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ABSTRACT

Cognitive style, measured by Myers-Briggs Type Indicator, was used to categorize decision makers. Information source in the form of different DSS types was provided to help the decision makers make more effective decisions. The research attempted to investigate systematically the effects of cognitive style and DSS usage on the decision maker's perception of risk in the context of capital expansion projects.

The research encompassed analysis of behavior under conditions of uncertainty for two values of the cognitive dimension, sensing-intuition (S-N), and use of two types of information sources, data-bases DSS (DBDSS) and model based DSS (MBDSS). The behavior was studied within the boundaries of four decision scenarios (2 information sources x 2 cognitive styles). The research attempted to establish the interaction of decision support systems and cognitive style on perceived risk, in a decision-making situation under uncertainty.

The decision maker's choice in a risky situation is influenced by the risk perceived by the decision maker. The perception of risk is a result of an interaction between a decision maker's personal characteristics and the environment in which he/she faces the problem. Each type of individual needs the kind of information to which he/she is psychologically attuned in order to use it most effectively. The information needed by the decision maker can come from different types of DSS. DSS supports the decision-making activity and enhances the decision maker's effectiveness. From the literature review, previous researchers have indicated that considering the human variable of cognitive style is very necessary for the successful design of decision support systems.

The objective of this research was to study the level of risk perceived by people of different cognitive styles, using different types of decision support systems, when they face problems under uncertainty. The following research hypothesis was supported in Experiment 2, when decision environment was introduced as a control variable.

"Perceived risk will be influenced by the compatibility of the information source and the cognitive style of the decision maker."

RESEARCH HYPOTHESIS

The research attempted to complement and extend Henderson and Nutt's research. The contributions of this research is the identification that information source (type of DSS) might moderate the influence of the cognitive style. The research design allowed a test of whether decision makers used Model Based DSS (MSDSS) with differential effectiveness as a function of the cognitive style (Sensing-Intuition).

*State of Research Hyp*othesis

Primary Research Hypothesis. The research hypothesis is stated as follows: H1: Perceived risk will be lower when the decision maker's cognitive style and decision support systems type are compatible than when they are not compatible.

a. Sensing type (S) decision makers will assess less perceived risk when using data based DSS (DBDSS) than when using model based dss (MBDSS)

b. Intuitive type (N) decision makers will assess less perceived risk when using MBDSS than when using DBDSS.

Cognitive style may explain why a given choice was made and the level of uncertainty felt by the decision maker when making the decision. This research hypothesis seeks to determine whether cognitive style can be isolated as an important variable in explaining the choice behavior of decision makers.

The review of literature suggested that information sources might moderate the influences of cognitive style. The combined effect of these variables was directly tested in a simulated case scenario, where the information source was made available to the experimental subjects in the form of DBDSS and MBDSS and the subjects were classified on the information acquisition cognitive dimension (MBTI model). The experimental design provided a way to test whether cognitive styles and DSS types influenced "perceived risk."

Statistical Hypothesis. The following hypothesis (Research Hypothesis H1) was tested using ANOVA.

HO: There is no interaction between cognitive style and information source. Their joint effects on "perceived risk" are independent.

HA: There is an interaction between cognitive style and information source to determine "perceived risk."

If research hypothesis H1 is rejected, the following proposition could be made. Information Source moderates the influence of decision style in an individual decision making environment. In an environment of uncertainty, the degree of perceived risk affects the desirability of an outcome. The decision maker adjusts the value of an alternative based on his/her perception of how much risk is associated with the outcome of that alternative.

The model for the completely randomized two variable classification model is given in equation (1). Let /U represent the expected value of an uncertain decision. "r" represent any information brought to the decision environment by the decision maker. R represents any information contained in the environment including both objective and contextual information. "rR" represent that provides him/her with "information" about the riskiness of an alternative, and AV represent the adjusted value of an uncertain decision.

$$AV = /U + r + R + r*R + error \qquad (1)$$

Different information processors would have different risk adjustments because of their decision making preferences.

Based on model (1), while assessing perceived risk, the decision maker chooses MBDSS or DBDSS (information source) depending on his/her cognitive style. Perceived risk would be low when the following propositions are valid.

a) S type decision makers using DBDSS assess less perceived risk than S type decision makers using MBDSS;
b) N type decision makers using MBDSS perceived less risk than N type decision makers using DBDSS.

The above propositions stem from statistical significance of research hypothesis H1.

In Experiment 1, each subject received DL or ML treatments (DL = Data Based DSS, as information source, with objective risk equal to low; ML = Model Based DSS, with objective risk equal to low). DSS types and cognitive style types were treated as between-subject variables, so that the decision maker did not have to move between different setups.

