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Explaining MCDM acceptance: a conceptual model of influencing factors

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***Abstract*—The number of newly developed Multi-Criteria Decision Making (MCDM) methods grew considerably in the last decades. Although their theoretical foundations are solid, there is still a lack of acceptance and application in the practical field. The objective of this research is the development of a conceptual model of factors that influence MCDM acceptance that serves as a starting point for further research. For this purpose, a broad diversified literature survey was conducted in the discipline of technology adoption and related topics (like human computer interaction) with special focus on MCDM acceptance. The constructs collected within the literature survey were classified based on a qualitative approach which yielded a conceptual model structuring the identified factors according to individual, social, technology-related, task-related and facilitating aspects.**

***Index Terms*—Technology Acceptance, Multi Criteria Decision Making, Decision Support.**

I. Introduction

RESEARCH in the field of technology acceptance has been subject to numerous developments in the last decades. Additionally, research in this specific area is of quite broad nature, such that it builds on various contributing domains like innovation-research, human-computer interaction (HCI) and many others.

Moreover, the advent of decision support technologies in the early 70s has been the start of what should become an active research field in both information systems (IS) and operations research (OR). While theoretical contributions show significant advancements in this area, the adoption rate of sound decision support methodologies in the practical field remains on a rather poor level. Thus, the acceptance of decision support systems (DSS) evolved as a special case of technology acceptance research.

The underlying paper aims at analyzing and integrating the main research streams in the fields affected. Therefore, a comprehensive literature survey was conducted to identify the inner structure of this field. This laid the groundwork for the design of our conceptual model. We started the survey by examining the most prominent models in the discipline of technology acceptance. These basic publications then served as a starting point for a snowball-technique based literature search. We reviewed all major journals for research of technology acceptance-related topics for the time span of 1980 until today. Furthermore, special attention was given to those research efforts that were concerned with multi-criteria decision-making (MCDM) problems. Although the term MCDM emphasizes the complexity of the decision problems targeted, both terms DSS and MCDM are often used synonymously (as in the underlying paper). This initial phase resulted in a compendium of over 100 constructs that were found in literature to have an influence on technology acceptance, respectively MCDM acceptance.

In a second phase we performed a qualitative analysis on the (at this point) inhomogeneous collection of influencing constructs. There were also many variables with different levels of semantic granularity. Thus, the main objectives of this analysis were (i) to clearly define the semantics and denotation of each construct as intended by the original author, (ii) to identify any redundancies and (iii) to mark different levels of detail within the constructs. Furthermore, we established a mapping over the course of the analysis that builds up to a network-like structure and allows us to depict related constructs and parent-child relationships.

In a third phase, the consolidated and non-redundant list served as a basis for a process of inductive category formation [1]. We therefore discussed various schemata and concepts that could fit the underlying data along with a review of classifications proposed by other researchers or theories. The category formation process led to valuable insights on the details of the constructs and its interdependencies and eventually resulted in the categorization scheme and conceptual model that will be described in Section III.

The remainder of this paper is structured as follows. First, we present a review of the major streams that constitute the basis for our research, as described in Section II and with special focus on technology acceptance and MCDM acceptance. Section III presents and discusses the conceptual structure and the developed model. A detailed description of each group is given along with exemplified member constructs. Section IV provides a conclusion and points out promising research areas for ongoing investigations.

II. Literature Survey

This section describes two of the major streams of research that were examined within the literature review. As stated before, special focus was on technology acceptance models, related domains and on topics concerning MCDM acceptance.

A. Technology Acceptance Models

Research in the field of technology acceptance has been an active field of research for the last decades. It is a telling observation that the original reason for academics to perform research in this area was mainly of practical nature: What are the driving factors for failure or success of technology? This was soon adapted to a behavioral, human-centered view on the problem, changing the main research question to: How do individuals perceive software, their surroundings and what beliefs ultimately lead to usage of a technology? Consequently, much research effort was put into psychological analysis and theory-building of cognitive processes that resulted in numerous models and theories in the respective field. While these advancements are undoubtedly valuable for the forthcoming of the scientific field, some researchers call for more diversification in this research area. When Orlikowski and Iacono titled their heavily discussed research paper "Desperately seeking the 'IT' in IT research: A call to theorizing the IT Artifact" [2], they intended to break the ice for what is often prematurely dismissed as system-building task: research on the actual IT artifact. Although the area of technology acceptance can be considered a rather broad research field with numerous drivers for successful acceptance, the usage of a certain technology is at the very core of it. Prominent behavioral models try to explain the lack of acceptance from a human centered perspective. While these models do not differentiate much from a technological point of view, research in human-computer interaction (HCI) focuses on the investigation of specific characteristics. Additionally, investigations on the influence of individual traits, the social environment and task specifics have been successfully added to the field.

