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Business Processing Modeling Success: An Empirically Tested Measurement Model

Wasana Bandara
Queensland University of Technology

Guy Gable
Queensland University of Technology

Michael Rosemann
Queensland University of Technology

BUSINESS PROCESS MODELING SUCCESS: AN EMPIRICALLY TESTED MEASUREMENT MODEL

Alternative Approaches to Information Systems Development

Wasana Bandara
Queensland University of Technology
w.bandara@qut.edu.au

Guy Gable
Queensland University of Technology
g.gable@qut.edu.au

Michael Rosemann
Queensland University of Technology
m.rosemann@qut.edu.au

Abstract

The visualization of business processes in the form of process models has increased in popularity and importance. The resultant prevalence and magnitude of process modeling projects demand appropriate means of evaluating such initiatives. This paper presents a validated measurement model and instrument for assessing process modeling success. The final validated model employs 15 measures within the three dimensions:- Model Quality, Process Impacts, and Project Efficiency. The model was empirically tested with 290 responses to a global survey of process modelers. The overall study design consists of an exploratory model building phase (extensive literature review and multiple case studies) to identify salient success dimensions and measures, which was followed by an exploratory model testing phase. Test results evidence the discriminant validity of the model dimensions as well as their convergence on the single higher-order concept:- Process modeling success (PM-Success). Criterion validity testing further evidences the additivity of the three dimensions of success, and the completeness of the resultant overarching second-order measure of PM-Success.

The contributions from this work are twofold. From the perspective of practice, it offers a validated success model and measurement instrument that can be employed by organizations to measure the degree of success of completed process modeling projects. From an academic perspective, it presents a validated success measure, which can be used as the dependent variable in further research aimed at a better understanding of the important antecedents of process modeling success. Process modeling success can also be an important independent variable in research that aims to explore causal relations further along the Information Systems Development (ISD) cycle. In both research and practice, process modeling success benchmark scores can be valuable in comparative analyses across project types and project contexts, for highlighting process modeling related problems and issues deserving of attention, or best practices worthy of replication.

Keywords: Process modeling, survey method, success measures, construct validity, criterion validity

Introduction

Process modeling is an approach for visually depicting how businesses conduct their operations by defining the entities, activities, enablers, and further relationships along control flows (Curtis et al. 1992; Gill 1999). It is widely used to increase awareness and knowledge of business processes, and to deconstruct organizational complexity (Davenport, 1993; Hammer and Champy 1993; Smith and Fingar 2003). In this study, the term 'Business Process Modeling' encompasses all graphical representations of business processes and related elements such as data, resources, etc., as employed for diverse purposes including process documentation, process improvement, compliance, software implementation, or quality certification, among others. As such, process modeling has become a central task in the requirements specification of so-called Process-aware Information Systems, i.e., Information Systems with explicit knowledge about the process flow (e.g. workflow management systems or Enterprise Systems such as applications from SAP and Oracle).

The success or not of process modeling has become a critical concern, as its consequences can often be substantial, resulting in the implementation of new processes, organizational structures, and, subsequently, IT systems. Yet, little research has been conducted on process modeling practices, or on the post-hoc evaluation of process modeling projects. This study aims to address this knowledge gap, and the research question: *How can process modeling success best be measured?*

To our knowledge, this is the *first* published study that attempts to quantitatively measure the success of process modeling initiatives. The study unit-of-analysis is the 'process modeling project', which encompasses the models (the output) and the process of deriving the models. In the context of this study, the process modeling project is considered a success if it is *effective and efficient.* A process modeling project can be considered *effective* to the extent it fulfils its objectives. A process modeling project can be considered *efficient* to the extent that process modeling activities are completed with the allocated resources (such as time, effort, and budget).

The remainder of the paper will first present a brief literature review followed by the overall research design employed. Subsequently, the study findings are reported, and the paper concludes by summarizing the study contributions, limitations, and recommended follow-up.

Literature Review

Past studies have described and justified the use of process modeling at various stages of business and systems engineering. Process modeling is used for (1) model-based identification of shortcomings in a process, (2) adapting global practices in certain domains (e.g. SCOR, ITIL), (3) the design of a new business blueprint (as a form of documentation and communication), (4) the specification of the process view as part of an Information System, and (5) end-user training (Bartholomew 1999; Becker et al. 1997; Curtis et al. 1992; Gulla and Brasethvik 2000; Peristeras and Tarabanis 2000; Rosemann 2000). Information Systems (IS) success factor studies, especially those reporting on large-scale, multimillion dollar implementations such as Enterprise Systems projects, explicitly and implicitly suggest the importance of process modeling and its contribution to the success of these projects (Bancroft 1998; Clemons et al. 1995; Forsberg et al. 2000; Parr et al. 1999; Wreden 1998). Kesari et al. (2003) specifically state the advantages of process modeling in Information Systems projects and classify process modeling benefits into three main categories: (1) documentation benefits (a common language with clients, a means for basic communication, and having a flexible template), (2) design benefits (understanding the current business processes, generation of new possibilities and a means of planning for the project implementation), and (3) use benefits (visual representation of processes, supporting the iterative development process of systems, and time efficiency).

Most of the published work pertaining to process modeling describes new or extended process modeling techniques (see e.g. the papers at the annual ER, CAiSE or BPM conferences), describes the design of corresponding modeling tools (e.g. Scheer 1998), or describes the application of modeling languages (e.g. Rosemann and zur Mühlen 1997). Some articles provide descriptions in the form of case narratives based on reflective learning from past projects (e.g. Scheer et al. 2002). New streams of process modeling research, such as the use of reference process models, are now emerging (e.g. Fettke and Loos 2003; Rosemann and Chan 2000). One potentially relevant framework for the process modeling context is the Guidelines of Modeling (GoM) framework (Becker et al. 2000). It presents six dimensions of quality that can be used to evaluate a process model. However, this framework has not been operationalised or empirically tested. In summary, literature related to process modeling tends to focus on the intrinsic factors of process models (e.g. modeling techniques, model quality) and is less focused on the process of modeling and corresponding extrinsic factors which determine its successful application. Empirical studies on process modeling are scarce and, to the authors' best knowledge, there have been no studies that identify how to evaluate the overall success of a process modeling project. Addressing this gap has been the motivation for this study.