The statistical Hypothesis can be rewritten as:

HO: /U MS + /U DN - /U DS - /U MN < = 0
HA: /U MS + /U DN - /U DS - /U MN > = 0

Analysis of Research Hypothesis

The experimental design was as follows (Figure 1).

Figure 1. Experimental Design

	COGNITIVE STYLES TYPES	
DSS Types	**Sensing (S)**	**Intuition (N)**
Data Based DSS	/U DS	/U DN
Model Based DSS	/U MS	/U MN

Because of the individual differences in perception of the risk assessment scale (1 to 100), the decision-makers were required to evaluate the perceived risk in the decision scenario first without any DSS support and later on with additional information by using output from either DBDSS or MBDSS. The change in perception of risk was used as the outcome variable in the analysis.

Hence, each experimental subject assessed one decision scenario using one DSS type (one section of BA 822 MBA class got DBDSS output, and the other section got MBDSS output for the perceived risk assessment). The algebraic difference between the perceived risk sources (Perceived risk without the use of DSS - Perceived risk with DSS usage [Pr1 - Pr2]) was used in the statistical analysis.

In the Experiment 2, cognitive compatible ST and NT types environments were introduced in the decision scenario. DSS types was treated as a within subject s variable, and objective risk was held constant (low objective risk); environment was made richer (as compatible to S type decision makers and N type decision makers) and was introduced as a control variable. The hypothesis used was the same as in Experiment 1 (primary research hypothesis: H1).

RESEARCH DESIGN

In the research design, the independent variables were cognitive style (CS) and information source (DSS). The dependent variables were perceived risk (PR) and change in perceived risk (PR1 - PR2). Environment (ENV) was the control variable (Henderson & Nutt, 1980).

The research instrument used a simulated case approach (decision scenarios) in order to control the decision and the environment. The decision scenarios included objective and subjective information. Capital expansion projects were selected that would increase the service capacity (bed count in hospitals) of the organization. A capacity increase of 25% was used to insure that the decision would have considerable strategic importance. A hospital setting was chosen because capital expansion could be stated in terms of capacity increase of 25% (bed count) in easily understood terminology (as compared to aggregate production plant capacity increase in firms).

Objective information on risk was derived from return on investment (ROI) estimates made available to the decision makers in a written report.

In the Experiment 2, two decision styles were used to define an organizational environment compatible with each decision style (ST compatible environment and NT compatible environment). The research used Henderson and Nutt's (1980) framework to define processes of information generation and ways to verify a decision (validation) that seem compatible with the cognitive styles.

Treatments, Variables, and Measurement

Experiment 1

The primary experiment used a two-by-two factorial arrangement with cognitive style and type of DSS as factors. The arrangement is shown in Table 1.

The decision-makers in this research were students in nonresidential MBA programs, who study decision making under DSS environments. The Myers-Briggs type instrument (MBTI) was administered to each subject. The MBTI was used to categorize the cognitive style of the participating executives along the Sensing-Intuition (S-N) dimension.

Table 1. Orperationalization of Experiment 1

	Cognitive Style Dimension	
Decision Support Dimension	S	N
Data Based DSS (DBDSS)	/U DS	/U DN
Model Based DSS (MBDSS)	/U MS	/U MN

Each decision maker received one project outlined in appendix A, in the primary research design. The results of the study were analyzed by performing ANOVA. The effect of age, background, and work experience were accounted for by selecting the subjects from a homogeneous population. The research attempted to determine how cognitive style, information source, and their interactions influence the perception of risk.

Experiment 2

In Experiment 2, each decision maker received four projects (or four treatments). Treatment one was comprised of Data Based DSS outputs, along with ST compatible decision environment. Treatment two was comprised of Data Based DSS outputs, along with NT compatible decision environment. Treatments three and four contained Model Based DSS outputs along with ST compatible decision environment and NT compatible decision environments, respectively. In the Experiment 2, the treatment order was partially randomized. The data based DSS was used with random ordering of ST and NT environment. Similarly, the model based DSS was used with random ordering of ST and NT environment. The occurrence of DBDSS and MBDSS was also randomized. The decision makers were encouraged not to review previous decisions. Each participant evaluated the perceived risk using the scale given in Appendix B.

In Experiment 2, the effects of cognitive style (S/N), decision environment (ST-NT compatible environment), the DSS types (data-model), and their interaction on perceived risk were determined.