1) Behavioral models: One of the most prominent and disputed contribution to the area of technology acceptance has been made by F.D. Davis with the proposal of the technology acceptance model (TAM) [3]. TAM is a psychological model based on the theory of reasoned action (TRA), developed by Ajzen and Fishbein [4]. It tries to illustrate the abstract relationships that lead to failure or success of a technology. The original version of TAM is limited to only a few very high-level constructs, such as perceived usefulness or perceived ease of use, and has hence been subject to criticism and further development. Follow-up models such as TAM2 and TAM3 basically augment the initial high-level model with the integration of numerous fine-grained influence factors [5], [6]. TAM and its successors have been used intensively in empirical research and therefore constitute one major part in the field of technology acceptance. Alongside, DeLone and McLean proposed the information systems success model, integrating six major categories of measures that affect IS success [7]. In contrast to TAM, the IS success model is not only focused on acceptance of a technology but rather on the individual and organizational impacts. After numerous contributions following the initial proposal a revised model of the IS success model was proposed ten years later that replaced the orientation on impacts with net benefits and allows for feedback loops [8].

In addition to these specialized works many other contributions from psychology and cognitive sciences have found their way into technology acceptance research (e.g. Bandura's social cognitive theory (SCT) or the motivational model (MM) proposed by Davis et al. [9], [10]).

2) Technological research: Due to the fact that the technological artifact is at the center of technology acceptance research, many contributions from the field of human-computer interaction (HCI) are valuable when adopted and integrated into acceptance research. HCI research can be considered the intersection between behavioral sciences and computer science, therefore offering insights into the design and perception of IS-artifact characteristics. Especially when considering visual representations for IS, the cognitive fit theory (CFT) proposed by Vessey allows for a deeper understanding of the possible disadvantages that come with the utilization of such [11], [12]. Moreover, the computers are social actors (CaSA) approach shows how different levels of perceived social presence can influence acceptance and usability of a technology [13].

3) Other contributions to the field: As follows from the above, technology acceptance research is embedded in a rather broad social environment and subject to numerous influencing factors. Many other research streams aside from the aforementioned behavioral and technological research areas are providing promising contributions to this field. A prominent example is the model of task-technology fit (TTF), that focuses explicitly on the degree of compatibility between task and technology [14]. While most research attempts incrementally add to the forthcoming of the field, others try to abstract existing knowledge to form a more holistic approach. This strategy has been pursued by the authors of the unified theory of acceptance and use of technology (UTAUT), who tried to integrate the findings of eight existent models/theories (including TRA, TAM, MM, etc.) to establish a single but comprehensive approach [15].

B. MCDM Acceptance

Within the broad field of technology adoption the usage behavior of decision support systems (DSS) has emerged as an important subfield of research. We argue that several reasons account for this development. First, the problem of supporting decision makers in making good decisions has always attracted many researchers. On the other hand, the acceptance of decision support methods and systems (further referred to as DSS acceptance) within the practical field is rather low. Therefore, it does not come as a surprise that the gap between theoretical advancements in decision support and poor adoption of DSS in the practical field has become its own research area. A second reason for this development is that there are several major differences between most conventional information systems and decision support technologies. Conventional IS technologies (e.g. mail clients, word processing, etc.) are rather simple in terms of control. This means, that the user usually has the ability to understand and to predict the system's reaction to inputs. Therefore, the user perceives nearly absolute control over the outputs generated by the system. In contrast, most DSS are based on complex mathematical models to process information which reduces the understandability and predictability of the system's reactions. Thus, the user perceives substantially less control of the decision support system's behaviour and outputs than he perceives using a conventional IS technology.

As DSS acceptance is considered a special case of technology acceptance, research in DSS usage behavior evolves around similar main constructs as research in technology adoption (e.g. intention to use decision aid [16], decision quality [17], perceived usefulness [18]). However, research in DSS acceptance differs distinctly from other areas of technology adoption due to the explicit separation of the acceptance of the system from the acceptance of the underlying theory implemented in the system. The rationale for this is that the user has to accept both the MCDM method (theory) and the technology (tool) implementing this process [18].

A prominent model in the context of evaluating the acceptance of decision making methods is the effort-accuracy model of cognition developed by Payne et al. [19]. This model suggests that decision makers are naturally capable of several decision making strategies and select one of these strategies based on trade-off considerations between the effort to implement a strategy and its accuracy. This model has been extensively used in the context of decision support acceptance, for example by Benbasat and fellows (e.g. [20], [21], [16]) but also by others (e.g. [18]). Based on this model, it was shown that a certain decision making strategy is more likely to be used if a DSS reduces the cognitive effort to employ this strategy relative to other strategies [20].

