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A Comprehensive Framework Approach using Content, Context, Process Views to Combine Methods from Operations Research for IT Assessments

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Abstract

Motivated by IT evaluation problems identified in a large public sector organization, we propose how evaluation requirements can be supported by a framework combining different models and methods from IS evaluation theory. The article extends the content, context, process (CCP) perspectives of organizational change with operations research techniques and demonstrates the approach in practice for an Enterprise Resource Planning evaluation.

Key words

IT evaluation; Information systems; Multi criteria decision making; Case study; Decision support systems

1 INTRODUCTION

We have seen a steady inflow of models and tools in operations research (OR) for decision support in the area of Information Systems (IS) evaluations in last decades in particular working with multiple criteria assessments (Chou, Chou, & Tzeng, 2006; Shim et al., 2002). Some are based on rather simple cost-benefit multiple criteria analysis (Olson, 2007) while many rely on rather complex models and methods at least from the viewpoint of practitioners. In terms of method application in practice, there seems to be a noticeable gap between academic theories and commercially available methodologies within organizations (Smithson & Serafeimidis, 2003). Contemporary research agendas for decision support systems mention the need for explicit efforts to apply analytic models and methods (Gunasekaran, Ngai, & McGaughey, 2006; Shim, et al., 2002). The reliance on a sole technique, however, can lead to sub-optimization or even failure in IT evaluation (Milis & Mercken, 2004). Especially large scale IT projects such as IT infrastructure investments seem to lack comprehensive support from multiple methods that acknowledge the identification and measurement of intangibles and other non-financial performance criteria besides considering the cost side of the evaluation task (Gunasekaran, et al., 2006). While IT cost centers are common, arguments for the value side of IT are currently regularly supported by weak assumptions about benefits connected with information integration, improved availability of information, increased automation, more efficient processes, uniform architectures, higher transparency and other aspects without putting these into context and, more importantly, without any structural and methodological foundation (Irani, 2002). This lack of formality makes it difficult to accept and also understand statements about the value side and its connection with the cost side. The crucial question that business management faces about the contribution IT makes in the businesses' value chain is currently insufficiently answered by simple cost-benefit analyses and classic net present value considerations (Edward W. N. Bernroider & Stix, 2006). Those evaluations focus extensively on tangible benefits, mostly neglecting intangible or strategic effects, as well as “soft” in-house factors related to employees and stakeholders.

In this article we focus on the needs for IT evaluation and the development of a comprehensive framework for senior IT management in a public organization facing huge IT expenditures in their different territorial authorities and administration units. Trends in public administration starting already with new public management but especially newer approaches like digital era governance (Dunleavy, Margetts , Bastow, & Tinkler, 2006) act as catalysts in both directions, by advocating reengineering of processes within administrations, often resorting to IT-based solutions, and also placing higher demands on accountability and governance to ensure the validity of those expenses. Following recommendations from literature this paper acknowledges the need for IT evaluation framework building (Björnsson & Lundegård, 1992; Gunasekaran, et al., 2006; Joshi & Pant, 2008; Jukic & Jukic, 2010) and investigates the use of a well known framework approach originally named the content, context and process (CCP) structure (Pettigrew, 1985). This method supports the requirement for IS evaluations to be tailored to the needs of individual settings based on their environment, the context of the evaluation, what is to be evaluated and the inclusion of needed stakeholders (Stockdale & Standing, 2006). Additionally, we answer the call for more advanced, or combined instruments to take into account multi-criteria, multi-stakeholder and systemic streams of operations research (Kunsch, Kavathatzopoulos, & Rauschmayer, 2009).

Consequently, we target the following research objectives: (i) A case based identification of general IT evaluation requirements in a public sector organization; (ii) Adaptation and extension of the Content, Context and Process framework approach to include a wide selection of methods from OR; (iii) And an empirical application of the framework approach.

This article is based on more than twelve months of extensive field research in a multi-method approach including 23 interviews and a survey with more than three hundred gathered data sets to support all assessed constructs. It is important to note that we sought to use the framework not only as a tool to support the evaluation task and reduce complexity but also as a means to utilize and combine known models and methods useful for IS evaluation. We needed structures that provide semantically clear dimensions and provide guidance on cause and effect relationships between dimensions. Examples for well established causal base models are the „IS Success Model“ from DeLone und McLean (W. D. DeLone & McLean, 2003; DeLone & McLean, 1992), the Task-Technology Fit model (Goodhue, 1995; Zigurs, Buckland, Connolly, & Wilson, 1999), or the Balanced Scorecard

model (Kaplan & Norton, 1992). One essential contribution of this article is to design and test not only an established model but also specific methods, e.g., for quantification of metrics, within a generic framework approach.

The following section gives more theoretical background and focuses on the CCP framework, the Delone and McLean IS success model and additive value models, which constituted the theoretical foundations of our framework design and tests. This is followed by the applied research methodology. The empirical part refers to the Austrian Ministry of Finance and covers the evaluation requirements, framework design and implementation for an Enterprise Resources Planning (ERP) system as well as references to a second Business Intelligence (BI) case study for validation purposes. The last section summarizes the results and contributions of this article.

2 THEORETICAL BACKGROUND

2.1 Content, context, process (CCP) approach

A main challenge for IT evaluation is to construct frameworks that are sufficiently generic to be useful to a wide range of applications but also sufficiently detailed to provide effective help to the evaluator (Stockdale & Standing, 2006). We sought to design a framework based system that can be effectively used to guide and assess any IT investment in the public sector. For this purpose we looked for a generic approach and chose the content, context and process (CCP) idea originally proposed by Pettigrew (Pettigrew, 1985), for his work on organizational change, which was later expanded in the context of information systems evaluation (Serafeimidis & Smithson, 1999; Symons, 1991; Walsham, 1999), and more recently applied by Stockdale and Standing (Stockdale & Standing, 2006) in an interpretive approach again to evaluate information systems. There seems to be a widespread support in academic evaluation literature for this approach (Smithson & Serafeimidis, 2003). The use of CCP provides a source of questions to guide the design of the model in terms of relating to what is being measured, by whom and for what purpose. The content dimension focuses on the subject of the evaluation (i.e., "what" is decided), which is considered as a crucial factor in any evaluation. The context specifies the inner or organizational context as well as the outer or external context, which both together influence evaluation and its management. The process view considers the activities leading to and supporting the evaluation (Stockdale & Standing, 2006).