Constructing the Project Summaries

Objective risk was controlled in the decision scenario. The mean ROI for each project was set at 10%. Risk was defined by the range of expected return for a project. "Low risk" projects were defined with a return on investment that ranged from 8% to 12%. The level of risk was held at a low level in the current research.

In Experiment 2, information source and the environment were varied in the project summaries presented to the decision makers as described in Appendix B and Appendix C.

The environment dimension was not considered when the decision scenario was designed for Experiment 1. (Refer to Appendix A)

For Experiment 2, environment was introduced, in terms of the organization. A project has an organizational environment based on one of the two decision styles. Multiple factors were incorporated into the environment in order to increase the prospect that the environments would be viewed differently. Each experimental subject received four treatments. Each subject received each of the two environmental factors (NT and ST) and each of the two information sources (Data or Model DSS with a low objective risk). The objective of the experiment was to test for interactions among cognitive style (S - N), the DSS types (D - M), and the environment (ST-NT compatible) on perceived risk.

The information describing the project's ROI estimates, namely Data Based DSS or Model Based DSS and environmental information for capital project decision, were presented in terms of decision style. A compatible project was defined as using "information" that is consistent with the decision maker's style. The process used to identify the ROI estimates, called information source was also controlled in the project descriptions. Information source was described as resulting from accessing Data Based DSS or accessing Model Based DSS.

Table 2 provides the framework for operationalizing the experimental variables in conducting the decision oriented research (with the use of project summaries as decision scenarios).

Each project was summarized in the form of a report. The report described the organizational environment and the capital expansion project and contained a risk rating scale.

Table 2. Approach Used to Design Project Summary

OPTIONS

1. Environment - Two paragraphs prepared (two environments ST, NT compatible)
2. Information Source - Data based and Model Based DSS
3. Level of Risk - Low (8% to 12%) with regulatory agency approving

Decision Support Systems

The decision support systems for the research provided a support tool to analyze the time series data of interest--demand for the number of short-term general and special hospital beds in the geographic region of interest in the Hospital Administration Project (discussed in the Decision Scenario). The forecast for the number of beds in 1996 based on the available data in the data base and the indication of the time series model (secular trend, seasonal variation, cyclical variation, and irregular variation) was based on the DSS types available--DBDSS and MBDSS.

Time series analysis is a primary importance in the Hospital Administration Project in order to forecast, with a reasonable risk, the estimated future demand for increased hospital beds (the project suggests a scenario with 25% increase in number of beds). The time series analysis consists of the application of certain statistical procedures to historical data. As a hospital administrator, the decision maker might use the results of this analysis to make estimates or projections of bed capacity in the future (1996). The value of such estimates depends on the extent to which past experience provides a reasonable representation of future experience after proper adjustment for trend, seasonal, cyclical, and erratic (error term) influences.

Data Based DSS. The database comprising the raw data, with number of short-term general and special hospital beds demanded, for years starting with 1984 and continuing to 1995 was created in LOTUS 1-2-3 database (spreadsheet). The Data Based DSS would provide the user with the tabular form of raw data with year and demand for beds (number of short-term general and special hospital beds) for the specified range of the years. The Data Based DSS also presented a graphical picture of the actual number of beds plotted against years, using the Lotus 1-2-3 graphics function. The database in the table form is shown in Table 3.

Using Lotus 1-2-3 software, a secular trend model was built, which forecasted "demand for hospital beds." The functions like @SUM, @DAVG, @DVAR, /DATA REGRESS, and /PRINT GRAPH were used in the construction of Model Based DSS (MBDSS) outputs. Tabular output contained year, modeled demand, predicted demand plus confidence interval (CI), and predicted demand minus CI (Table 4).

Model Based DSS

Table 3. Demand for short-Term General and Special Hospital Beds

Data Based DSS Output-Actual Demand for Hospital Beds

Year	Demand for Number of Beds	Year	Demand for Number of Beds
1984	473	1990	531
1985	465	1991	546
1986	472	1992	553
1987	477	1993	568
1988	505	1994	586
1989	516	1995	595

Model Based DSS Output

Table 4. Modeled Demand for Hospital Beds

Serial Number	Year	Modeled Demand	Predicted Demand + Precision	Predicted Demand - Precision
1	1984	454.2820	464.35023	444.21387
2	1985	466.9428	475.73654	458.14923
3	1986	479.6037	487.22583	471.98162
4	1987	492.2645	498.87308	485.65605
5	1988	504.9254	510.76120	499.08961
6	1989	517.5862	522.99443	512.17805
7	1990	530.2470	535.65527	524.83889
8	1991	542.9079	548.74372	537.07212
9	1992	555.5687	562.17728	548.96024
10	1993	568.2296	575.85170	560.60750
11	1994	580.8904	589.68409	572.09678
12	1995	593.5512	603.61946	583.48310

