ASSESSING WORKFLOW MANAGEMENT SYSTEMS
A Quantitative Analysis of a Worfklow Evaluation Model

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Abstract: Despite the enormous interest in workflow management systems and their widespread adoption by industry, few research studies are available that empirically assess the effectiveness and acceptance of this technology. Our work exactly aims at providing such insights and this paper presents some of our preliminary quantitative findings. Using a theory-based workflow success model, we have studied the impact of operational workflow technologies on end-users in terms of perceived usefulness, end-user satisfaction and perceived organisational benefits. A survey instrument was used to gather a sample of 246 end-users from two different organizations. Our findings show that the considered workflow applications are generally accepted and positively evaluated. Using partial least squares analysis, the success model was well supported, making it a usefull instrument to evaluate future workflow projects.

1 INTRODUCTION

Workflow management systems (WfMSs) (or Business Process Management systems - BPMSs) have been important information systems to automate and increase the efficiency of business processes for almost two decades. A WfMS is essentially a set of tools enabling the modelling, enactment, and monitoring of business processes (Jablonski, 1996). Workflow functionalities have also been integrated in other contemporary enterprise systems such as ERP, and call-centre applications.

It is clear that a pervasive enterprise system such as a WfMS, often influencing the daily work of numerous employees, can only be successful if the targeted end-users accept the system and experience a performance growth in their jobs. If the workflow technology is not designed in a way that meets the needs of both the end-users and the management, the consequences might be dreadful, leading to the existence of shadow systems and a loss of productivity.

Despite this argument, only a few empirical studies on the usage and success of operational WfMSs exist. In this paper we present the first results of a quantitative evaluation of two workflow applications in different organisations.

In the next section we give a concise overview of the extant WFM research and of the literature on the acceptance and success of information systems. Next we present our workflow system's evaluation model. The model has been validated and analysed, using a sample of 237 end-users. After analysing the results, we discuss the conclusions and future research.

2 LITERATURE OVERVIEW

2.1 Workflow Literature

The existing literature on workflow systems can be subdivided into three research areas. A first research thread is technology-driven and deals with topics such as adaptive workflow systems and the

development of intelligent tools to support exception handling (see Weber, 2008; Casati et al., 1998).

Secondly and more recently, a number of studies have been conducted using process mining methods to measure the efficiency impact of workflow systems on business process indicators such as lead and throughput time (Van der Aalst et al., 2007).

A third research thread concerns the usability, and usage of WfMSs. This field has so far received only limited attention. Some studies point to the negative impacts of a WfMS, while others report on succesful projects (see Kueng, 2004; Dourish, 2001; Bowers et al., 1995). However, as these studies are restricted to a explorative quantitative analysis of one case, a systematic comparison is hampered.

Exceptions are Reijers et al. (2007) and Poelmans (2002) who evaluated and compared several succesful workflow project in a qualitative and quantitative way (using a survey).

In the underlying study we put forward a theory-based, quantitative usability study that includes several workflow projects and divers end-users. In particular, we developed and validated an explanatory workflow evaluation model that can be applied to other workflow usability studies and even to other enterprise systems.

2.2 ICT Acceptance and Usability

The use, success, and acceptance of information systems have been investigated in an overwhelming amount of studies, using widespread research models such as the technology acceptance model (TAM, Davis, 1989), and Delone & Mclean's IS success model (henceforth ISS model) (Delone et al., 2003).

These models focus on the individual end-user and have been applied to assess a diversity of IT systems (like ERP systems, GSS systems, e-commerce systems, etc.) (E.g. Wu et al., 2005; Delone et al., 2004; Karahanna, 2002).

Whereas the TAM is particularly valid to predict future acceptance and voluntary usage of ICT, the ISS model focusses more on the evaluation of objective system and information characteristics that can enhance user satisfaction, perceived usefulness, and individual impacts of an information system (Wixom et al., 2005). The ISS model does not necessarily imply (future) usage as a dependent variable, so it can be used to evaluate both mandatory and voluntary use of information systems.