Research Design

The research problem, the search for an aggregate, higher-order process modeling success measure (following the definitions and processes presented by Law et al. 1998) was: *exploratory* in nature, conducted in an *area not researched before,* and the target *output was a measurement model*. There was little theory to guide the research process. A multi-method approach combining exploratory and model testing phases was followed, combining case study and survey methods (adapted from Gable 1994) in an attempt to address this gap. The process followed in the research design consistently applied the "theory of analyzing" as described by Gregor (2006).

First, an a-priori PM-Success model (henceforth referred to as PM-Success) was derived from the literature. The a-priori model was then adapted and extended through a multiple case study entailing nine case studies across three large Australian organizations. The resultant conceptual model constructs were then operationalised as a survey instrument designed to collect evidence to further validate the success model. The following sections briefly discuss each of the phases of this research design, prior to presenting the main findings of the study.

Deriving the A-Priori PM-Success Model

Success is a complex, multi-dimensional concept. Hence, having a correct and complete set of measurement dimensions is important (Garrity and Sanders 1998; Kanellis et al. 1999). Gable (1996) suggests that the employment of only one or a subset of the dimensions of success as a surrogate for overall success may be one of the reasons for mixed results reported in the literature regarding the antecedents of IS success (e.g. Barki and Hartwick 1989; Gatian 1994; Ginzberg 1981; Hawk and Aldag 1990; Ives and Olson 1984; Myers et al. 1998).

Due to the lack of any reported process modeling success studies, IS success frameworks were evaluated as a proxy, to identify candidate process modeling success dimensions (e.g. De Lone and Mclean 1992; Garrity and Sanders 1998; Goodhue 1992; Myers et al. 1998; Seddon 1997). Sedera et al. (2002) describe and justify the identification and adaptation of these success frameworks and extracted dimensions, relating them to the process modeling context. Five a-priori process modeling success dimensions were identified through this effort and were adopted in this study (see Table 1).

Table 1. Defining the A-priori Process Modeling Success Dimensions

Modeler Satisfaction: The extent to which the modelers (those who design the process models) believe process modeling fulfils the objectives that underlay the modeling project.
Process Model Quality: The extent to which all desirable properties of a model are fulfilled to satisfy the needs of the model users in an effective and efficient way.
Model Use: The extent to which the process models are applied and utilized.
User Satisfaction: The extent to which the model users believe process modeling fulfils the objectives that underlay the modeling project.
Process Modeling Impact: The effects of process modeling on the performance of the processes. Here, the 'process' refers to the processes to which process modeling is being applied.

*Adapted from Sedera et al. (2002).

Re-specifying the PM-Success Model - the Case Study Phase

The case study method was employed to further specify the a-priori model derived from the literature. The case study method emphasizes qualitative analysis. It is a scientific and recommended way to research an emerging area in which few previous studies have been conducted (Lee 1989; Yin 1994).

Case Study Design

A single pilot-case study and nine subsequent (a total of 10) case studies were conducted, with the primary goal being to instantiate the candidate success dimensions identified from the literature. In attention to several known potential weaknesses of the case study method (Benbasat et al. 1987), a case study protocol was designed, carefully documenting all procedures relating to the data collection and analysis phases of the study.

Qualitative data collection mechanisms including in-depth interviews and analysis of existing documentation were used to collect 'rich' descriptive evidence about the process modeling projects. Observations and documentation were used only to augment and corroborate interview data, which was the main input to data analysis. Whenever possible, interviews were conducted with multiple stakeholders in each process modeling project, namely the modelers and the project sponsors. The interviews were semi-structured, each completed within 60-90 minutes. All interviews followed the same structure and format (as pre-specified by the case protocol), commencing with an open discussion on perceived success dimensions of process modeling in relation to the selected project. Subsequently, the individual constructs of the a-priori model were introduced (for the first time), and the respondents' opinions on the overall relevance and importance of these constructs were sought. This approach enabled the researchers to obtain new ideas to enhance the model, while simultaneously validating a-priori constructs.

Reliability was enhanced through the use of the case protocol and a structured case database. All relevant data (interview transcripts, research memos, sample process models, documented modeling guidelines, etc.) were maintained in a 'case database' (Mile and Huberman 1994; Yin 1984). Close linkages between the research questions, evidence, interpretations, and conclusions were maintained throughout the analysis. The qualitative data analysis tool NVivo 2.0 was utilized during this phase to capture, code, and report the findings of the case study. Construct validity was strengthened within the study through the use of multiple sources of evidence, establishing a chain of evidence with a well-structured case database, and by having key informants review draft case study reports at the completion of data analysis at each case site. External validity, or extensibility of the findings, has been improved through the conduct of multiple cases studies.

About the Case Study Participants

Case studies were conducted on nine independent process modeling projects (the process modeling project is the unit of analysis) in three large Australian organizations, namely, Queensland Rail (QR) (four case studies), Queensland Treasury (QT) (one case study) and Telstra (four case studies). The pilot case study was not included in this analysis as its primary purpose was to assist in the derivation of the detailed protocol that was applied across the other case studies.