2.2 Delone and McLean IS Success Model

We included the IS Success Model from DeLone and McLean in the CCP approach (W. D. DeLone & McLean, 2003; DeLone & McLean, 1992), which is probably the most tried and tested model for IS evaluation. The original model published in 1992 was derived from communication research of Shannon and Weaver (Shannon & Weaver, 1949), the information influence theory of Mason (Mason, 1978) and empirical IS related research studies. The DeLone and McLean model was widely applied as measurement model (Armstrong, Fogarty, Dingsdag, & Dimbleby, 2005; Wu & Wang, 2006) in particular in an ERP environment (Edward W. N. Bernroider, 2008; Chien & Tsaur, 2007). Literature suggested this framework is applicable to the public sector (D. Sedera, Gable, & Palmer, 2002; Thomas, 2006). The model satisfied the mentioned constraints as it suggested a number of distinctive dimensions with cause and effect relationships between them. Specifically, the model uses six different dimensions covering a wide range of perceivable consequences of IS. These dimensions are grouped into three causal stages where each stage has an effect on the next. In the first stage the consequences of introducing an IS are seen in the quality specific dimensions (System Quality, Information Quality, Service Quality). Changes in terms of this quality dimension should in turn influence the middle user dimension which constitutes the second stage (Intention to Use and Use, User Satisfaction). The users themselves affect the organization, and thereby Net Benefits connected with the initial investment are expected. Wide spread empirical research have validated the causality claim of the model (Roldan & Leal, 2003; P.B. Seddon & Kiew, 1996), which was found to be stronger at the individual level of analysis (Petter, DeLone, & McLean, 2008). Figure 1 depicts this process oriented model and shows the relationships between dimensions. The model of DeLone und McLean is primarily targeted at ex-post valuation. With suitable measures and methods, however, also an ex-ante valuation can be conducted.

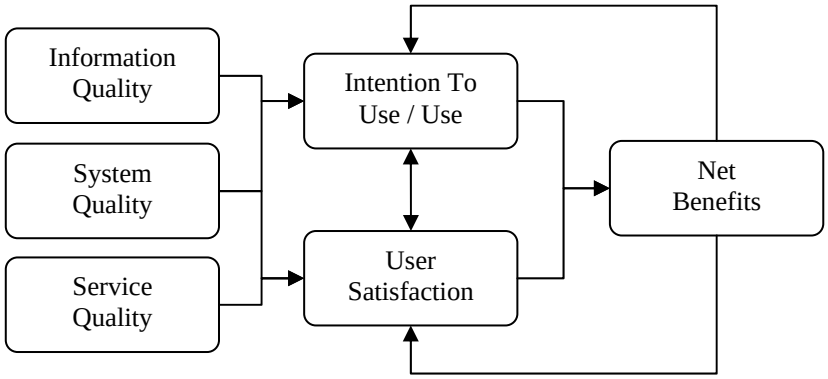

Figure 1: A base model structure according to the DeLone and McLean IS success model (DeLone & McLean, 2003)

2.3 Additive value models and aggregation

Usually frameworks used in systematic IS evaluation and selection are based on additive value models. Within multiple attributive decision making, which is concerned with selecting the best alternative among a finite set of possible choices based on multiple, usually conflicting, attributes (Yoon & Hwang, 1995), probably the most well known models are the Analytic Hierarchic Process (AHP) (Saaty, 1980) or variants of utility ranking models (based on the so-called "Nutzwertanalyse" - NWA) (Zangemeister, 1976). In both cases the decision maker tries to maximize a quantity called utility or value. This postulates that all alternatives may be evaluated on a single scale that reflects the value system of the decision maker and his preferences. To generate this super scale, multiple single-attribute value functions are aggregated, most regularly by a simple additive weighting procedure. The value aggregation per alternative is in the case of AHP undertaken by a weighted sum of single-attribute value functions. In terms of NWA, the decision maker is allowed to choose among a set of methods and typically relies on the standard recommendation, again formally a weighted sum approach. In the weighted sum method the overall suitability of each alternative is thereby calculated by averaging the score of each alternative with respect to every attribute with the corresponding importance weighting. Other more contemporary approaches in operations research to aggregation can be supported by Data Envelopment Analysis (Cooper, Seiford, & Tone, 2000), or the Profile Distance Method (Edward W. N. Bernroider & Stix, 2006). In business practice important pre-conditions of additive value models and aggregation are regularly violated (Edward W.N. Bernroider & Mitlöhner, 2006) such as incompleteness or the requirement of non-redundancy in the form of independent criteria (Keeney & Raiffa, 1976). A another major problem lies in the necessity of defining attribute weights, which is known as major challenge for decision makers. AHP has a relative advantage over NWA due to its explicit support for deriving weights based on pair wise comparison of attributes on a pre-defined AHP-Scale (1/9 to 9), followed by a mathematical procedure, usually the Eigenvector method, and consistency tests. In the Eigenvector method the normalized Eigenvector corresponding to the greatest Eigenvalue of the comparison matrix is used as weighting vector. We therefore incorporated the AHP process into the CCP framework.

3 METHODOLOGY

Our research aim was twofold. First, we intended to identify and describe key IT evaluation requirements in a large scale public sector organization, which can be ideally supported by focused qualitative case studies (Stuart, McCutcheon, Handfield, McLachlin, & Samson, 2002). However, our aim also included the application and testing of a framework and inclusion of OR methods from theory, which can be well supported with quantitative techniques. We therefore used an extensive two staged multi-method approach supported by qualitative and quantitative techniques, which we applied to the Austrian Ministry of Finance (AMF) representing a large scale public sector organization in

Austria. In this section we present aspects of the empirical research methods which followed a two-step design.