3 RESEARCH MODEL

Since WfMSs determine the collaboration of employees and often integrate other legacy systems, an individual employee has no real alternative but to use the system. Therefore, usage frequency should be considered as mandatory and has no added value as a success measure. In this view, we turned to the ISS model to develop our evaluation model.

Figure 1 presents the model that we used and validated to measure the acceptance and success of two workflow applications. The model uses three general concepts as measures of success: perceived usefulness, end-user satisfaction and, as an ultimate dependent variable, perceived organisational benefits.

In accordance with the ISS framework, our model presumes that if a WfMS does increase job performance (perceived usefulness), it will increase the end-user's satisfaction. Both measures will impact the employee's belief that the WfMS is suitable for the supported business process (as measured by organisational benefits).

While the three dependent variables are general indicators of the acceptance of a WfMS, information and system quality are multi-faceted constructs that include design characteristics of an IS. Including these more specific measures is useful to provide feedback to the designers or administrators of the WfMS.

Following the ISS literature, system quality refers to the quality of the software and hardware. It is a broad concept, including several facets such as the ease of use, reliability, flexibility and responsiveness of an IS (Delone et al., 2003). Information quality refers to the contents, timeliness and availability of the information that is provided by the WfMS. Based on our previous research and on interviews that we conducted in the projects; we contend that 'information quality', in the context of a WfMS, is not sufficient as an evaluation instrument. Typically, workflow technology is used by diverse types of employees, ranging from administration personnel to management and other kinds of end–users. As we noticed in previous workflow research, some end-users (mostly within administrative jobs), only use the WfMS as an application to register their tasks or to insert data that will be used by other employees along the business process. For those kinds of users, data entry facilities are even more important than getting information out of the system. Usually, a combination of both was required. As employees were assigned a case, they had to look up

information in the workflow system and complete it with new data. Therefore, we distinguish between 'input quality' and 'output quality'. As far as we know, this distinction has not been applied before.

In the past, end-user training and support (the ongoing efforts to help end-users who are working with the WfMS) have been defined as being a part of end-user satisfaction measures (see for instance Doll et al., 1988). We agree however, in accordance with the TAM and the ISS model, that training and support are only a means to increase the productivity and success of the workflow technology. Both factors are by no means a goal in itself and should therefore be considered as external factors that can influence the perceived system or information quality.

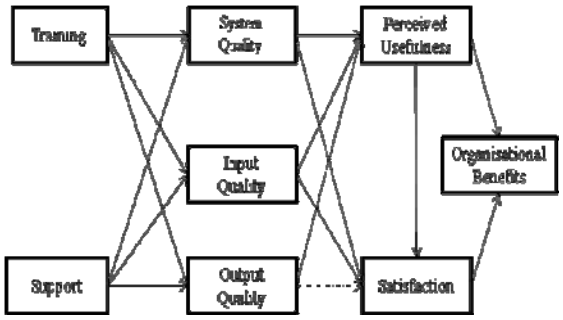

Figure 1: A Workflow Success Model.

4 RESEARCH METHODS

4.1 Sample and Data Collection

The sample that we tested in this study was collected using an online survey that we administered in the course of 2007 and 2008. The total sample consists of 246 end-users of two workflow projects in different organizations in Europe. Prior to the administration of the survey, some in-depth interviews were held with management or IT personnel. Both workflow applications have been used for several years. In the first organization, a workflow application was developed in the 'TIBCO BPM Suite' (formerly known as Staffware), in order to enact and monitor a communal invoice and order process. The business process has more than 450 end-users. 108 end-users filled out the survey. In the second organization, a workflow application was developed in the WfMS Flower. The application was used nation-wide (with more than 1200 end-users) to support a strictly regulated governmental process that deals with objection and appeal requests from citizens. At the moment of this writing we dispose of 138 responses.