Queensland Rail is a Queensland State Government owned corporation that provides transport and logistics business solutions to a diverse range of customers throughout the State, Australia and overseas. Business process modeling is used within QR for a variety of purposes. Over a period of four months (Jul-Nov 2002), 18 interviews were conducted with modelers and project sponsors involved in four process modeling projects within QR. Over 30 project-related documents (e.g. project charters, business cases, modeling related procedures, project management documentation, etc.) were analyzed in detail. Queensland Treasury (QT) provides core economic and financial policy advice to the Queensland Government, and assists the government in managing the State's finances, including the preparation and oversight of the budget to meet community needs. Over a four-week period (Apr-May 2003), four detailed interviews and over 10 different types of documents were assessed in relation to a single detailed process modeling project at Queensland Treasury. Telstra is a semi-government telecommunications organization with a 100-year history of providing telecommunications services to the whole of Australia. Telstra competes in a very competitive global market, and is continuously revising its strategies and business processes. Small- and large-scale projects have been initiated within Telstra for the continuous improvement of its products and services. Process modeling has played a substantial role in many of these corporate initiatives. Four process modeling projects were analyzed over a period of two months (Jun-Aug 2003). Six key respondents were interviewed at 11 meetings, and a range of project related documents were analyzed in detail.

Summary of the Case Study Findings

Explicit or implicit counts are often reflected in qualitative analysis when judgments are made. For example, we "identify themes or patterns that happened a number of times and that consistently happen a specific way" (Miles and Huberman 1984, p. 215). Analysis of the case study data was conducted mainly by coding the data (through the use of NVivo 2.0), thereby yielding counts and data points that were then analyzed further.

A starting set of codes was defined ["Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study"; Miles and Huberman, (1984, p.55, 57)]; these codes were refined, as the analysis evolved. A tree-like node structure ("Nodes" are 'folders', within NVivo where one can store ideas and categories) was initially created within NVivo to depict the success dimensions of the a-priori model. The coding of the interview data was then conducted in three phases. Phase 1 coded any direct or implied existence of the constructs (of the a-priori model) within the data, simultaneously identifying any new constructs. Phase 2 analyzed the information already coded within phase 1 (extracting the information already coded under each of the constructs) to confirm the appropriateness with the categorization. Furthermore, the codes assigned to the data were refined to distinguish between citations that indicated mere existence of the constructs, versus those that specified the criticality of the construct. Phase 3 conducted in-vivo coding, i.e.,, a method of coding available through NVivo in which the selected document text becomes the title of a new node created to hold that text. Keywords are identified and allocated to each construct as a means of identifying potential sub-constructs (as input to the survey design process that was to follow).

Table 2 indicates general citations (each time the construct was merely mentioned) by interviewees (internal or external modeler, or project sponsor) within each of the nine modeling projects. The data from the individual case studies are presented in chronological order. The primary goal of this analysis was: (a) to evaluate the sufficiency of the set of model constructs, and (b) to evaluate the necessity of each model construct. When new constructs were identified through a case site, these were integrated in the protocol of subsequent cases. Since case study analysis was completed on a within-site basis (hence in three stages; corresponding to each case site), any new constructs that were identified within one site, were tested in case studies conducted at the next case site. Table 2 reflects nine success measures (S1-S9). S1-S5 are the starting five success measures of the a-priori model (previously introduced in Table 1) while S6-S9 are new success measures identified through the case studies.

In addition to analyzing the general citations (those depicted in Table 2) for each construct, we also analyzed those instances in which the construct was specifically stated as being important for a successful process modeling initiative (hereafter referred to as specific citations[1]) and conducted redundancy checks with 'matrix intersection and difference' searches using NVivo. A Matrix Intersection search is a two-dimensional type of Boolean search made available through NVivo. It takes the searched feature from two collections at a time, and finds passages in the documents or nodes, in which the search term is contained in both. Matrix Difference search, another type of NVivo Boolean search, takes one feature from each collection at a time, and finds passages in the documents or nodes having the feature from the first collection but not the second.

Redundancy checks enabled the researcher to identify possible instances where two or more constructs overlapped and when potential sub-constructs were incorrectly depicted as core constructs in the a-priori model. The tool's (NVivo 2.0) capacity to maintain a chain of evidence, with its provision to move back and forth from the summary matrices to the original transcripts and memo notes in the case database, aided the researchers to carefully analyze and justify modifications to the model, raised through these redundancy checks.

[1] Summary extractions of these specific citations are not presented separately as for the general citations (i.e., Table 2) in this paper due to space constraints, but are referred to within the text when deemed relevant and required.

Table 2: Summary Results of Coding the Case Study Data (chronologically presented)

Case site / Case study (CS)	SUCCESS DIMENSIONS								
	A Priori Constructs					New Constructs			
Respondent	S1	S2	S3	S4	S5	S6	S7	S8	S9
	Modeler satisfaction	Model quality	Model use	User satisfaction	Process modeling impact	Usefulness	Individual impact	Process impact	Others
STAGE 1: Queensland Rail (QR)									
CS1: Work request automation project: Technical Services Group (TSG)									
Internal Modeler 1	0	0	1	1	0				
CS2: Freight booking system project: Infrastructure Services Group (ISG)									
Internal Modeler 1	0	0	0	1	0				
CS3: Train control transition project : across Queensland Rail									
Internal Modeler 1	0	2	4	0	1				
Project Sponsors	0	0	3	0	0				
CS4: Rail Supply Chain Optimization (SCOR) Project: supply division									
Internal Modeler 1	1	1	2	0	1				
Project Sponsor	0	0	3	0	4				
OVERALL SITE analysis	1	3	13	2	6				
STAGE 2: Queensland Treasury (QT)									
CS5: K-economy project									
External Modeler 1	1	3	5	2		2	2	1	Achieved objectives - 3
External Modeler 2	0	5	4	1		2	1	0	Achieved objectives - 2
Internal Modeler	1	3	4	3		1	5	4	Achieved objectives - 1
Project Sponsor	1	3	2	1		5	0	6	Achieved objectives - 3
OVERALL SITE analysis	3	14	15	7		10	8	11	9
STAGE 3: Telstra Queensland									
CS6: IP Telephony Assurance project									
Internal Modeler 1	1	2	1	3		1	2	1	met purpose - 1
CS7: Interim Mini-Stats Ordering Project									
Internal Modeler 1	1	2	0	5		3	2	2	met purpose - 1
CS8: Payphone Faults Detection Project									
Internal Modeler 1	0	0	1	1		1	0	0	
CS9: Supplementary Worker Project									
Internal Modeler 1	0	0	0	2		0	2	0	
OVERALL SITE analysis	2	4	2	11	0	5	6	3	2
Consolidated TOTAL	6	21	30	20	6	15	14	14	N/A

Comparison of citations that merely mentioned a construct with instances that specifically stated its importance was used to justify the criticality or necessity of each construct. These 'specific' citations were analyzed in conjunction with the general citations and redundancy matrixes as further evidence when deciding the inclusion/ exclusion and merging of a-priori constructs for the re-specified model.