$Yt = 454.2820 + 12.66083 * Xt$

APPENDIX-A

ST Compatible Environment - Decision Scenario

Decision Scenario - HOSPITAL ADMINISTRATION PROJECT

Sample ProjectSummary (ST) type (Low Objective Risk)

Imagine that you are a chief executive officer in a hospital with 600 beds and $15 million revenues. In this organization, performance is based on objective assessment of performance of each cost center. The organization is centralized. There is well defined authority in the centralized organizationa lstructure. The organization is known for stressing a single goal such as profitability. Leadership is thought to stem from result oriented personality traits.

Your organization is planning an expansion project which would increase your beds by 25%. The additional space would be used to enlarge all hospital departments. Preliminary discussions with the health planning agency indicate that the expansion was viewed as needed. Experienced managers who understand investment decisions, project accounting, and financial data have predicted that the return on investment for this project is 8% to 12%.

Systematic analysis by experienced managers in investment decisions showed that return on investment for similar hospital projects has been 7%. The project offers you a chance to check the details of the calculations and the accuracy of data acquisition procedure. Assume that the other factors are favorable.

Please indicate the level of risk you believe is associated with this project on the following scale.

no risk	some risk	normal risk	considerable risk	too risky
I	I	I	I	I
0	25	50	75	100

APPENDIX-B

NT Compatible Environment - Decision Scenario

Decision Scenario-HOSPITAL ADMINISTRATION PROJECT

Sample Project Summary (NT) Type (Low Objective Risk)

Imagine that you are a chief executive officer in a hospital with 600 beds and $15 million revenues. In this organization, performance is assessed by comparing the cost center's performance with perceived potential (comparing with widely accepted norms). Organizational structure is based on liaison to power centers. A generic form of sensitivity analysis is performed, where assumptions about demand are progressively relaxed. The organization is known for stressing peer group domination and following market share. Leadership is thought to stem from proven ability to define and solve problems.

Your organization is planning an expansion project which would increase your beds by 25%. The additional space would be used to enlarge all hospital departments. Preliminary discussions with the health planning agency indicate that the expansion was viewed as needed. Experienced consultants review cost and revenue data and have estimated ROI, considering possible demand changes, that the return on investment for this project is 8% to 12%. Computer based model is used to predict return on investment for similar hospital projects and is determined as 7%. The project offers you a chance to validate RO1 projections based on the sensitivity of ROI estimates to external factors. Assume that the other factors are favorable.

Please indicate the level of risk you believe is associated with this project on the following scale.

no risk	some risk	normal risk	considerable risk	too risky
I	I	I	I	I
0	25	50	75	100

Experiment

Analysis of Risk for Subjects Classified as S or N

Perceived risk was modeled as follows:

RISK CHANGE = f (COGSTYLE< DSSTYPE< COGSTYLE * DSSTYPE)
RISK CHANGE = differences in perceived risk without and with DSS usage.
COGSTYLE = classificatory variable, as S or N type according to the MBTI score received
DSSTYPE = type of DSS used, D for DBDSS and M for MBDSS.
COGSTYLE * DSSTYLE = interaction between cognitive style and decision support systems.

Results of the Experiment

In this analysis, 91 experimental subjects (from a population of MBA students taking Applied Decision Sciences course) were used, with 34 subjects classified as S type and 57 as N type. The subjects were classified as S type or N type according to MBTI instrument. The total number of subjects who received DBDSS treatment was 50. The analysis of variance results, and the means for each cell with corresponding numbers per cell were found to support that the following propositions are valid.

a. Sensing (S) subjects using DBDSS assessed less change in risk than Sensing subjects using MBDSS.
b. Sensing (S) subjects using DBDSS assessed less change in risk than Intuitive (N) type subjects using DBDSS.
c. N type subjects using MBDSS assessed less change in risk than N type subjects using DBDSS.

When the experiment was conducted using the decision environment (ST and NT compatible environment) with four treatments using 61 subjects, significant interactions were observed for--DSS and Cognitive Style, Cognitive Style and Environment, and DSS and Environment. The experiment validated our main research hypotheses. It also suggests the influence that decision environment and "DSS types" have on decision making is stronger. Further research can be attempted to investigate the influence of the three way interaction among DSS types, Cognitive Style types and Decision Environment on decision making behavior.

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