4.2 Measures

Several items were used per construct. Where possible, we based ourselves on existing scales and adapted them if necessary. All items were measured on a 6-point likert-scale, ranging from 1 ('totally disagree' or 'not at all') to 6 ('totally agree' or 'almost always').

Satisfaction, Perceived Usefulness and Perceived Organisational Benefits. Perceived organisational benefits consist of two reflective items, asking the respondent whether the workflow application increases the efficiency of the business process in general.

Perceived usefulness is a concept that stems directly from the TAM. It measures the degree to which the workflow application enhances the employee's job performance and entails 4 reflective items.

Contrary to perceived usefulness, end-user satisfaction is not an instrumental concept, as it includes a more general attitude towards the IS. We used two items asking in a general way whether the employee was satisfied with the provided solution.

System Quality. System quality is a multi-faceted concept consisting of dimensions such as: the reliability, the flexibility, and the ease of use of the provided hardware and software solution (Delone et al., 2003).

Reliability was measured using 3 formative items. (E.g. Is the WfMS available if required? Does it crash? Does information get lost?)

Flexibility can be regarded as a general construct, measuring the way in which end-users can re-configure or adjust an operational IS if required. In the case of WfMSs, the routing of cases (through the business process) and the assignment (or allocation) of cases to end-users are two core workflow functionalities (see Joosten et al., 1994). If these features do not fit the tasks at hand or if they cannot easily be adapted, the resulting workflow application might indeed result in a bureaucratic despot. As a result, we measured workflow flexibility using two constituent constructs: Allocation and Routing Flexibility. In particular, we used 3 formative items for each construct. We asked respondent for instance, to what extent they could choose the cases they were going to process; to what extent the routing procedure (backward and forward

routing) was fixed and to what extent they could access cases of colleagues.

Ease of use was taken from the TAM and measured with 3 reflective items.

In our evaluation model, system quality was tested as a global second-order factor, but additional tests, using the constituent factors have also been performed.

Information Quality. As explained previously and contrary to the IS success literature, we splitted information quality into two disjoints factors: input and output quality.

Input quality is measured using 6 formative items; output quality is formed with 9 items. The items concern issues such as: the provided facilities to insert and retrieve information, and the degree to which information can be entered and retrieved in a complete, readable and timely way.

Training and Support. To measure training, we asked the participants to evaluate specific courses and workshops that had been organised to help future and novice users. Next we listed a number of support facilities (such as help desk, on-line documentation, etc.). The resulting evaluations were then used as formative items to measure support and training. The measures were based on 2 to 6 items, depending on the case at hand.

The questions can be received from the authors upon request.

4.3 Analysis Techniques

Next to descriptive statistics, and Anova, we used PLSGraph and thus partial least squares analysis (PLS) to test our explanatory model. PLS is less restrictive than covariance-based structural equation modelling like LISREL in terms of sample size and distributional requirements (Chin, 1989). PLS combines a structural model (i.e. paths between constructs) with a measurement model (i.e. the constructs with their items) and has become very popular in the past 10 years in multiple IS-related journals.

Convergent validity was evaluated by examining the factor loadings. With loadings of more than 0.7, our reflective items exceed the threshold level of 0.5 (Hair et al. 1992). Discriminant validity is achieved (i) when the items load much higher on their own latent variable, and (ii) when the square root of each construct's Average Variance Extracted is larger than its correlations with other constructs (Chin, 1998). In our sample both conditions are met. The relevant loadings can be given by the authors upon request.

5 FINDINGS AND DISCUSSION

5.1 General Results

The mean scores on all the factors are presented in table 1. System quality (SQ) is represented by its constituting factors (SQ1 to SQ5).

The mean scores on organisational benefits, usefulness and satisfaction vary between 3.87 and 4.20 (on a 6-point scale). This means that in general the end-users evaluate their workflow solution as (rather) good or satisfying.

For organisational benefits, satisfaction and usefulness, 74%, 72% and 62% of all the respondents gave a clear positive evaluation (>=4). These results confirm that the workflow solutions have been accepted in general.