In the first interpretive and explorative stage we performed six face-to-face interviews with executive internal and external IT management to identify the evaluation problem and explore IT evaluation requirements from the viewpoint of senior IT management (see Appendix 1: Sessions 1 to 6). The case study was therefore initially engaged in an exploratory approach with open questions where we asked about IT projects types, respective evaluation requirements, and specific IT evaluation scenarios faced by the organization. We linked answers back to supporting theory, selected IT projects as candidates for evaluation and designed the framework approach with a list of potential methods for the selected IT evaluation problem. These initial research findings were revised in two further workshops (see Appendix 1: Sessions 7 to 8), where we presented and discussed the resulting model design termed Public IT Assessment framework (PITAF).

In the second research stage this evaluation framework was extensively tested and applied in the context of a post project review of a large scale ERP project named HV-SAP by the organization. Following a positivistic approach we expected to see whether the framework elements and especially the selected generic framework (the Delone and McLean IS success model) can be specifically applied to holistically structure and consequently assess IS success and benefits on different levels of the organization related to the chosen ERP scenario. The ERP solution from the vendor SAP was implemented from 1998 to 2004 with investment costs of EUR 78 million. The system was targeted to ultimately include approximately 4000 users. Due to its major and far reaching impact this IT scenario was well suited to test the modular validation framework developed in this paper. Data gathering methods for this second stage included two principal methods supported with internal documentation: An organization wide user survey; interviews; and workshops. To support the survey we firstly profiled the target population, which excluded users from the Department of Defense due to security and data protection issues. We were able to successfully extract a population of 1,006 users from the role specifications defined in the ERP system, which we grouped into three different clusters (see Table 1). We administered the questionnaires to all users from all groups to assess the various user related constructs as detailed later in the article. Due to several invitations and reminders backed up by senior internal project sponsors, we were able to achieve a high overall return quota of 33%. In terms of potential response bias, we analysed the distributions of the group clusters between respondents and non-respondents with a Chi^2 test. The comparison revealed no statistically significant differences, thus providing no evidence of non-response bias. The resulting extensive field work in terms of contacting and reminding users and conducting assessment workshops were operationally conducted by project partners under our guidance with interview manuals, method handbooks and questionnaires.

User group	**Respondent**		
	No	**Yes**	**Total**
Active system users	378	185	563
Semi-active system users	197	90	287
Decision makers	99	57	156
Total	674	332	1006
	Value	df	p
Pearson Chi-Square	1.24	2	.54
Overall return quota	33%		

Table 1: Sample characteristics for ERP survey

The primary concerns for case studies include construct validity and internal validity (Stuart, et al., 2002). To ensure construct validity we used different triangulation techniques (Denzin, 1984; Yin, 2003). A triangulated research strategy can occur with data, researchers, theories, and even methods. Following Yin's recommendation we applied *data source triangulation* by using multiple sources of data for the same problems, e.g. by interviewing internal and external IT managers about IT project types and structures in public administration (see Appendix 1), and used different data gathering methods (survey instruments, interviews/workshops, and documents) at different research stages. We also rotated the interviewers to ensure a degree of *investigator triangulation* while exploring the same phenomena. Multiple frameworks showing processes and key variables in IT evaluation were considered and linked with the data, which accounts for *theory triangulation*. To further support construct validity we based the assessment framework on well validated measurement constructs and methods (see Apendix 2). The survey instrument was the result of panel and expert discussions and the wordings of questions (face validity) and appropriate scales were pre-tested. We believe to have achieved a high level of internal validity across sites in particular by choosing ERP as our unit of analysis, which is fundamentally a cross-sectional and organization wide IS solution. Its wide applicability and high usage allowed us to target a large sample of users from all sections of the organization. We were allowed to refer and use a wide selection of different data sources for evaluating this IT project. Finally, we conducted another ex post IT evaluation in a second case study referring to a Business Intelligence (BI) system (Cognos) within the same organization following the same process with the intention to validate the framework. While scope and depth of this second roll-out was considerably less, we were able to highlight interesting similarities and differences between the two considered evaluation scenarios.

4 FRAMEWORK DESIGN

The design of the public IT assessment framework (PITAF) considered elements of the generic content, context and process views. The principle was to offer an abstract framework by defining a generic model and instructions which can be used to create separate framework instances for each specific IT evaluations. After initialization of the pre-defined steps and elements of the framework, an evaluation instance reflected an independent and ready to use manifestation of the framework. Continuous learning, which is central concept in the CCP approach (Serafeimidis & Smithson, 1999; Stockdale & Standing, 2006), was incorporated in the methodology as knowledge from domain and method experts from one evaluation should improve the framework for the next evaluation. The underlying knowledge strategy for the framework design is therefore a knowledge codification approach (Hansen, Nohria, & Tierney, 1999), which seeks to make implicit knowledge of experts explicit by constantly improving the PITAF data repository, instruction and process guidelines. Figure 2 shows the structural elements of the framework design, which will be referred to in the next sections. The following design description includes the context of evaluation (the why and who), the content aspects (the IT artifact and the multi-dimensional structure according to a "base model"), and the process views with all activity related measurement aspects (methods for quantification and aggregation, and selection).

