

Dissemination and Impact of Multi-criteria Decision Support Methods for IT Project Evaluation

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Abstract

The aim of this paper is to demonstrate whether knowing or applying selected multi-criteria decision support (MCDS) methods make decisions more effective or efficient in the context of IT project proposals. Results from a nationwide empirical survey conducted in Austria (N = 114) show a method diffusion - infusion gap. In other words, many organizations are aware of MCDS methods but do not apply these methods in IT evaluation practice. We show that knowing or using MCDS methods increases decision effectiveness, but not impacts time to decision. The study has implications for practice and research. Particularly, it calls for more attention to determine factors that increase acceptance of MCDS methods in decision making practice.

1. Introduction

The systematic, inclusive and transparent evaluation of IT projects in organizational contexts remains as one of the important unresolved concerns in management [1]. With regard to any significant IT investment, such as information systems [2] or Enterprise Resource Planning solutions [3], problems were reported concerning high levels of intangibility and subjectivity and the complexity and amount of different dimensions when it comes to stakeholders, socio-technical criteria [4] and IT related risks [5, 6].

Multi-criteria decision support (MCDS) offers theory and solution approaches to handle these dimensions and views by involving multiple criteria and a broad selection of methods [7]. Previous research highlights the importance of applying more analytic models and methods in practice [8]. A systematic approach to decision making complemented with decision support systems and management support seems to increase decision making satisfaction [9]. However, there seems to be a persistent diffusion-infusion gap when it comes to decision method application [9, 10]. This means that these methods are not fully absorbed by the

organization. Available methods are becoming more known through exploration but are not transformed and exploited in evaluation practice within organizations [9]. Hence, the use of simple heuristics may still dominate in organizational decision making [11].

Against this backdrop, we aim at enhancing our understanding of IT project evaluation by reviewing the levels of knowledge about and actual use of specific MCDS methods in practice and by relating these levels with achieved decision process performance. Our aim is to understand whether the low or partial absorption of decision methods into organizational practice can be justified [9]. The results offer managerial insights on the use of MCDS methods and their potential impact on decision performance. These insights are needed to develop more effective support for evaluating and selecting IT projects in organizations.

The research methodology is based on a quantitative empirical survey of Austrian IT decision makers considering dominant methodological perspectives from IS literature. We focus on the IT project proposal stage to support decision making and system justification. Our random sample comprises 114 data sets with regard to major IT driven organizational innovations such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) systems. We run Kruskal-Wallis one-way analysis of variance by ranks to test the developed research hypotheses after assigning the respondents to different levels of MCDS method absorption.

2. Theoretical background

This section very briefly summarizes results of previous research about methods available to organizations to evaluate and select the right IT strategies, and research about method use in practice.

2.1. MCDS theory

IS research has provided a plethora of approaches and technical advances in decision making to strengthen analytical capabilities in particular for IT investment analysis. Recent formal advancements focused not only on rather simple views with multiple criteria assessments [8], cost-benefit multiple criteria analysis [12], and holistic approaches considering business process transformation [13], but also on more mathematically complex multi-criteria models and methods at least from the viewpoint of practitioners. For example, the profile distance method [14] is merging the utility ranking method [15] with concepts taken from data envelopment analysis [16] to form a versatile multi-criteria decision making tool. To stipulate access and use, many methods and frameworks are summarized in substantial review papers [10, 17-23].

Many different attempts have been made to develop theoretical taxonomies of methods used in IT appraisals, which essentially constitute different views on the wide field of supporting methods and frameworks. The classification of methods can be guided by the type of IT investment decision and time of decision [24], type of evaluation support [25-27], purpose of evaluation, breadth of impact and evaluation complexity [28], relevance to IT practice [29], and other characteristics. Within these categories different types of MCDS methods are usually listed, which typically include the Analytical Hierarchy Process (AHP), Balanced Scorecard (BSC), Information Economics (IE), Kobler Unit Framework (KUF), Utility Ranking Method (URM) and the Strategic Investment Evaluation and Selection Tool Amsterdam (Siesta) among many other approaches available in theory. Each of these methods are shortly introduced in Section 3.2.

