSS applications which have to support multi-tasks.

DSS which have a strong and/or long-term impact on organization usually require heavy investment. Therefore, it is necessary to estimate costs and benefits associated with DSS development. However, in order to incorporate user views as well as system specialists' viewpoints into the design process, it may be necessary to use the AHP as a complementary method. For DSS which provide mainly qualitative benefits, VA is useful to estimate the benefits as well as to incorporate the uncertainties. However, to align the system with corporate goals, AHP should be used together with VA.

The evaluation of DSS applications which are used by many users in a single or few functional areas, need to incorporate different user views. Therefore the MA is a proper method. On the other hand, it is necessary to align a DSS with corporate goals. Therefore, the use of the AHP in addition to MA is suggested.

DSS which are used in many functional areas such as marketing, accounting, finance, or in different divisions typically involve multiple objectives. The AHP can be useful for such an application. However, it is also important to estimate costs and benefits by using the C/B analysis or VA, depending on whether the benefits are of a tangible or intangible nature, respectively.

DSS which have to provide multi-functions to users (i.e., not only modeling but also data management, graphics, communication, and integrated capabilities) require the consideration of each of these functions along many different dimensions. Either the MA or the AHP can be useful. If benefits and costs estimation is necessary, the C/B analysis or VA should be used for tangible and intangible benefits, respectively.

Table 3 summarizes the relationships among DSS application characteristics, the most important evaluation effectiveness criteria, the main evaluation method and the complimentary evaluation method most appropriate for the case.

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