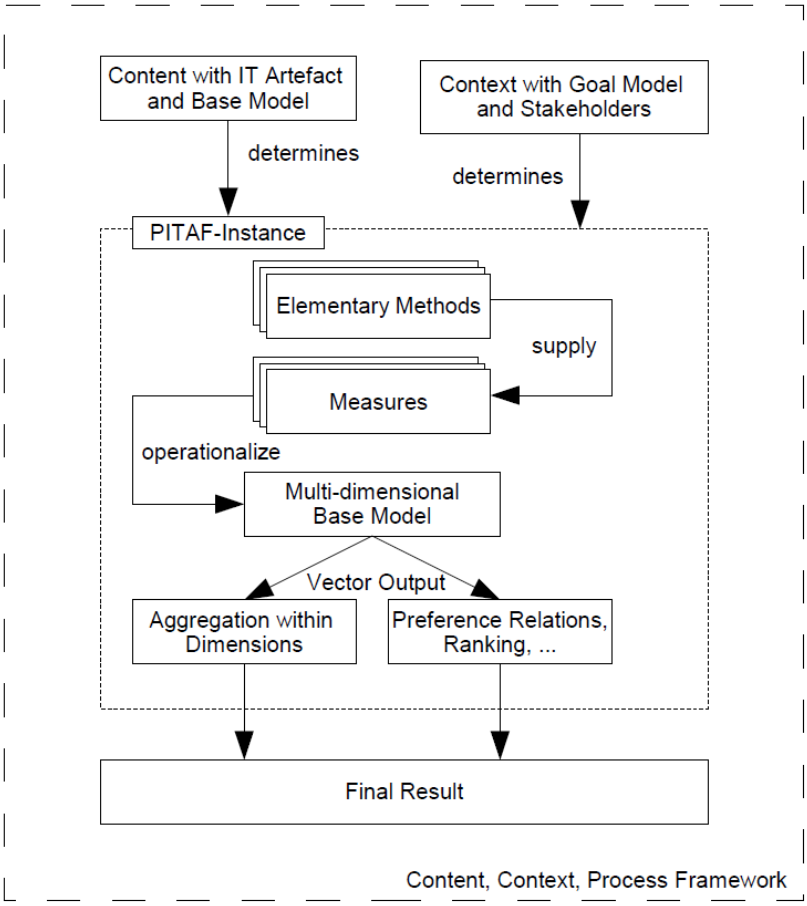

Figure 2: Key elements of the public IT assessment framework (PITAF)

4.1 Context

Our first research objective was to explore the specific evaluation requirements for an IT framework in the context of the chosen Austrian public administration organization from the perspective of IT management. In this first interpretive and explorative stage we conducted a series of open interviews with the chief technology officer of Austrian Ministry of Finance and an IT senior manager from the dominating IT service provider (see Appendix 1) to inquire the why and who of evaluation to be considered according to the contextual view in the CCP framework (Stockdale & Standing, 2006). Both interviewed internal and external IT executives had a long experience in managing IT. Internal management expressed a strong need to systematically assess and control IT benefit realization, which was the original trigger of this research project into IT evaluation. The following section briefly summarizes and discusses the identified requirements and provides the identified links into supporting theory (see Table 2).

Case requirement	Description	Supplementary supporting references
General applicability	The framework should be applicable to any major IT investment while accounting for the individual requirements of specific IT objects.	(Farbey, Land, & Targett, 1995; Irani, 2002; Joshi & Pant, 2008; Seddon, Staples, Patnayakuni, & Bowtell, 1998)
Method flexibility	It should be able to include different methods according to the specific requirements of the IT artefact.	(Lin & Pervan, 2003; Seddon et al., 1998)
Full scope	The evaluation should comprehensively cover the cost and benefit side of IT evaluation.	(Bernroider & Stix, 2006; Gunasekaran, Love, Rahimi, & Miele, 2001)
Time dependency	It should be applicable to different phases of the evaluation process according to the systems lifecycle which again potentially requires different methods.	(Anbari, Carayannis, & Voetsch, 2008; Love, Irani, & Edwards, 2005; Myers, Kappelman, & Prybutok, 1997; Serafeimidis & Smithson, 1999)
Transparency	Results should be transparent enough to allow results to be defended and understood.	(Bernroider & Stix, 2006; Geldermann, Bertsch, Treitz, French, Papamichail, & Hämäläinen, 2009)
Analytical use	Usage should also incorporate analytical applications where causes to problems can be explored.	(Chand, Hachey, Hunton, Owhoso, & Vasudevan, 2005; Milis & Mercken, 2004)
Validity and reliability	Approach should be repeatable and include trails of evidence to support validity and reliability of results.	(Bernroider, 2008; Rozinat, Mans, Song, & van der Aalst, 2009)
Roles and responsibilities	The evaluation should allow different inputs, views, and usage scenarios by different stakeholders.	(Connell & Young, 2007; Myers et al., 1997; Seddon et al., 1998; Stockdale & Standing, 2006; Wilson & Howcroft, 2005)

Table 2: Main areas of requirements for IT evaluation frameworks from empirical analysis

It quickly became clear that IT management was looking for a tool applicable to any major IT evaluation problem the organization is facing. Mentioned IT evaluation scenarios included Enterprise Resource Planning, Customer Relationship Management and Business Intelligence systems. We linked those IT projects into taxonomies from literature to identify IT objects and consequently propose certain levels of complexity and evaluation consequences, such as the Benefits Evaluation Ladder (Farbey, Land, & Targett, 1995) or a discretionary-mandatory classification (Joshi & Pant, 2008). While discussing different aspects, it became clear that the framework needed not only to be general but also specific enough to account for the potentially different evaluation requirements of different IT objects, therefore following Seddon at al.'s argument that evaluation is dependent on the