2.2. MCDS practice

Decision makers in organizations continue to struggle with choosing and applying IS investment methods in IT investment appraisals [4, 29, 30]. Especially large scale IT projects such as IT infrastructure investments seem to lack comprehensive methodological support to acknowledge intangibles and other non-financial performance criteria besides considering the cost side of the evaluation task [17]. Noticeable gaps that exist between the availability of methods and their uptake in actual evaluation practice within organizations [9, 10]. Lack of method support makes it difficult for evaluation practice to understand the full impacts of

the IT investment [14]. Calls were made to apply more analytic models or multi-criteria methods [8, 17]. Consequently, based on specific content and processes [31, 32] prescriptive guidelines and frameworks are being developed to guide the process of investment appraisals, to develop a selection of appraisal methods within taxonomies and given structures [e.g. 33].

Methods in IS investment appraisals are grounded on decision theory, and promise a more rational and normative approach with formal guidelines to assess and manage the complex appraisal problem. Normative and descriptive models of human behavior in decision making do not usually coincide [34]. New challenges in method development therefore are in particular focused on better supporting human behavior in decision making [35], reasoning about methods [36] and making methods more intuitive [37] and better accessible through Decision Support Systems [38, 39]. The levels of decision formality of methods maybe an explanation for their under-utilization in practice [9].

3. Research design

3.1. Exploratory and confirmatory research

Our exploratory research component utilizes descriptive data analysis and the classification of respondents to different groups differentiated by their use and knowledge of MCDS methods. We then ran further statistical analysis to test, whether these groups are related with decision effectiveness and efficiency in accordance with research hypotheses given in the next sub-section.

3.2. Research hypotheses

Prior research reported gaps between the availability of methods and their uptake in actual evaluation practice within organizations [10], and gaps between the levels of known and applied methods in IT decision making [9]. Hence, decision makers seem to regularly rely on their own heuristics and regularly depart from normative models [34]. Therefore, more intuitive and cooperative tools are constantly being developed to counteract the lack of evaluation in decision making practice [e.g. 38, 39, 40]. Despite these initiatives to stipulate method dissemination, we assume that these gaps still exist for the MCDS domain:

H1: A significant gap exists between the levels of known (diffusion) and used (infusion) MCDS methods in organizations.

Literature suggests that successful IS adoption depends on the IS organization's ability in assessing the full range of potential business value contributions in particular in the context of transformational IT projects [41-43]. New evidence confirms the importance of method application in decision support systems with sound management support [9]. Different methods with different features such as analytical and strategic methods, multiple criteria frameworks, financial and non-financial methods or portfolio methods are known to support certain tasks in semi-structured decision making by humans [35, 36]. A lack of evaluation in practice may lead to a lack of understanding the full range of impacts of the IT investment [8, 17]. Therefore, we derive the following hypothesis from prior research.

H2: Higher levels of decision effectiveness are associated with higher levels of knowing (a) and using (b) MCDS methods.

H3: Higher levels of decision efficiency are associated with higher levels of knowing (a) and using (b) MCDS methods.

3.3. Selection of methods

This study considers a total of 6 different MCDS methods, which also featured in our main reference meta-studies [21-24, 27]. The selected group of methods is believed to give a good overview of prominent and inclusive MCDS methods, in particular covering the MCDS methods mostly used in Austria, which hosts our target population [e.g. 44, 45]. In addition to their widespread global recognition, all of these methods have in common that they have been successfully implemented and made available by means of computer software [46], which is fostering acceptance in the practical field [39, 47]. Some of these methods have been used together [48] or extended with other analytical approaches to counteract individual weaknesses [49, 50]. Our research findings, however, only relate to this list of methods, which is not exhaustive and representative for all known MCDS approaches. The methods are briefly described below with further references for more detailed information:

Analytical Hierarchy Process (AHP): AHP is a process oriented multi-criteria approach relying on

pair wise comparisons for all criteria and alternatives on pre-defined scales, which can be used to derive weights and utilities for single elements in a mathematical procedure such as the Eigenvector method. Consistency tests can be used to validate the estimated comparison matrices. The process spares the need for absolute measurements and subsequent scale transformations, and the problematic absolute estimation of attribute weight [51, 52].

Balanced Scorecard (BSC): A BSC seeks to derive a structured scorecard of key performance indicators from a strategic viewpoint. These indicators can be aligned along the original four different perspectives: financial; internal business processes; learning and growth; and customer. In addition the BSC also features a cause-and-effect diagram, which displays antecedents and consequences of targets while connecting different perspectives of the scorecard with each other [53]. While the BSC was originally developed as an instrument for strategy development and performance control, it can also be used for supporting MCDS, in particular in combination with other methods [54].