We can also state that training and support was well provided and organised in a sufficient way, with 75% and 87% of the respondents giving a score of at least 4.

A first remark concerns perceived usefulness. Its score is still positive but significantly less than the scores on satisfaction and organisational benefits. Based on the interviews, we argue that the workflow systems have been improved over the years, leading to a satisfying and appropriate solution. Perceived usefulness however, appraises also the impact of the workflow application on an individual's job performance. We therefore contend that end-users were more critical regarding the impact on their own productivity, believing that the workflow could still be improved to support their daily individual needs.

Using Anova, table 1 also points to significant differences between the two projects, whereby the invoice & order application is better assessed than the occupation & appeal requests process.

The differences in the two cases occur not only in the first three general factors, but also in input quality and some factors of system quality. Interestingly, training and support have also received a different score. In the future, we will use additional factors (such as individual and task characteristics) and a more detailed analysis to explain the differences between the two projects.

5.2 Validation of the Success Model

In figure 2, we present the validation of the workflow success model. Because of missing values,

Table 1: General Results.

Construct	Mean (n=246)	S.D.	Positive Scores (> = 4)	Mean Case1 (n=108)	Mean Case2 (n=133)
Org. Benefits	4.20	1.21	181 (74%)	4.44	3.96*
Satisfaction	4.14	1.11	177 (72%)	4.24	3.84*
Usefulness	3.87	1.20	152 (62%)	4.51	3.56*
Ease of Use (SQ1)	3.96	1.11	152 (62%)	4.33	3.62*
Responsiveness (SQ2)	3.56	0.69	152 (62%)	3.48	3.62
Reliability (SQ3)	4.24	1.04	160 (65%)	4.44	4.07*
Routing Flexibility (SQ4)	4.25	1.22	156 (63%)	4.27	4.22
Allocation Flexibility (SQ5)	4.75	1.03	203 (83%)	4.98	4.56*
Input Quality	3.95	1.03	136 (55%)	4.06	3.77*
Output Quality	4.16	1.11	162 (66%)	4.30	4.23
Training[1]	4.11	0.98	183 (75%)	4.26	3.97*
Support[2]	4.33	1.08	214 (87%)	4.62	4.22*

*: significant difference (Anova-test)
1: 237 respondents; 9 missing values; 2: 241 respondents; 5 missing values

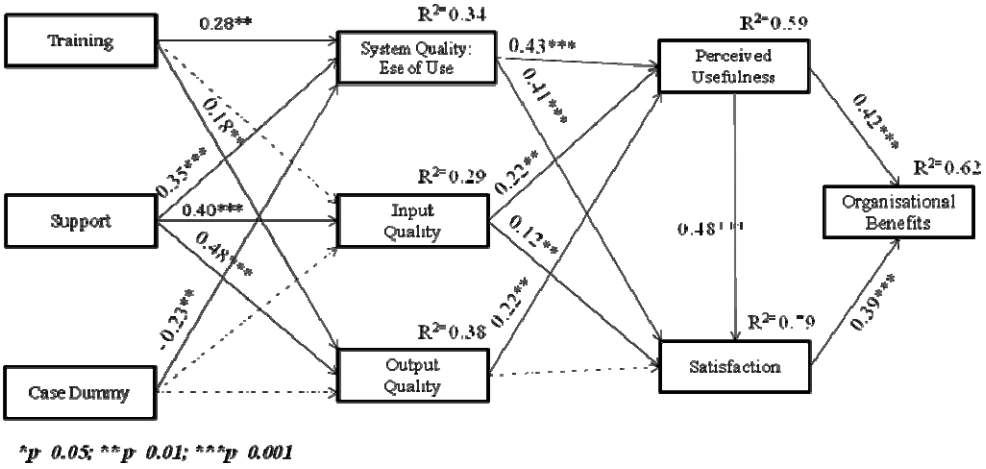

Figure 2: Model Validation, Using PLSGraph.

the entire model was tested with a sample of 237 end-users. Figure 2 shows that the three general success measures, organisational benefits, satisfaction and usefulness, have an R-square varying between 60 and 80%, indicating that these factors are well explained by the model. Perceived usefulness strongly influences satisfaction, and both variables are strong predictors of organisational benefits. System quality is the best predictor of usefulness and satisfaction. However, in figure 2, only ease of use represents system quality. Indeed, including the other factors - routing and allocation flexibility, and reliability – and thus using a second-order factor for system quality, did not improve the model.