class of IS under consideration (Peter B. Seddon, Staples, Patnayakuni, & Bowtell, 1998). While we saw the necessary generality in the abstract structures and processes, we conceived specific links into evaluation methods, which also supports Irani's view that generic evaluation alone is not effective (Irani, 2002). The interviewee complained about the common usage of heuristic approaches ("educated guesses", "rules of thumb") that need to be substituted by more formal and flexible rational approaches. This method flexibility was identified as another major requirement. Consequently, we could not follow a single instrument approach, which is dominating the existing IT evaluation literature. We needed to capture the richness of data and of methods in a systematic way, which also addresses the reported lack of uniformity in the formality of approaches (Lin & Pervan, 2003). Evaluation of IT is a complex task due to many intangibles and non-financial criteria inherent in the implementation of IT (Gunasekaran, Love, Rahimi, & Miele, 2001). While traditional approaches and very specific single methods were known to management and have been applied with mixed success, a principal desire was to capture the full scope of essential intangible and tangible impacts that can be related to the IT evaluation artifact. Previous evaluations were mentioned to be isolated to certain stages of the IT lifecycle, most notably connected with initial system justification. Internal IT management expressed an evaluation need in different phases of the adoption and usage processes necessitating different evaluation goals. The model should be useable for measurements ex-ante (to support decision making), during the project (for controlling purposes) and ex-post for post implementation reviews (Anbari, Carayannis, & Voetsch, 2008). Literature justifies this empirical need (Serafeimidis & Smithson, 1999). It was reported that ex-post evaluation and especially regular operational use assessments are far less common in enterprises than ex-ante evaluations, but if applied are of clear value to the organization (Hussein Al-Yaseen, Eldabi, Lees, & Paul, 2006). The desire to let results flow from one stage into the next stage of evaluation was already mentioned but with each evaluation stage working with its own targets. In terms of ex-post evaluation the public organization did not only mention targets related to organizational learning, which was reported to be the main opportunity for construction organizations associated with ex-post IT evaluations (Love, Irani, & Edwards, 2005), but also controlling needs. Analytical use in particular for controlling purposes was mentioned to be most important, which is a feature regularly attributed to Balanced Score Card based assessments (Chand, Hachey, Hunton, Owhoso, & Vasudevan, 2005; Milis & Mercken, 2004). Further requirements captured the need for transparency often attributed as benefit of multiple criteria approaches (Geldermann et al., 2009), and validity. Both aspects are essential for communicating and defending IT evaluation results. Recent work presented empirically validated measurement constructs in particular for IT governance purposes (Edward W. N. Bernroider, 2008). Pure black box model approaches were explicitly mentioned as not desirable. Results should not be static but support problem solving by exploring possible causes to problematic evaluations. Finally, many different stakeholders with different roles, responsibilities and interests should be explicitly captured and serviced by the framework, which is needed in socio-technical and socio-political perspectives (Connell & Young, 2007; Wilson & Howcroft, 2005). The importance of stakeholder inclusion is increasingly accepted in IT project evaluations (Peter B. Seddon, et al., 1998). The contextual element in the CCP framework explicitly asks about the *who* of IT evaluation (Stockdale & Standing, 2006). In public sector organizations special external stakeholders can be the general public or national government representatives. This requirement also includes the responsibilities and communication systems to be put in place.

4.2 Content

The content view and the question of what is being measured of the CCP structure exhibited a specific evaluation object, e.g., an enterprise information system or a service-oriented architecture and the appropriate „base model", which lends a structural foundation to the evaluation at hand. A crucial aspect in this design step is to reflect on completeness of dimensions while minimizing overlaps between dimensions. An important requirement is also independence between measures (in a statistical interpretation). Following our previous discussion, we chose to select the well validated and generic Delone and McLean Information Systems model to structure and prepare the evaluation problem for subsequent measurements.

4.3 Process

Measurement aspects and quantification methods

Based on the given project content and context different measures with appropriate techniques for quantification can be used in IT evaluation. We conducted a review of literature (e.g. Auer, 2004; W. H. DeLone & McLean, 1992; Kütz, 2003; Myers, Kappelman, & Prybutok, 1997; Nokes, 1978; Roldan & Leal, 2003; Schott, 1988; Scudder & Kucic, 1991; Sudzina, 2007) suggesting metrics in IT assessments, which we hardcoded into a relational database together with content and context information following our knowledge codification approach (Jashapara, 2004). This measure repository included a list of relevant measures for each available base model comprising a few hundred different measures. The majority of measures, however, focused either on technical performance or the financial value of IS, which we perceive as a deficit of prior research into IT evaluation. In order not to undervalue the more intangible side of benefit quantification, we also considered studies that specifically concentrated on those benefits in terms of IS (e.g. Chang & King, 2005; D. Sedera, et al., 2002). Through this comprehensive approach the measure repository offered a resourceful criteria list of validated metrics and items for the specific IT evaluation projects. Every measure was defined with a description, scale, several classifying elements such as the type of measure and connected with elementary methods to be used for quantification. Furthermore, each measure was related with according dimensions of base model structures. This allowed for a prescriptive suggestion of the measurement model followed by an empirical validation through questions directed at the decision maker considering appropriateness for the evaluation task such as feasibility of the suggested quantification method, and the history of prior selections.

Aggregation methods

Within the different dimensions of any chosen model, suitable methods were needed to support the aggregation of single measurements into aggregated measures per dimension. For our case, the Delone and McLean model uses six different dimensions, e.g. information quality, as seen in Fig. 1. Subsequently, these dimensions can be further consolidated by another aggregation and evaluation step where the decision maker or user can include preferences. In order to support practicability we sought to hardcode the aggregation mechanism during design time. Thus, the given approach does not delegate the task of selecting the aggregation technique to the practitioner. A single dimensional evaluation function aggregates all dimensions of the used base model into a final one. Metric and non metric scales were treated separately (thereby avoiding the many problems and mistakes made with scale transformations). This aggregation step was supported with the Analytic Hierarchy Process (AHP) as well as with quantifiable causal relationships given by the base model. The underlying AHP structure was given by the structure of base model and the selected measures. The user can introduce preferences and can aggregate the model from different angles, e.g., only benefits, only quality aspect, costs, etc. With this aggregation the user can make conclusions based on a simpler representation of the data. However, a limitation is that aggregation leads to information losses and bias. The user can explore this matter or weaken the consequences by utilizing sensitivity analyses proposed by the process model. The type of results depend completely on the manifestation of the framework, e.g. on the chosen aggregation method or even just on the used base model and according measures with elementary quantification methods. Through this design the framework is desired to be generic enough to be applicable to a wide range of IT artifacts while still allowing the user to embrace specific methods and techniques. In the end, the user may only receive a single value or a vector consisting of multiple values, a ranking or a list of superior alternatives. If the aggregation is not fully committed, a final multi dimensional value would result. The user can, however, receive support from decision theory to tackle this issue. This support comprises ordering based on preference relations, selection methods for multi-dimensional decision problems, etc.

5 FRAMEWORK APPLICATION

5.1 Context

The process model was triggered with defining the problem, the stakeholders, and the specific external and internal goal models in the context of IT evaluation. *Stakeholders* are all relevant persons

and roles with stakes in or expected benefits from the ERP project. In the given case, roles and responsibilities to be assessed and tied to elements of the evaluation content comprised initiators, decision makers, evaluators and experts, users, and interested parties. Initiators were responsible for bringing the framework to an organization and defining major components of the system to be stable over several uses. Decision makers used the framework for single valuation tasks. Evaluators and experts assisted the decision maker in using advanced methods or in aggregation tasks. Users supplied information via the methods and interested parties represent diverse stakeholders. As the organizational context also inquires about the *why*, it specifies the reasons for the evaluation which in the framework were included in a goal model. The goal model was derived from the problem statement and also included assumptions related to the scope of the investment elements (hardware, software, IT service organization). Finally, the *when* is of crucial importance, and related to whether an ex-ante or ex-post evaluation is the current focus. In this case an ex-post analyses of the ERP investment was undertaken. Naturally, the context of the evaluation changes constantly, which potentially influences the properties of the content and process views of the evaluation.