Information Economics (IE): The IE approach was explicitly developed to evaluate IT-investments and essentially states that the value of an IT-investment is a sum of an enhanced Return on investment (improved operations, increased productivity, etc.), a business domain assessment (competitive advantages, management information, etc.) and a technology assessment (alignment with IS-strategy, risk measures for the project, etc.). To exercise this method weights for each factor are assigned and each factor from each alternative receives a value between 0 and 5 based on either ROI or management judgment. Factor values are multiplied with weights and summed up. Information Economics also features risk-related measures to assess the overall risk of each alternative [55].

Kobler Unit Framework (KUF): The KUF consists of four sequential stages comprising evaluating an investment against a checklist of critical success factors, estimating costs, evaluating business performance indicators and comparing relative benefits of alternatives. As in other multi-criteria approaches, a decision is made based on weighted criteria [56].

Utility Ranking Method (URM): URM is a rather broadly defined method composed of a set of alternatives, a set of criteria derived from defined targets, weights for each criteria and estimates how

well an alternative performs relating to each criterion. Many different aggregation methods are known to estimate a super scale used to rank the alternatives such as the prominent weighted sum approach [15, 21, 22].

Strategic Investment Evaluation and Selection Tool Amsterdam (Siesta): The Siesta method features 20 criteria and strongly relies on the use of questionnaires and software to analyze the results. Similar to Information Economics the Siesta method is composed of domains (business and technological) and moreover three levels of decision making with a strong focus on strategic alignment [57].

3.4. Instrument development

We conducted three rounds of iterative pre-testing each composed of a review by respondents and after implementation of the changes an academic review resulting in eventual changes to almost all elements of the instrument. The first two rounds of pre-testing were undertaken by two groups of eight people, composed of undergraduate students and graduates with an Information Systems background. Professional occupation of participants included IT and management activities. In the third round of pre-testing the instrument was administered to three practitioners in the IS area only. Most importantly pre-test recommendations included changes to the industry classification, orientation of the scales, shortening of lengthy questions and texts, and wording related issues.

3.5. Data collection

The data for this study was extracted from a wider empirical survey, which served to investigate IT decision method dissemination. Preliminary results were already published to show which factors from the technological, organizational and environmental contexts influence decision making satisfaction [9]. The sampling frame for the survey consisted of 850 randomly selected companies from the industry-independent target population defined as all enterprises in Austria with a reported last year's total balance sheet total of over € 5 million. We chose to use the Amadeus Database containing financial information on 7 million public and private companies in 38 European countries [58], which supplied as with representative and extensive list with contact information for the sampling procedure.

The questionnaire was administered to managers in a multi-staged procedure, who had to be an "IT-decision maker or a person that has decision making

authority concerning IT-investments", a statement used as a prelude. Depending on the structure and size of the company, this can as well be an IT manager as well as a general manager. In our cover letter, we asked for linking all answers to the most recent transformational IT project assessed in the organization, exemplified by mentioning ERP or CRM systems. We therefore assumed the organization was able to conduct an independent IT evaluation process and that a comparable level of decision complexity was achieved over all data sets.

All companies were initially contacted by phone and invited for participation. Only those who indicated their interest received the link and an email for participation. This procedure was necessary to comply with the Austrian telecommunication law on bulk-Emails prohibiting invitations to more than 50 companies per Email. As an incentive companies were offered the study results, to be informed about new developments in decision making and experimental case studies in their firms.

3.6. Return quota and response bias

The phase of executing the survey implied calling more than 850 companies, with 787 answering the call. From the companies who answered 510 gave the allowance to receive an email or agreed to directly take part in an ad-hoc interview. The time consuming process of calling companies and sending questionnaires took ten full working days and was concluded with a number of 114 completed questionnaires, which corresponds to a net return quota of 14.5% considering neutral dropouts (63 companies). Neutral dropouts that do not decrease the return quote refer to companies that could not be contacted because they ceased to exist or closed their business, or because the address was incorrect and they could not be found. Non-response bias analysis considered potential respondents and definite non-respondents as two different groups. The differences between two means for each group are not statistically significantly different from zero for all three considered characteristics: The number of employee; operating revenue; and total assets. Thus, we see no evidence for response-bias.

4. Data analysis

4.1. Dissemination of MCDS methods

BSC and URM methods are known by the majority of decision makers and only small minorities are aware of the other inquired methods.