Based on our knowledge of the two projects, we contend that by the time of our investigation, the two systems were mature and did not cause major technical disruptions..

Routing and allocation flexibility may have caused disorders when the systems were introduced, but by now, the routing and allocation features did fit the daily needs of the end-users.

However, as has been stated by Reijers (et al. 2007), there is no free lunch. To a certain extent, individual end-users had to perform some tasks in the interest of the organisation or business process as a whole. Examples of such tasks include the registration of data and activities, and following standard procedures (even if this is not always efficient for the individual end-user). Therefore it seems that end-users have different opinions and experiences regarding the efforts that are required to work with the system. As a result, ease of use

(measuring if the workflow is 'free of effort'), remains an important factor that should not be overlooked by management.

As explanatory factors, we used training and support. Although training is to some extent still an important factor, the relative importance of support is considerably higher. This result is not surprising. Because the WfMSs have been used for some years, most end-users are familiar with the system. Consequently, it is at present less relevant whether or not they received a good training to learn how to use the system. Support however refers to facilities (such as a help desk) that remain useful to support even experienced end-users in their day-to-day activities.

In order to account for project-specific factors that we did not measure, we added a case dummy to the evaluation model. The dummy indicates that the occupation & appeal process scores significantly lower on perceived ease of use.

6 CONCLUSIONS AND FUTURE RESEARCH

Workflow Management Systems (also known as Business Process Management systems) are systems that enable the modelling, enactment, and monitoring of business processes.

Although workflow systems may have a considerable impact on the way employees collaborate and perform their tasks, not much empirical research has been done on their usage and acceptance.

Existing empirical studies are scarce and in most cases limited to qualitative and single case studies that are difficult to compare.

The lack of systematic empirical studies on the effects of workflow systems may feed speculation. Whereas some researchers point to the risks of workflow systems that might behave like bureaucratic dictators, others have focused on the (potential) benefits and success of workflow technologies. To contribute to this debate we present in this study the first quantitative results of a systematic, end-user based evaluation of 2 workflow applications in different organisations. Based on the Delone & McLean's IS Success model, we developed a workflow evaluation model that is reusable for the assessment of other workflow applications or even other enterprise systems.

The study uses a sample of 248 end-users to analyse the evaluation model. One project concerns the support of a European communal invoice and order process (using the TIBCO BPM Suite); the other project entails the automation of a governmental objection and appeal request process (using Flower).

In particular, information and system quality are defined as multi-dimensional concepts that are supposed to impact end-users' satisfaction and the perceived usefulness of workflow systems. The ultimate success factor is defined as perceived organisational benefits. End-user training and support were entered as external factors. Multiple items were used per construct and scales from the literature were adapted or completed if required.

Next to descriptive statistics, we used PLSGraph and thus applied partial least squares (PLS) analysis to test our explanatory model. After having performed the necessary validity checks, we found that the proposed success model has considerable explanatory power.

In general the workflow systems are accepted and positively evaluated. Using a scale from 1 to 6, general measures such as perceived usefulness, satisfaction and perceived organisational have a score ranging between 3.87 and 4.22. A great majority of the end-users (varying between 62% and 74%) give a positive score (at least 4) on all the success measures.

In the future, we will add more workflow projects to increase our sample and to validate our current findings. Next, we will also focus on additional external factors such as task characteristics and individual traits. Finally, a task-technology fit analysis, testing for interaction effects between workflow flexibility and task and process characteristics, is a topic that deserves special attention.

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