Re-specifying the Success Measures

Modeler Satisfaction (S1) was the least supported success dimension, with relatively fewer general citations. There were citations (three in total) that specifically denoted its 'irrelevance' as a success dimension; identified by analyzing the specific citations. Respondents referred to its potential for being biased, especially when respondents are modelers, and suggested it is unsuitable as a success dimension. Thus, it was removed from the modified model.

Both **Model Quality (S2)** and **User Satisfaction (S4)** constructs were supported by the case studies, always scoring a relatively higher number of general citations (Model Quality 21, User Satisfaction 20) and specific citations (Model Quality 7, User Satisfaction 13) discussing its importance. Thus, both Model Quality and User Satisfaction were included as success dimensions in the modified model. **Model Use (S3)** received the highest number of general citations (30 in total). However, very few respondents supported its relevance as a success dimension and they frequently commented on the difficulty of effectively measuring the 'level of model use', suggesting that it was not a suitable dimension for measuring process modeling success. Similar concerns with the 'use' construct are raised in the IS success literature. Seddon proposes 'usefulness' in place of use (Seddon 1997). Thus, **Usefulness (S6)** was added to the modified a-priori model for consideration in the subsequent case studies (after the Queensland Rail projects analysis was completed). It was also observed that the Use construct substantially overlapped with the new Usefulness, Individual Impacts and Process Impacts constructs (evident from a matrix intersection search).

Both Use and Usefulness were tested for in the subsequent case studies. There was a substantial number of citations on usefulness (15 in total from just five investigated process modeling projects; subsequent to the QR case study), but usefulness also showed substantial overlap with the impacts constructs, when an intersection search was conducted through NVivo. Thus, both Use and Usefulness were removed from the modified model. While it may seem inappropriate to remove Use and Usefulness, which had the most general citations, they were removed from the model due to the overlap they shared with each other and with the Impact(s) construct(s), and due to the vagueness of perceptions that was continuously observed in related quotes from the case study data.

Data analysis within the first case site (Queensland Rail) suggested decomposition of the a-priori **Process Modeling Impacts (S5)** construct into two separate constructs, namely, **Individual Impacts (S7)** and **Process Impacts (S8).** Individual Impacts refers to how process modeling has influenced the process stakeholders, those who have a role in the processes being modeled (e.g. involved end-users). Process Impacts refers to the overall effect of process modeling on the processes modeled (e.g. improvements achieved). This distinction was initially tested within the analysis of Queensland Treasury. This decomposition was further tested within the Telstra projects and was supported (most citations related to impacts were around the two main themes of impacts to individuals and impacts to the processes being modeled). Thus, the single a-priori 'Impacts' construct was replaced by 'Individual Impacts' and 'Process Impacts' in the modified model.

Other potentially useful success dimensions were carefully explored from the data collected on the case studies. The degree to which the modeling activities fulfilled their initial objectives and met intended goals was suggested as an important aspect at several points in the case studies. Citations often referred to the process modeling project's ability to maximize outcomes in relation to the invested resources. While this was considered important, it did not 'fit' within any of the existing success dimensions. Thus, a new dimension; **Project Efficiency** was later added to cater for this, and was defined as "the ratio of obtained outcomes over invested resources".

In summary, case study data analysis resulted in the following insights: (a) Modeler Satisfaction was removed from the model due to its potential for bias and its perceived lack of relevance as a success dimension; (b) The Model Use and Usefulness constructs were removed from the model because of perceived overlap with the other measurement constructs and their vague conceptualization as observed from the case study quotes; (c) two types of potential process modeling impacts were identified, process modeling impacts at the individual process stakeholder level (Individual Impacts) and process modeling impacts at the overall process level (Process Impacts); and (d) a new success measure, Project Efficiency, was identified and included in the model.

Operationalization of the PM-Success model

The next step was to operationalize the derived success model constructs for the purpose of a quantitative survey and subsequent statistical testing of model completeness and validity.

Zmud and Boynton (1991, p.154) state that *"one should never develop an instrument from scratch when a well-developed, or fairly well-developed instrument that fits the level of analysis and level of detail required by a particular research model already exists*". A comprehensive literature review was conducted in an attempt to identify all related past studies that had made any attempt to operationalize the identified success dimensions. Separate log books were maintained for each construct, each documenting (a) prior established definitions for the constructs, (b) a pool of items used to measure the construct, (c) implied or explicitly stated sub-constructs in relation to the main construct, (d) reliability and validity results if reported, (e) notes on the potential credibility of the measures based on where they were published (i.e., top tier journals versus conference proceedings) and a track record of which studies (or measures) were reused, and how many times.

The operationalization of the success dimensions for this study occurred in two main phases. The goal of the first phase was to identify all the relevant sub-constructs that pertained to each identified dimension. We consolidated the sub-constructs identified from the three separate case study sites and those gathered from the literature review for this process; the goal being to have a list of sub-constructs that were as complete as possible, in terms of describing the success dimension (construct). The second step was to derive survey questions (here after referred to as 'measures', 'questions' or 'items') for the constructs to match the identified sub-constructs. Thus, each construct was measured by multiple items, and all items were designed to be reflective in nature (following Edwards and Bagozzi 2000).