5.2 Content and Process

ERP measurement model and methods

The test case refers to an Enterprise Resource Planning (ERP) project. We briefly define ERP as process-oriented systems that integrate the planning, management and use of all of an organization's resources (Rainer & Turban, 2009) and refer to additional literature for more information. The prescriptive suggestion of the ERP measurement model is grounded on the previously verified sources and was retrieved from the developed measure and method repository. However, the decision maker had the freedom to adapt the model considering adequacy, accuracy, actuality, achievability, simplicity und auditability of measurement items. Missing evaluation aspects at this stage could still be introduced into the model. The final set of measures for the ERP instance structured according to the Delone and McLean base model together with supporting information are shown in Table 3. The next step involved quantifying each given dimension with appropriate methods. This complex quantification process was conducted by a multi-method approach thereby following the recommendation that a reliance on a sole technique may lead to sub-optimization or even failure in IT evaluation (Milis & Mercken, 2004). Besides using multiple methods, we also used multiple sources in our approach which in our view is more accurate than single data sources used in other studies. Items were assessed based on the needed information either through documentation such as system logs, interviews with experts and users, or the IT user survey. Appendix 2 gives more details for the measurement model in terms of data sources and quantification results with supplementary supporting references. The experts and evaluators worked in cooperation with our research team to quantify each element supported by the associated method and its description, which included the how and who attributes of evaluation to arrive at, e.g., mean time between failures (e.g. Kütz, 2003) and discounted cash flow (e.g. Romney & Steinbart, 2009) calculations. For example, to assess the first measure in the list, system availability, we refer to the probability that the system is operating at a given time (Der Kiureghian, Ditlevsen, & Song, 2007; Kütz, 2003), which we calculated from historic data based on down times provided by the SAP system referring to a two year period (2005-6).

Relating to the survey method, each dimension was designed as a reflective multi-item construct, which is deemed more accurate than single item assessments. We computed composite scores for each latent survey item by equally weighting and averaging the sub-item scores, which was shown to be optimal compared against weighted summated scores (McDonald, 1997). Main directions for scale design comprised the original work from Delone and McLean (W. D. DeLone & McLean, 2003; W. H. DeLone & McLean, 1992) which also provides a comprehensive overview of empirical measures, and follow-up work validation or consolidation around the Delone and McLean model (Myers, et al., 1997; Roldan & Leal, 2003; Darshana Sedera & Gable, 2004). Additionally, the design was supported by the behavioral model of executive information systems (EIS) use (Bergeron, Raymond, Rivard, & Gara, 1995), a seminal article on information criteria for information quality (Zmud, 1978), and work in the context of Decision Support System (DSS), which helped to understand user satisfaction (Sanders & Courtney, 1985).

Dimensions	Metrics
System Quality	System availability, average response time, error rate, mean time between failures, mean duration between maintenance runs, system support, ease of learning, efficiency of the system
Information Quality	Information relevance, information usefulness, information adaptability, information completeness, information validity, information legibility, information comprehensibility
Service Quality	IT service coverage, system maintenance coverage, support costs per user, mean time between repairs, mean response time of the IT-department, quality of external consultants used, competence of IT department, quality of training courses
Intention to Use/Use	Usage of the system, motivation to use the system
User Satisfaction	Overall system satisfaction
Net Benefits	Discounted cash flow (DCF) or extended DCF, turn-around times, legacy system replacement, adherence to laws, internal communication, decision quality, external business relations, business service quality, process quality, strategic benefits

Table 3: Classification of ERP metrics according to the D&M base model

Aggregation and selection

The evaluation initiator not the decision maker defined the necessary parameters in particular weights for aggregating measures within dimensions. The definition of weights for aggregation was supported by experts with an AHP method while the search for measures was driven by the Delphi approach. We suggested rules for the level of aggregation of measures to avoid aggregation with inconsistent scales of measurements. The approach distinguished between qualitative and quantitative measures resulting in a vector for each dimension with at least two elements. Based on this result, the user can trigger subsequent selection functions that take these vectors into account. The diversity of measures clearly showed the problem with non-uniform scales, which can be in principal tackled with scale transformations, e.g., as suggested by popular utility ranking techniques (Zangemeister, 1976). Some methods seek to gain a uniform target scale to allow the application of mathematical operations. In our case we operated with two different scaled groups of measures and did not attempt to engage in full scale transformations. In terms of the net benefits dimension, we finally arrived at two remaining measures (a first set and DCF for two different scenarios). Management suggested that retaining the meaning of DCF is more important than an overall aggregation. All other measures in set one were aggregated using weights calculated by the AHP in a weighted average method (see Table 4). It is important that the decision maker cannot change the aggregation weights offered by the framework which were derived from pre-coded expert valuation following the AHP suggestions in the design of the ERP framework instance under supervision of an initiator.

Level	D&M model dimension	No. of metrics	Aggregation results	Transformed
1	Information Quality*	7	2.10	Good
	System Quality*	8	2.13	Good
	Service Quality*	8	1.88	Good
2	Intention to Use / Use*	2	2.28	Good
	User Satisfaction*	1	2.53	Satisfactory
3	Net Benefits: Set 1*	9	2.03	Good
	and DCF	1	€ 18-151 mio	Very good

Table 4: Aggregated view on ERP assessment (with partial aggregation)

The further evaluation is left to the decision maker who can either directly work with these multi-dimensional outputs or attempt further aggregation. In this instance it was suggested to aggregate the three quality dimensions (System Quality, Information Quality and Service Quality) to receive one single value for the quality aspect of the ERP system. Furthermore, Use und User Satisfaction were consolidated into one value for the user perspective and the two-dimensional Net Benefits assessment was left unchanged. Consequently, the decision maker receives one value for the overall quality of the system, one for the IS user perspective and two for the Net Benefits. The latter consists of a qualitative-strategic and a financial effect (see Table 5).