On the system-side of DSS acceptance, much research focuses on the identification and evaluation of design features that influence the acceptance of DSS technologies. This includes, for instance, the design of the user interface (e.g. [22], [23] and other topics related to human-computer interaction like the wording and structuring of the dialogue with the user [24]. An important concept within DSS acceptance literature is the decisional guidance framework developed by Silver [25]. Decisional guidance is defined as the way how a DSS guides and directs its users as they execute their decision processes. It has been the groundwork for much empirical research (e.g. [18], [16]) and has been incorporated in Benbasat's concept of explanation facilities, which provide the user with how and why explanations as well as with process guidance [26], [16].

III. A CONCEPTUAL PERSPECTIVE ON MCDM ACCEPTANCE

Research in technology acceptance is closely related to and often based on psychological concepts that target human cognition and perception. Due to the broad area of possible influences on the usage of technology, most researchers try to narrow down the scope of their research by limiting empirical investigations to certain areas of technology acceptance (e.g. visualization capabilities, individual differences). As a result of this practice a great number of models and theories have spawned that explain small parts of this research area. This process led to a rather unstructured research field where it seems hard to identify clear streams and future research possibilities. Therefore, as stated in Section I, one main goal of this research attempt is to synthesize and structure the list of possible influence factors and to conceptualize a model. Using an inductive categorization formation approach, we established the following major groups of influencing factors: individual, task, technology, method, social and facilitating conditions. These groups are intended to serve as a conceptual categorization for low-level constructs. High-level constructs (e.g. intention to use or perceived ease of use) tend to be an aggregation or a result of the combination of multiple low-level constructs and are therefore not clearly assignable to a single group. Due to the focus on MCDM systems the technical terms of this research area are used when applicable (individual - decision maker, technology - MCDM tool, task - decision problem).

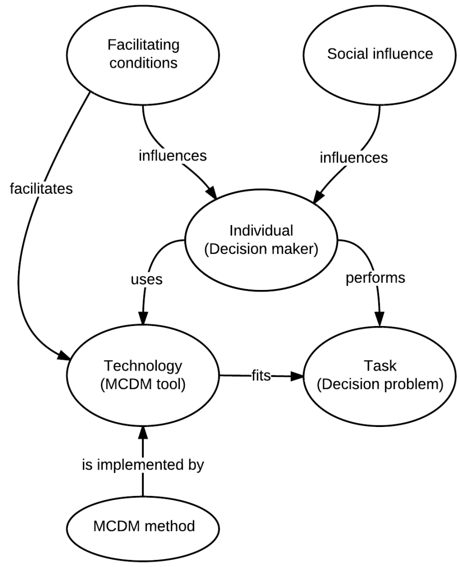

Fig. 1. Conceptual model of factors involved in MCDM tool usage behavior

The model presented in Fig. 1 provides a static perspective on the system at hand. It is not intended to explain or hypothesize on causalities or dependencies. It depicts a conceptualized overview of the field of MCDM acceptance and its key influences. Each ellipse represents one group that has been identified as described above. Edges between the groups model their associations and are labeled to describe the respective semantics of their relationship. The edge "uses" represents the most important relationship concerning acceptance, that is, the actual usage of the MCDM tool by the decision maker. In fact, this edge represents the core of MCDM acceptance research. Of course, this research includes not only the acceptance of tools but also the acceptance of MCDM methods. The method itself, however, is used (and perceived) only via the MCDM tool which implements the method. The same line of arguments also applies to the relationship between the MCDM method and the decision problem (task) at hand. While the MCDM method supports solving the decision problem for sure, this relationship is conveyed by the tool implementing the method and assisting the solving of the task. Thus, there is only an arrow, from MCDM tool to decision problem, but no arrow from MCDM method to decision problem. The edge "performs" reflects the original problem situation or motivation for the usage of most IS, that is an individual has to carry out a specific task. While the relation between the decision maker and the MCDM tool as well as the relation between the decision maker and the decision problem are shown as activities by the decision maker ("uses" and "performs"), the groups facilitating conditions and social factors influence the decision maker (edges pointed towards DM). The edge labeled "facilitates" accounts for the need of certain enabling resources for some MCDM tools.

In the following we will give a short definition of our understanding of each group along with a presentation of key concepts and exemplary constructs.

A. Individual

The group of individual characteristics covers relevant aspects of the individual (decision maker) that influence the willingness to use a technology. This covers a quite wide range of factors like personality traits, demographic criteria, abilities, knowledge and affects.