The entire collection of past studies was reviewed in search of the best potential measures. The selection process was based on documented evidence from the prior mentioned log books, which included an analysis of which item best suited the related construct; in other words which items best suited the definition of the constructs (adopted from Davis 1989, p. 323). When multiple items seemed fit for the same purpose, the choice was based on the reputation of the study in which the item was published (how many times has it been cited before, the quality of the source, reliability/ validity test results published, etc.). This process was conducted through a series of joint meetings with the three main researchers over a period of nine months. The overall results were presented to a group of experts in process modeling and another group of experts in survey instrument design. Their feedback was also incorporated into this process. Columns 3-5 of Appendix A summarize this effort, depicting the sub-constructs derived for each success measure, the final survey question, and the origin and rationale of each question. A total of 22 measures of process modeling success were included (together with three other criterion measures – 25 measures in total).

Designing the Survey Instrument

With the aim of an empirical investigation where data from a large number of globally distributed respondents can be collected through a questionnaire, a survey approach was used (following Gable 1994). The main data collection employed both Web- and paper-based instruments.

Prior success research has shown the importance of properly identifying the correct 'stakeholder(s)' and seeking the appropriate perspective(s) (Seddon et al. 1999). We adapted Seddon et al.'s (1999) framework for identifying relevant stakeholders and identified three main stakeholder groups in relation to process modeling; modelers, model users, and project sponsors. Modelers were those who worked as either an external consultant or as an internal member of the organization in the process modeling project and whose primary role was to design the process models. Model Users were defined as those who used, use, or will use the process models. Project Sponsors were defined as those who provide the necessary resources to commence and sustain the process modeling project (they often hold a senior management role in the organization).

This study targeted modelers, those who develop the process models. This was primarily based on feasibility, as they are the only cohort economically reachable globally. Also, given the unit of analysis of this study (process modeling projects, including the process and products), it was important that the stakeholder group targeted had exposure to both the process and the product. Thus, modelers seemed the most appropriate single target respondent group, as they are knowledgeable on details of the derivation of the models, and are also able to respond on the model-use phase (modelers who did not have this exposure were discouraged from participating).

While the actual survey instrument included additional questions, those specific questions that informed the findings reported herein are presented in Table A.1 of Appendix A. Respondents scored the items on a 7 point Likert-scale with the end values (1) strongly disagree and (7) strongly agree. A set of criterion variables to measure overall process modeling success were also incorporated in order to conduct a range of validity tests. The finalized survey instrument was pilot tested in three stages. Firstly, the research team requested that six candidate survey respondents complete the survey while 'thinking out loud'. Modifications were made to the instrument based on the feedback gathered. A second round of pilot testing targeting 100 candidate respondents was next conducted (using the paper based version); 19 responses were received from this phase, with only a few resultant minor changes to the layout and presentation. A third and final round of pilot testing was conducted prior to initiating the actual global data collection effort; 120 process modeling practitioners were contacted and 17 responses were received. These 17 responses were analyzed with exactly the same approach as for the second pilot testing round. The results evidenced the robustness of the survey design, as only very minor semantic and aesthetic changes (to the Web instrument) resulted.

Data Collection

Deriving a sample frame, representative of the population of interest is a critical aspect of survey research. However, due to the nature of the process modeler role, defining an appropriate sampling frame was a challenge. In order to gain a sufficient survey response, a combined judgmental and snowball sampling technique was applied, whereby a long list of modelers was identified through personal contacts. We also distributed the survey as a Web link through other means. Membership forums of professional societies and user communities with potential process modelers were targeted. (e.g. BPMG org, Australian Computer Society, New Zealand Computer Society), and a Web link was included within user group newsletters of leading process modeling tool vendors' who showed interest in supporting the study (i.e., IDS Scheer, Ultimus). Data was also gathered from several specialized Business Process Management (BPM) forums and conferences. The overall data collection phase extended over 6 months (from March 2004 to August 2004) until sufficient responses were collected (~300 was the target, we received 290 valid responses). Table 3 summarizes the origins of responses.

The responses were collated, cleansed and codified. All fields were mandatory, thus there were no missing values in any of the responses. Records were analyzed for perceived frivolous data and none identified. A total of 290 responses remained in the database after this initial cleaning phase.

Table 3: Summary of the Different sets of Respondents Gathered

Wave	Mode	Comments	
1	**Paper**	Responses from paper based surveys, distributed to pre-identified modelers. Data was collected nationally.	24
2	**Web**	Responses from those who were contacted from a potential-process-modelers database (which was derived by amalgamating each research-team members' personal contacts and contacts within their research centre databases). Data was collected globally, via the *Web version* of the instrument.	160
3	**Web**	Responses from advertising the study in related, specialized associations and forums. Data was collected globally via the *Web version* of the instrument.	106
		TOTAL	**290**

Findings

The purpose of the survey was to re-specify the success dimensions and measures derived as previously described (exploratory) and to validate the result (confirmatory). The success dimensions and measures were tested for validity and reliability as described following.

Construct Validity

The 22 measures of process modeling success were included in an exploratory factor analysis. An Oblimin rotation method was employed as the underlying constructs were posited to be correlated[2]. Correlations between factors were greater than 0.6 thus, justifying the Oblimin rotation technique (see Table A.2 of Appendix A) (Gorsuch, 1983). A Kaiser-Myere-Olkin Measure of .962 (>.6) and a Bartlett's test of sphericity with a significance level of .000 ($p < .05$) was reported, both justifying the appropriateness of Factor analysis (Tabachnick and Fidell, 2001). The ratio of subjects (290) to items (22) also satisfied various heuristics suggested in the literature[3].

Table 4 depicts results of this analysis (with loadings < 0.5 suppressed). The items naturally fell into a 3 factor solution (as supported by the scree plots and eigen values). Note that a single measure (PI2) was dropped from the original list due to it loading across multiple factors (didn't load above 0.5 on any factor).