When it comes to infusion, i.e. actual method use, these diffusion rates drop significantly. The paired samples t-test revealed that five out of six diffusion-infusion gaps are significantly different from zero ($p < .05$). Additionally, a standardized measure (r) can be calculated to measure the effect size for these differences [59, 60]. It was suggested that r values of 0.10, 0.30, and 0.50 mean small, medium, and large effects, respectively. The findings show that a significant gap exists between the levels of known and used IS investment appraisal methods in Organizations, thereby supporting hypothesis (H1).

Table 1 Diffusion (known) and infusion (used) of IT appraisals method categories

Variable	Known (%)	Used (%)	Gap (%)	Sig.(paired sample test)	Effect size
BSC	58.8	23.7	35.1	0.000	0,59
URM	53.5	15.8	37.7	0.000	0,61
AHP	21.1	5.3	15.8	0.000	0,40
IE	16.7	3.5	13.2	0.000	0,36
SIESTA	5.3	1.8	3.5	0.045	0,19
KUF	2.6	0.9	1.7	0.158	0,13
At least one	71.9	33.3	38.6	0.000	0.62

4.2. Decision making performance

We assessed decision making process performance in two dimensions. First, we were interested in the achieved effectiveness of decision making, and second in efficiency measured by time to decision. The effectiveness dimension was assessed by a reflective four-item construct derived from previous research [61, 62], which we validated in terms of uni-dimensionality and consistency. We used exploratory factor analysis to test for uni-dimensionality (see Table 2). The significant outcome confirmed that all four direct measurement items loaded cleanly onto the latent factor with loadings well above the 0.5 threshold [63]. In the next step we evaluated internal consistency with Cronbach's Alpha, which for the construct surpassed the recommended value of 0.7 [64].

Table 2 Rotated component matrix for decision making effectiveness

Indicator	One factor solution	
	Loadings	Cronbach α
Confidence in the decision	.718	.758
Decision taking was easier	.601	
Satisfaction with the decision	.879	
Benefits from the decision	.844	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.666	
Bartlett's Test of Sphericity	χ^2	136.138
	df	6
	p	.000

Next we considered efficiency of decision making using time to decision as proxy [65]. Efficiency, however, could also be measured by additional metrics such as the decision costs or the number of alternatives evaluated. Table 3 shows that the average time to complete a decision process from initiation to selection is 13.35 weeks with a standard deviation of 10.49 weeks indicating a high diversity in times to decision between different companies. Sorting the time to decision into quartiles shows that while the median is at twelve weeks and the 3rd quartile at 17.25 weeks, the 4th reaches up to 52 weeks. This fact indicates that some firms needed especially long to arrive at a decision.

Table 3 Time to decision

Statistic	Time in weeks
Mean	13.35
Standard deviation	10.49
Median	12.00
Variance	110.02

Data shows that time and effectiveness levels are negatively correlated ($p < .01$, see Table 4) indicating that longer IT appraisal procedures lead to lower effectiveness levels.

Table 4 Correlations between time to decision and effectiveness

	DM effectiveness	Time to decision
DM effectiveness (regression score)	1	-.319**
Time to decision	-.319**	1

^T $p < .10$; * $p < .05$; ** $p < .01$ (Pearson correlation)

4.3. Impact of MCDS on decision performance

Next, we classified each respondent into three groups reflecting their level of MCDS absorption, which corresponds to either not knowing any, or knowing or using at least one MCDS method. Therefore, we used the two consolidated variables to assess knowing and using at least one of the MCDS methods listed in the last row of Table 1. Consequently, the *MCDS ignorance group* (no. 1) only includes cases, where no MCDS method is known nor applied. The *MCDS awareness group* (no. 2) features managers with passive knowledge about MCDS methods. In other words it was decided to apply none of the MCDS methods, while at least one was known. The *MCDS acceptance group* (no. 3) includes only cases, where at least one of the assessed MCDS method was applied. The three groups (see Table 5) have fairly equal sizes with the ratio of the largest to the smallest group at 1.38.