Level	D&M model dimension	Aggregation results	Transformed
1	Quality*	1.98	Good
2	User*	2.34	Good
3	Net Benefits: Set 1*	2.03	Good
	and DCF	€ 18-151 mio	Very good

Table 5: Aggregated view on ERP assessment (with full aggregation)

A major aspect is the possibility to decompose the final construct to explore possible shortcomings or strengths within each dimension. This feature extends the usage of the framework into problem analysis, tracking and controlling applications. The decision maker is free to explore the individual aspects of each aggregated dimension.

5.3 Validation of the framework

Essential evaluation requirements established by IT management in our first exploratory research stage were general applicability and method flexibility. We therefore validated the framework in a much smaller Business Intelligence (BI) case study which related to an IT project with an investment value of EUR 680 thousand and a user base of 200. We used the established framework and methods and contacted 17 users to assess the user related constructs and achieved a return quota of 71%. Due to space considerations we have limited this section to highlight main similarities and differences only. For the new BI instance of the framework we reverted to the same DeLone and McLean model as base model for the framework. This model was of sufficient generality to be also applicable for BI evaluation. As it includes dimensions such as information quality which are of special importance for BI type investments, it was deemed well suited to also structure the second evaluation problem. The first major difference to the ERP case was the selection of suitable measures and methods for quantification of effects. The selected BI measures were different related to system-inherent factors (less technical measures were used) and information-related factors, especially measures related to cost of information gathering. Regarding aggregation the internal AHP process resulted in different

weight profiles for the dimensions. While Net Benefits were relatively less important in the BI case, both the quality and user dimensions in the framework became more important in comparison to the ERP evaluation. This reflects the importance of model parametrization and the value of the AHP approach to derive the adequate weightings for each IT evaluation type.

6 CONCLUSIONS AND DISCUSSION

The CCP approach proposed in this article makes a distinct contribution to IT evaluation literature because it provides an integrated and detailed extension to the original CCP perspective based on a large scale case study embracing and exploring known models and methods from operations research. We sought to apply different approaches to inform one another and thus lay the foundations for a more integrated analysis in IT evaluation. First, we developed empirical needs supported by views from literature to initiate the context of the evaluation project. Second, we introduced the DeLone and McLean IS success model (W. D. DeLone & McLean, 2003) model together with the IT artifact thereby providing the missing structure and content of IT evaluation. However, this structure alone provided no guidance on how to engage the evaluation process, which is also an early critique of the original Delone and McLean model (Myers, et al., 1997). We sought to resolve this issue with well designed and documented process related elements in a codified knowledge management approach, which included a repository augmenting the framework with established methods for quantification and aggregation. This step answered the need to explain how the evaluation should be conducted. All elements were situational, i.e., can be applied according to specific content and context. We argued that if certain elements, e.g., certain methods or models, are applied in isolation, essential aspects of IS evaluation are either not or insufficiently considered (Milis & Mercken, 2004). Finally, we tested the framework approach for an ex-post ERP evaluation in our public administration.

Through our first initial exploratory field work into requirement analysis the lack of simple and pragmatic yet generic and plausible IT evaluation models and methods was found to be a major challenge to the Austrian Ministry of Finance. As expected single evaluation methods previously applied by the organization were reported to have provided only partial views on IT impacts and limited transparency not allowing needed analytical insights on how to control IT costs and benefits. The desire to engage more in IT evaluations related to post-implementation and ongoing operational use stages is a trend also observable in the private sector (H. Al-Yaseen, Eldabi, Paul, & El-Haddadeh, 2008). In our current times public sector organizations seem to be under increasing pressure to deliver IT audits and reviews supported by methodologically sound evaluations. Continuous learning to improve efficiency and effectiveness is only one aspect; accountability and control seem to be equally important.

The use of CCP views as an overarching approach to guide evaluation, helped to define and position evaluation elements such as methods and stakeholders, and proved to be useful for undertaking the evaluation following the developed requirements. It helped to acquire an understanding of what needs to be measured, why the evaluation is being applied, who is conducting it, how measurements are conducted and for what audience. The different views of CCP supported completeness and understanding of the complex activities and interactions needed in the evaluation.

It seems that an important added value of using operations research techniques for modeling and assessing lies in the combined strength of discovery of open questions as well as in finding closed-form solutions. The process of exploration strongly focused on multi-criteria and multi-stakeholder views, which seemed important to strengthen results. The application of multiple attributive decision making principles supported the needed comprehensiveness and flexibility to account for the different investment periods for the multiple stakeholders involved. The applied AHP approach was also used in other hybrid multi-criteria decision aids for IT assessments (e.g. Wang & Yang, 2007) and also in the context of this study proved to be a useful and accepted technique for consolidation and weight estimation.

The empirical illustration gave insights in terms of the how holistic IT evaluation could proceed and which results can be received. While the methodological elements of the method are straightforward, we see the major challenges in their linkages with stakeholders as well as with allocating sufficient resources in terms of managing the process and quantifying the results to overcome resistance and promote a change in evaluation practice. A further finding is the importance of understanding the content of the evaluation project before initiating the needed framework instance

determining the models and methods. The evaluation content is not only determined by the investment object but also strongly influenced by the time frame of the context (ex ante, ex post/review, continuous) and the individual reasons given by the stakeholders. Both aspects were identified as key requirements of the evaluation framework. We recognised this need by explicitly modeling a goal model but we can see great potential in building public IT evaluation taxonomies especially for different timed evaluations. Central cause and effect relationships were considered as valuable to reduce complexity while at the same time being able to better understand the underlying properties of results and control investment objectives as well as its leading and lagging indicators. Another recommendation from the case study is a systematic adaption of a content and context dependent knowledge codification strategy as applied in the framework approach to shift some complexity of IT evaluation into pre-defined framework specifications and repositories (Hansen, et al., 1999). A well defined knowledge management strategy would benefit scale in knowledge re-use and make evaluation results better comparable over time. Representatives of the case organization confirmed that the evaluation results were in line with their overall perception of IT impact in both cases (ERP and BI). Consequently, the PITAF method was endorsed by the Director General for Information Technology (DG-IT) at the Austrian Federal Ministry of Finance in 2008. In particular, it was stated that the method achieves a good balance between practice and theory, and supports transparent and reliable IT evaluation to the benefit of all major stakeholders (Promberger, Janko, & Ihle, 2008).