Table 4: Exploratory Factor Solution – Oblimin Rotation

	Component		
	1	2	3
Q1M	.866		
MQ2	.904		
MQ3	.890		
MQ4	.752		
MQ5	.881		
MQ6	.856		
MQ7	.954		
MQ8	.868		
SAT1	.876		
SAT2	.873		
SAT3	.726		
II1	.841		
II2	.630		
II3	.782		
PI1		.883	
PI3		.646	
PI4		.914	
PI5		.775	
PE1			.609
PE2			.645
PE3			.681

While PI - Process Impacts items (Factor 2 of Table 4) and PE - Project Efficiency items (Factor 3 of Table 4] fell out as anticipated; Model Quality (MQ), Individual Impacts (II) and Satisfaction items (SAT) loaded together (Factor 1 of Table 4). These same results were observed from a variety of alternative factor analyses. This suggested the need to further investigate the relationships between the Model Quality, Individual Impacts and Satisfaction dimensions.

While many studies have used 'satisfaction' as a dependent variable, its appropriateness as a 'dimension' of success has been scrutinized in recent work (e.g. Gable et al. 2003; Khalifa and Liu 2004). Past studies [i.e., Rai et al. 2002; Teo and Wong 1998 and Gable et al. 2003] argue that most IS success studies that have used Satisfaction have mixed measures of multiple dimensions of success, rather than measuring satisfaction in isolation. Some studies suggest that Satisfaction is an overarching IS success dimension (Sedera and Tan 2005). This could explain the tendency for the Model Quality (MQ) and Individual Impacts (II) items to load with Satisfaction (SAT) (a similar argument is empirically tested and supported by Gable et al. 2003).

Based on these arguments, several exploratory factor analyses were conducted. First a 5 factor solution was forced (see Table 5A: with values below .3 suppressed). Though Individual Impact (II) items fell out separately as originally expected, Satisfaction (SAT) items continued to overlap with Model Quality (MQ) items.

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[2] The constructs were conceptualized as 'dimensions' of the same, overarching multidimensional concept – Process Modeling Success.

[3] For example, Nunnally (1978) recommends a 10:1 ratio between cases and items, while other widely cited sources such as Tabachnick and Fidell (2001) recommend a 5:1 ratio between cases and items.

Table 5A: Exploratory Factor Solution with forced 5 Factors Including all Success Items

	Component				
	1	2	3	4	5
MQ1	.443				-.439
MQ2	.425				-.387
MQ3	.519				
MQ4	.867				
MQ5	.457			-.426	
MQ6	.526				
MQ7	.516				-.397
MQ8	.560				-.334
SAT1					-.535
SAT2					-.607
SAT3					-.901
II1				-.754	
II2				-.904	
II3				-.797	
PI1		.862			
PI2		.488			
PI3		.687			
PI4		.966			
PI5		.715			
PE1			.876		
PE2			.972		
PE3			.950		

Table 5B: Exploratory Factor Solution with Forced 4 Factors after Removing Satisfaction Items

	Component			
	1	2	3	4
MQ1	.885			
MQ2	.821			
MQ3	.734			
MQ4	.834			
MQ5	.604			
MQ6	.800			
MQ7	.924			
MQ8	.906			
II1				-.693
II2				-.873
II3				-.745
PI1		.876		
PI3		.669		
PI4		.970		
PI5		.725		
PE1			-.849	
PE2			-.958	
PE3			-.922	

Next, all Satisfaction items were removed and a 4-factor solution was forced in order to see how the remaining items load. Employing Oblimin rotation, again PI2 was dropped, along with the Satisfaction items. Table 5B illustrates the resultant factor solution [all loadings above 0.6 – only one (MQ5) below 0.7 rounded]. All individual dimensions (MQ, II, PI and PE) have a Cronbach alpha of greater than 0.9.

Criterion Validity

Criterion validity has many different facets. In this study, notions of criterion validity was conducted to see whether the proposed dimensions of process modeling success correlated with the overall construct of process modeling success, which was measured by multiple measures. The survey instrument elicited criterion measures of overall process modeling success in response to the three statements: (a) Overall, the process modeling project was *successful (CV),* (b) Overall, the process modeling project was *efficient (Effi)* (c) Overall, the process modeling project was *effective (Effec).* (b) and (c) correlated strongly with the overall success criterion item (CV) (r=.77 and .91 respectively - see Table A.2 of Appendix A), offering some evidence of the goodness of the overall success criterion measure (CV) and suggesting that CV measures both efficiency and effectiveness. Two further variables were derived from the criterion measures; OF (which was the average of the Effi and Effec items) and FAC_O (which was the factor score of all three criterion variables - CV, Effi and Effec[4]). A dimension average (DA^{Four}) was also computed (the simple average of all 4 success dimensions). Table 6 illustrates that all derived criterion variables behave consistently; thus evidencing convergent validity[5] and further validating the overall success criterion item (CV).

Table 6: Correlations across Success Dimensions and Criterion Measures

Dimension	CV	Effi	Effec	OF	Fac_O
MQ	.781	.723	.797	.803	.816
II	.745	.622	.738	.728	.753
PI	.753	.633	.738	.726	.755
PE	.761	.838	.765	.845	.837
(DA^{Four}) Dimension average	.876	.812	.880	.894	.911

Henceforth employing CV as the main criterion variable, and assuming that the criterion measure is valid (adopted from Kerlinger, 1988), the extent to which each dimension or the dimensions average correlates with CV is evidence of the criterion validity (Kerlinger 1988) of the dimensions (a form of 'concurrent' criterion validity). All correlations were significant at <.001 level, suggesting strong correspondence between the criterion measures and the success dimensions (all dimensions correlated with CV with an r value > 0.7 see Table 6).

In order to test the convergent validity of the factor solutions reported in Tables 4 and 5B, and having saved the respective factor scores, 2nd-order factor analyses were next conducted for each of these two factor solutions. In both analyses, the factors loaded on a single, higher-order factor, which then correlated strongly with the criterion variable (CV) (at .878 - with the Oblimin 3 factor solution in Table 4, and at .876 -with the Oblimin forced 4 factor solution in Table 5B); all of which evidences the convergence of the model dimensions on a higher-order concept – Process Modeling Success.