For example, individual characteristics like *computer self-efficacy* (beliefs of being able to perform a specific task by using an IT system) or *computer playfulness* (describing the degree of cognitive spontaneity in microcomputer interaction) have been found to show a significant effect on perceived ease of use and therefore on technology adoption behavior (TAM3, [6]). Furthermore, constructs like *age*, *gender* or *experience* (moderating the individual's usage behavior) establish this group (UTAUT, [15]).

From the five factor model's point of view (FFM [27]) there are five individual traits that represent a personality in a highly aggregated manner: *openness*, *conscientiousness*, *agreeableness*, *extraversion* and *neuroticism*. Combined with general models of technology acceptance, the "big five" have been used to show that the personality traits of an individual have a significant influence on the willingness to use a certain technology [28].

Since research on the individual is part of various academic disciplines, many other models and researchers contributed characteristics to this group. For example, *attitude* (TRA, [4]), *affect* ([29]) or *propensity to trust* (Integrative Model of Organizational Trust, [30]) are constructs which are summarized within this group.

B. Task

The group of task-related constructs covers relevant aspects of the task (decision problem) at hand, which effect the user's evaluations of technologies intended to support him in performing the task.

For example, *task difficulty* (non-analyzable search behavior) and *task variety* (number of exceptions) distinguish routine tasks from non-routine task. A prominent model, which is based on this characterization of tasks, is the task-technology-fit model (TTF, [14]). Based on former research, this model also characterizes tasks by their *task interdependence* (with other organizational units). The TTF states that the more users are engaged in non-routine and interdependent tasks the more they demand from the technology, which in turn leads to lower evaluations of the respective technology. The model further states that this lower evaluations will effect the perception of usefulness and thus the utilization of the technology.

A behavioral model focusing on decision making, which is based on task characteristics, is the effort-accuracy model of cognition [19]. Within this model, decision tasks are characterized by their complexity which increases with constructs like *number of alternatives* or *number of dimensions*. The effort-accuracy model of cognition states that the complexity of the decision problem has a significant influence on the decision strategy used by decision makers [31]. Thus, we argue that a DSS which does not provide decision strategies (MCDM tool) appropriate to the complexity of the decision problem at hand, is not likely to be used.

Besides these basic models, task-related characteristics are subject to active research. For instance, the *risk* inherent to a task can affect the willingness to delegate the task to others, which also might be true for technologies [30], [16]. Another example is the degree to which a DM is *accountable* for the decision, which also influences the behavior of the decision maker [19]. We subsume such and similar abstract properties of tasks under this category of task-related characteristics, and argue that these characteristics have a major influence on the perception of the system's usefulness.

C. Technology

The group of technology-related characteristics covers relevant aspects of the IT-artifact influencing the individual's willingness to use the respective IT-artifact (MCDM tool).

For example, *visualization* capabilities can be regarded as one key-characteristic of a technological system and is therefore subject to active research. Following a long discussion on whether to prefer graphical vs. tabular representations, Vessey proposed the theory of cognitive fit (CFT, [11]) to integrate the different perspectives on which type of visualization fits to different types of data and task (spatial vs. symbolic). It states that a picture is not always worth a thousand words but in fact hinders cognition when used for the wrong purpose. Based on CFT, Speier found that visual representations not only have to fit the underlying type but also the complexity of the task [22].

Social presence, to name another construct, states that humans frequently apply social norms and rules towards computers. Nass, Steuer and Tauber presented this new paradigm called computers are social actors (CaSA, [13]) and triggered a series of research attempts to investigate on how to increase or decrease the perceived social presence of computers in various fields of application (e.g. e-learning software, [32]).

Among a number of other constructs, we found that *job relevance* (degree of fit between technology and task [5]), *explanation facilities* (integration of how, why and process explanations into the software [33]) or *process guidance* (active guidance through the complete decision process [34]) belong to this group as well. Following the understanding that these characteristics of an IT artifact carry the potential to influence the degree of acceptance substantially, we subsume these factors within the group of technology-related influences.

D. Method

The group of methodical influences covers relevant aspects of the MCDM method influencing the individual's willingness to use the MCDM tool at hand. This group is a special case of technology related factors which can be distinctly attributed to the MCDM method underlying the respective technology.

For example, constructs like the *decision strategy* and perceived *decision strategy restrictiveness* and their respective influence were investigated by Wang and Benbasat on the basis of the effort-accuracy framework of cognition [16]. Their results showed that the more a user perceives a decision aid as being restrictive regarding the freedom to apply their preferred decision process the lesser is the user's intention to use the DSS.