Table 5 Decision groups according to MCDS method absorption levels

Group	1: MCDS Ignorance	2: MCDS Awareness	3: MCDS Acceptance
n	32	44	38
At least one method known (% within group)	0 %	100 %	100 %
At least one method used (% within group)	0 %	0 %	100 %
DM effectiveness (mean)	3.46	4.17	4.42
DM effectiveness (mean reg. score)	-0.59	0.09	0.32
Time to Decision (mean weeks)	9.75	13.23	9.74

Next, we examined the characteristics of decision variables from the previous section for each of three groups (second half of Table 5). These non-classifying variables indicate that the cases from the MCDS awareness and acceptance groups resulted in higher effectiveness rates in terms of decision qualities when compared against the cases from the MCDS ignorance cluster. Those companies have applied other methods or decision heuristics not related with our selection of MCDS methods. There seems to be no systematic impact on time to decision across all three groups. We run the non-parametric Kruskal-Wallis Test to see whether these differences between groups are statistically independent. Results in Table 6 confirm the above view. Only the DM effectiveness is related with group membership.

Table 6 Kruska-Wallis Test

	DM Effectiveness (factor scores)	DM Effectiveness (mean)	Time to decision (weeks)
Chi-Square	11.87	10.61	1.64
df	2	2	2
Significance	0.003	0.005	0.440

5. Discussion

In this section, we shortly discuss the major findings and make inferences according to the findings on the research hypotheses depicted in Table 7.

Table 7 Summary of tests of hypotheses

	Relationship	Support
H1	A significant gap exists between the levels of known (diffusion) and used (infusion) MCDS methods in Organizations.	Yes
H2a	Higher levels of decision effectiveness are associated with higher levels of knowing MCDS methods.	Yes
H2b	Higher levels of decision effectiveness are associated with higher levels of using MCDS methods.	Yes
H3a	Higher levels of decision efficiency are associated with higher levels of knowing MCDS methods.	No
H3b	Higher levels of decision efficiency are associated with higher levels of using MCDS methods.	No

In accordance with our expectations, a significant gap exists between the levels of known and used MCDS methods in organizations (H1). About a third of the IT assessments relied on MCDS methods, which promise a more holistic view and allow for a more systematic treatment of intangible benefits, which is important for IT projects [e.g. 14, 15]. The considerable gaps between diffusion and infusion rates indicate that many managers in practice seem to be aware of MCDS methods, but have difficulties or reservations in applying them.

Our next main observation is that MCDS methods seem to positively affect decision effectiveness but not efficiency. Greater effectiveness may result from various reasons. Among other benefits, MCDS methods allow organizations to illuminate the business value implications, to aggregate inputs from various methods and to learn by assessing [33]. Structural strengths and weaknesses of individual

alternatives can be explored and compared against each other, while allowing others to see the logic of the results [14]. This empirical observation is already valid when knowing but not directly applying MCDS methods. However, knowing or using MCDS does not make decisions more or less efficient in IT decision making in terms of time to decision. While a prescribed MCDS method may save time by providing process related guidance, it also may induce longer durations as most approaches need a full evaluation of all alternatives against the chosen criteria in the decision model [19, 22]. The allowance of incomplete information or rankings may help to improve efficiency levels in MCDS applications [66].

An important implication for practice and research is to foster diffusion and infusion rates of MCDS methods, which both positively impact decision effectiveness, while not increasing the time needed for making the decision. This implicates a number of measures. First, it warrants renewed attention to the role of organizational change in evaluation practice [31, 32], and organizational learning in the context of contemporary dynamic capability views [41, 67]. On the supply side, we need more research focusing on making existing MCDS methods more intuitive, potentially through IT support, to more successfully fully absorb the MCDS paradigm into organizational practice [8, 17].

6. Conclusion

The evaluation of complex IT projects at the proposal stage is a major issue for both IS management and academics to better understand the business value proposition of the underlying investment. This paper has firstly briefly introduced a selected set of MCDS methods used in IT investment appraisals with short descriptions and links to their main references. Based on a sample of IT transformations in 114 firms, we observed significant gaps between levels of diffusion (known) and infusion (used) of MCDS methods. Thus, organizations have acquired information about MCDS methods but are not equally applying their knowledge in practice to exploit their benefits. This finding adds more differentiation to previously published findings about the general use of IT decision making methods with regard to gaps between theory and evaluation or decision making practice [9, 10]. An important contribution is that infusion and diffusion of MCDS methods is connected with improved decision effectiveness levels, but not with the time needed to conclude a decision. In other words, MCDS methods make

decisions more effective while being as efficient as other approaches including other types of formal methods, ad-hoc approaches or simple heuristics. Future research should therefore place an emphasis not only on MCDS method enhancements but also on how existing and known approaches can be transformed and exploited in practice. A promising avenue would be to include organizational learning theories in the transformation of organizational IT decision making to enable higher rates of MCDS absorption.

7. References

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