In the interests of parsimony, we next explored the consequences of excluding one of the dimensions from the model. The obvious candidate for possible exclusion was Individual Impacts (II), it having overlapped substantially with MQ in Table 4, and it being the last factor extracted in Table 5B, explaining the least variance (4.24%) in that factor solution. Furthermore, the II items required that the modeler-respondents comment on how they thought the models had impacted those stakeholders who would use them[6]. In other words, the modeler-respondents were required to respond on behalf of these other stakeholders. This is perhaps why we observe confusion between the II and MQ loadings, with the modelers' scoring of II (something they are not close to) influenced by their perceptions of model quality (something they are close to).

In order to test the consequences of excluding Individual Impacts (II), we calculated a new Dimensions Average (DA^{Three}) from only the MQ, PI and PE dimensions. Correlating DA^{Three} with CV yielded a correlation of r=.87 (p<.001)[7]. On the basis of these results and of arguments presented earlier, and in the interests of parsimony, the Individual Impacts (II) dimension was excluded from the model.

As a final test of the relevance and additivity of the success dimensions, we next posited that each of the three dimensions explains a unique portion of the variance in overall success (as represented by the criterion item CV). To test this proposition, we regressed each of the three dimensions – MQ, PI and PE - on the variance remaining after having partialled out of overall success (CV) all variance explained by the other two dimensions. It is noted that in each case, the incremental r^2 was significant (p=0.001), thereby supporting our proposition. Note that this further

[4] These 3 items were included in an exploratory factor analysis. All three loaded on a single factor and the factor scores were saved as FAC_O

[5] Convergent validity is a kind of Construct validity test of whether those constructs that should be related are related.

[6] Definition and instructions for the Individual Impact items as it appeared in the survey→

Individual impacts refer to how process modeling has influenced the process stakeholders within your selected process modeling project.

Please respond from an overall perspective

[7] 2nd-order factor analysis of just these three dimensions again yielded a single factor solution, that 2nd-order factor too having a correlation with CV of r=.87 (p<.001).

supports our contention that the sum of the three dimensions yields a more comprehensive, overall measure of success, than does any subset the dimensions.

Summary

Correlation between Satisfaction and Model Quality was observed to be very high (the highest at 0.88, see Table A.2 of Appendix A) suggesting much overlap between these constructs. Given problems with Satisfaction and Model Quality items loading together in factor analysis, and given prior conceptions of satisfaction as an overarching measure of success rather than a dimension (e.g. Gable et al. 2003; Sedera and Tan 2005), Satisfaction was removed from the final model. Individual Impacts (II) was observed to overlap with Model Quality (MQ) and made only a minor incremental contribution to r^2 and thus too was removed from the final model.

Table 7: Final Process Modeling Success Measurement Items

	*[8]	**Question**	**Cronbach's alpha**
Model Quality	MQ1	The model users found the process models easy to use	.963
	MQ2	The process models met the model user requirements	
	MQ3	The process models accurately depicted the modeled processes	
	MQ4	The process models were easily modifiable	
	MQ5	Information available from the process models was important	
	MQ6	The process models provided relevant and complete information	
	MQ7	The process models were easy to understand	
	MQ8	The process models were concise	
Process Impacts	PI1	The process modeling resulted in cost effective processes	.914
	PI3	The process modeling helped to identify improvements to the quality of products and services resulting from the modeled processes	
	PI4	The process modeling helped to reduce the processing time of the modeled processes	
	PI5	The process modeling resulted in improved business processes	
Project Efficiency	PE1	The project was efficient in terms of the invested person days of effort	.950
	PE2	The project was efficient in terms of the overall project duration	
	PE3	The project was efficient in terms of the overall resources required	

The resulting final PM-Success model consists of the three constructs: Model Quality (MQ), Process Impacts (PI) and Project Efficiency (PE). Items for these dimensions load as expected[9], all three factors also converging on a single overarching measure of PM-Success in 2nd-order factor analysis. The final dimensions and measures are listed in Table 7.

*[8] Item ID used within this study

[9] This analysis was rerun after converting the data to normal distributions and no significant difference of the results presented above was observed.

Study Limitations and Follow on Research

This is the *first* study to empirically validate a process modeling success measurement model. No relevant, existing theory was identified. There were no extant, validated, quantitative instruments for measuring PM-success. The study drew heavily on referent domains to identify the initial set of candidate success dimensions and measures. These were trialed in a series of case studies, resulting in modifications to the model and measures. Analysis of the survey data revealed overlap between the Model Quality and Individual Impact dimensions; one possible explanation being that modelers have difficulty assessing the impact of their models on users. On this basis (and for other reasons outlined) it was decided to exclude the II dimension. Though the exclusion of II was found not to reduce the criterion validity of the remaining three dimensions (minimally reduced their power to predict the criterion measures), it must be acknowledged that the criterion items too were scored by the modelers. Thus while all of the study evidence suggests that the set of three final dimensions in the measurement model is largely complete and sufficient from a modeler's perspective (our view being that modelers are the best single stakeholder group for evaluating the goodness of both the process and products of modeling), follow on work should seek to gauge the perspectives of other stakeholders; study findings might be further tested through confirmatory analyses with multiple stakeholder input. Related future work would benefit from identification of underpinning theory on the relationship and nature of the proposed measurement dimensions.

Study Contributions and Conclusions

The increasing prevalence and magnitude of process modeling projects demand appropriate means for their evaluation. This paper presented a validated measurement model and instrument for assessing process modeling success. The final validated model employs 15 measures of the three dimensions: Model Quality, Process Impacts and Project Efficiency. The model was empirically tested with 290 responses to a global survey of process modelers. The overall study design consists of an exploratory model building phase – the trialing of analogous dimensions and measures from referent domains (from the literature) in a multiple case study – followed by an exploratory model testing phase. Test results evidence the discriminant validity of the model dimensions as well as their convergence on the single higher-order concept – Process modeling success (PM-success). Criterion validity testing further evidences the additivity of the three dimensions of success, and the completeness of the resultant overarching second-order measure of PM-success.