We targeted a generic framework that is sufficiently specific to be useful to evaluation practice. A needed further step is the incorporation of taxonomies of IT projects from literature or former evaluations. We therefore not only acknowledge Seddon's original argument that we need an appropriate diversity of IS effectiveness measures (Peter B. Seddon, et al., 1998) and not one pre-defined dependent measure, but also embrace structure with a suitable model taken from IS evaluation literature. In the given ERP case we found that the Delone and McLean IS success model dimensions were semantically and technically suitable for aggregating measures (W. D. DeLone & McLean, 2003). However, we would not simply suggest the applicability of this structure for evaluations targeting any other types of IT. Current literature on IT taxonomies such as the Benefits Evaluation Ladder (Farbey, et al., 1995) is quickly outdated due to the highly dynamic nature of IT and specific needs of certain industries. Contemporary approaches acknowledge the need for IT project specific modeling (Joshi & Pant, 2008). More work is needed to determine needed structures and parameters from positions in such taxonomies. This supports the choice of the underlying multidimensional structure, suitable evaluation methods, and the configuration of the apparent yet often ignored dynamic relationships. Future work will seek to extend the method, model and measure knowledge base and undertake further case study based iterations to revise and improve the used modular framework.

7 APPENDIX

No.	Interviewee	Type of session	Dates	Time (min)
1	Senior IT manager	Interview	17/10/2005	120
2	Senior IT manager	Interview	30/11/2005	80
3	External Senior IT manager	Interview	15/12/2005	45
4	Senior IT manager	Interview	15/12/2005	75
5	Senior IT manager	Interview	12/06/2006	100
6	External senior IT manager	Interview	28/7/2006	60
7	Senior IT manager	Workshop	29/9/2006	150
8	Senior IT manager	Workshop	13/10/2006	120

Senior IT management: Head of IT division, Austrian Ministry of Finance
External senior IT manager: Siemens Austria

Appendix 1: Interview and revision statistics (exploratory research stage)

Measures per model dimension		Quantification		
		Data source	Estimation[1]	Supplementary supporting references
System Quality				
SQ1	System availability	System log	1.00	(Der Kiureghian, Ditlevsen, & Song, 2007; Kütz, 2003; Myers et al., 1997; Nokes, 1978; Scudder & Kucic, 1991)
SQ2	Average response time	System log	2.00	
SQ3	Error rate	Expert-Interview	1,00	
SQ4	Mean time between failures	Expert-Interview	1,00	
SQ5	Mean time betw. maint. runs	Expert-Interview	1,00	
SQ6	System support	Survey (4 items)	2.98	(DeLone & McLean, 1992; Myers et al., 1997; Roldan & Leal, 2003; Sedera & Gable, 2004)
SQ7	Ease of learning	Survey (4 items)	2.66	
SQ8	Efficiency of the system	Survey (6 items)	2.48	
Information Quality				
IQ1	Information relevance	Survey (2 items)	2.09	(DeLone & McLean, 1992; Myers et al., 1997; Roldan & Leal, 2003; Sedera & Gable, 2004; Zmud, 1978)
IQ2	Information usefulness,	Survey (1 item)	1.94	
IQ3	Information adaptability	Survey (2 items)	2.60	
IQ4	Information completeness	Survey (2 items)	2.41	
IQ5	Information validity	Survey (2 items)	1.93	
IQ6	Information legibility	Survey (3 items)	2.32	
IQ7	Information comprehensibility	Survey (2 items)	1.82	
Service Quality				
EQ1	IT service coverage	Expert-Interview		(Kütz, 2003; Myers et al., 1997; Scudder & Kucic, 1991)
EQ2	System maintenance coverage	Expert-Interview	2.00	
EQ3	Support costs per user	Expert-Interview	2.00	
EQ4	Mean time between repairs	Expert-Interview	1.00	
EQ5	Mean response time of the IT-department	Expert-Interview	2.00	
EQ6	Quality of external consultants	Expert-Interview	2.37	
EQ7	Competence of IT department	Survey (6 items)	2.10	(Bergeron, Raymond, Rivard, & Gara, 1995; DeLone & McLean, 2003)
EQ8	Quality of training courses	Survey (6 items)	2.27	
Intention to Use/Use				
US1	Usage of the system	Expert-Interview	2.00	(DeLone & McLean, 1992; Myers et al., 1997; Roldan & Leal, 2003)
US2	Motivation to use the system	Survey (6 items)	2.38	
User Satisfaction				
SA1	Overall system satisfaction	Survey (6 items)	2.53	(Bergeron et al., 1995; DeLone & McLean, 1992; Myers et al., 1997; Sanders & Courtney, 1985)
Net Benefits				
NB1	Discounted cash flow (DCF)	Expert-Interviews	€18-151m	(Copeland & Weston, 1992)
NB2	Turn-around times	Expert-Interview	1.50	(Kütz, 2003; Myers et al., 1997)
NB3	Adherence to laws	Expert-Interview	2.00	
NB4	Legacy system replacement	Expert-Interview	1.00	
NB5	Internal communication	Survey (5 items)	2.59	(Bergeron et al., 1995; DeLone & McLean, 2003; Myers et al., 1997; Roldan & Leal, 2003; Sedera & Gable, 2004)
NB6	Decision quality	Survey (5 items)	2.69	
NB7	External business relations	Survey (3 items)	3.43	
NB8	Business service quality	Survey (7 items)	2.49	
NB9	Process quality	Survey (4 items)	2.63	
NB10	Strategic benefits	Survey (6 items)	2.92	

[1] Scale transformation or direct measurement on five point scale from 1 (very positive) to 5 (very negative) with the exception of NB1
[2] Survey method based on 332 returned data sets; return quota = 33%

Appendix 2: Measurement model and estimation results for the ERP instance of PITAF

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