Kotteman and Davis, on the other hand, found evidence in the literature that the degree of *decisional conflicts*, which increases with the salience of trade-offs, has a direct influence on the failure or success of decision support systems. They conclude that prominent constructs like perceived usefulness are not suitable indicators for actual performance of a DSS [35].

The constructs belonging to this group have an important influence on the acceptance of a DSS, since the user has to accept both, the decision strategy and its implementation (see Section II-B). Following this line of reasoning, we separate factors which can be attributed to the method from those that are attributed to the tool. We bear in mind, however, that this segregation is mainly conceptual since both groups are highly interconnected in empirical settings.

E. Social influence

The group of social influence covers relevant aspects of the social system influencing the decision maker's willingness to use the technology at hand.

For example, *subjective norm* (the degree to which an individual perceives social pressure to perform or not perform a behavior) is a major influence of the social system on the individual's behavior. Beside individual factors, *subjective norm* has been used within TRA and its successor, the theory of planned behavior, to explain intention to perform a behavior [36], [4].

Image (the degree to which an individual believes that using the technology will enhance one's social status) is another construct which falls into the category of social influence. Among other constructs, image and subjective norm have been integrated into TAM2 to explain perceived usefulness [5]. TAM2 accounts for the relatedness of image and subjective norm by pointing out that image is partly determined by subjective norm.

By incorporating the group of social factors, we acknowledge that individuals are always part of a social system which significantly influences their behavior and thus their technology usage.

F. Facilitating conditions

The group of facilitating conditions represent the organizational and technical support that is available to a decision maker or tool for the usage of a technology.

For example, *perceptions of external control* as proposed in TAM3 is used in a similar way, expressing the degree to which an individual believes that organizational and technical resources exist to support the use of the system [6]. Taylor and Todd propose further constructs in the decomposed TBP, like *resource facilitating conditions* (regarding beliefs about the availability of general resources such as time and money) and *technology facilitating conditions* (regarding technology compatibility) [37]. The construct of *end user support*, introduced in the work of Igbaria and Iivari [38], also suggests that organizational support for using a system can enhance acceptance.

Although the existence of facilitating conditions is not necessarily a prerequisite for general MCDM acceptance, these factors can directly influence the individual's perception of the technology. Hence, consistent with our findings, *facilitating conditions* have already been presented as a highly-aggregated factor in UTAUT [15].

Table I summarizes the assignment of constructs from the respective models/theories to the categorization proposed. It can be observed that while some models pursue a comprehensive approach and hence integrate constructs from many categories, others specialize on certain areas.

IV. Conclusion and further research

The objective of this study was to conceptualize a structural model that reflects the various research areas and perspectives on decision support acceptance. The model-building followed an extensive literature survey in the area of technology acceptance with special emphasis on MCDM acceptance. We could identify six major groups of influencing criteria that were put into context using a graphical representation. This conceptualization is consistent with former research results. For example, the UTAUT model also incorporates social influence, facilitating conditions and individual characteristics (the latter split into multiple detailed characteristics) as major determinants of technology adoption behavior. Furthermore,

TABLE I
SAMPLE MAPPING OF MODELS/THEORIES TO FACTOR GROUPS

	indiv.*	**social**	**facil. cond.***	**technology**	**method**	**task**
UTAUT	x	x	x	x		
TAM3	x	x	x	x		
TPB	x	x	x			
MPCU	x	x	x	x		
FFM	x					
EAMC					x	x
CFT				x		
CaSA				x		
TTF	x			x		x

*indiv. = individual, facil.cond. = facilitating conditions

UTAUT=Unified Theory of Acceptance and Use of Technology, TAM3=Technology Acceptance Model 3, TPB=Theory of Planned Behavior, MPCU=Theory of PC Utilization, FFM=Five Factor Model, EAMC=Effort-Accuracy Model of Cognition, CFT=Cognitive Fit Theory, CaSA=Computer are Social Actors, TTF=Task-Technology Fit

the TTF model is based on similar groups of characteristics (task, technology and individual) to explain IS utilization. That there is some agreement on major factors driving technology acceptance in general and MCDM acceptance in particular is a promising result towards a more unified view of and research in technology acceptance.

However, our findings also show that most research focuses on the individual's perception and related behavioral consequences. Rather little effort has been put into the analysis of the actual IT-artifact and how its characteristics influence its perception of the user. This also holds true for other drivers of technology acceptance. For example, questions like how to design user support services to increase the users' perception of facilitating conditions do not receive much attention although they have the potential to substantially increase user acceptance of technologies in the practical field. Thus, the analysis of how the design of concrete artifacts influences user evaluations seems to be a promising area for further research.

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