The contributions from this work are twofold. From the perspective of practice, it offers a validated PM-Success model and measurement instrument that can be employed by organizations to measure the degree of success of completed process modeling projects. From an academic perspective, it presents a validated process modeling success measure, which can be used as the dependent variable in further research aimed at better understanding the important factors of PM-success. PM-success can also be an important independent variable in research that aims to explore causal relations further along the Information Systems Development (ISD) process value chain. In both research and practice, PM-success benchmark scores can be valuable in comparative analyses across project types and project contexts, for highlighting process modeling related problems and issues deserving of attention, or best practices worthy of replication. This model complements the current body of knowledge in the area of process modeling, which tends to be focused on the intrinsic factors of models and modeling techniques.

References

Bailey, J. E. & Pearson, S. W. "Development of a Tool for Measuring and Analysing Computer User Satisfaction", *Management Science* (29:5), 1983, pp. 530-545.

Bancroft, N. H. "*Implementing SAP R/3: How to Introduce Large Systems into Large Organizations",* 2nd edition, Manning, Greenwich, 1998.

Bandara, W., Gable, G. G., & Rosemann, M.. Factors and measures of business process modelling: Model building through a multiple case study. *European Journal of Information Systems*, 14, 2005, pp. 347-360.

Barki, H. & Hartwick, J. "Rethinking the Concept of User Involvement", *MIS Quarterly* (13:1), March 1989, pp. 53-63.

Bartholomew, D. "Process is Back", *Industry Week*, Cleveland, 1999.

Becker, J., Rosemann, M. & Schütte, R. "Business to Business Process Integration: Functions and Methods", in *Proceedings of the Fifth European Conference on Information Systems (ECIS '97),* Ireland, Volume 2, 1997, pp. 816-827.

Becker, J., Rosemann, M. & von Uthmann, C. "Guidelines of Business process modeling, in Business Process Management: Models Techniques and Empirical Studies, van der Aalst, W., Sedel J. and Oberweis, A. (eds.), 2000, pp. 30-49, Springer-Verlag: Berlin et al.,

Benbasat, I., Goldstein, D.K. & Mead, M. "The Case Research Strategy in Studies of Information Systems", *MIS Quarterly* (11:3), 1987, pp. 369-86.

Clemons, E.K., Thatcher M.E., & Row, M.C. "Identifying Sources of Reengineering Failures: A Study of Behavioral Factors Contributing to Reengineering Risks", *Journal of Management Information Systems*, Armonk, Fall, 1995.

Curtis, B., Keller, M.I. & Over, J. "Process Modeling", *Communications of ACM* (35:9), September 1992.

Davenport, T. "Process Innovation: Reengineering Work Through Information Technology", Harvard Business School Press, 1993.

Davis, F. D. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology", *MIS Quarterly* (13:3), September 1998, pp. 319-340.

De Lone, W. H. & Mclean, E.R. "Information Systems Success: The Quest for the Dependent Variable", *Journal of Information Systems Research* (3:1), 1992, pp. 60-95.

Doll, W.J. & Torkzadeh, G. "The Measurement of End-User Computing Satisfaction", *MIS Quarterly*, June 1988, pp. 259-274.

Edwards, J.R. and Bagozzi, R.P. "On the Nature and Direction of Relationships between Constructs and Measures," *Psychological Methods*, 5, 2000, pp. 155-174.

Fettke, P. & Loos, P. (2003) "Classification of Reference Models - a Methodology and its Application", in *Information Systems and e-Business Management*, (1:1), 2003, pp. 35-53.

Forsberg, T., Rönne, G. & Vikström, J. (2000), "*Process Modeling in ERP projects - a discussion of potential benefits*", available at: http://www.processworld.com/content/22.doc, last accessed date 25 March 2001.

Gable, G.G. "Integrating Case Study and Survey Research Methods: An Example in Information Systems", *European Foundation of Information Systems* (3:2), 1994, pp. 112-126.

Gable, G.G. "A multidimensional Model of Client Success When Engaging External Consultants", *Management Science,* (42:8), 1996, pp. 1175-1198.

Gable, G.G., Sedera, D. & Chan, T. "Enterprise Systems Success: A Measurement Model", in *Proceedings of the 24th International Conference on Information Systems (ICIS),* 2003, pp. 576-590.

Garrity, E. J. & Sanders, G. L. "Dimensions of IS Success", *Information Systems Success Measurement*, Series in Information Technology Management, Idea Group Publishing, 1998, pp. 13-45.

Gatian, A. W. "Is User Satisfaction a Valid Measure of Systems Effectiveness", *Information and Management* (26:3), 1994, pp. 119-131.

Gill, P. J. "Application Development: Business Snapshot –Business Modeling Tools Help Companies Align Their Business and Technology Goals", *Information Week*, April, 1999.

Ginzberg, M. J. "Early Diagnosis of MIS Implementation Failure: Promising Results and Unanswered Questions", *Management Science* (27:4), 1981, pp. 459-478.

Gregor, S., "The Nature of Theory in Information Systems", MIS Quarterly, (30:3), September, 2006.

Goodhue, "User Evaluations of MIS Success: What are We Really Measuring?", Proceedings of the twenty fifth Hawaii International Conference of Information Systems,Vol IV, 1992, pp. 303-313.

Gorsuch, L. R. *Factor Analysis*, Lawrence Erlbaum Associates, Publishers, Hillsdale, 2nd Edition, 1983.

Gulla A.J. & Brasethvik, T. "On the Challenges of Business Modeling in Large-scale Reengineering Projects", in *Proceedings of the Fourth International Conference on Requirements Engineering*, Schaumburg, June 2000, pp. 17-26.

Hammer, M. & Champy, J.M. *Reengineering the Corporation: A Manifesto for Business Revolution*, Nicholas Brealey Publishing, Allen and Urwin, London, 1993.

Hawk, S.R. & Aldag, R. J. "Measurement Biasness in User Involvement Research", *Omega International Journal of Management Science* (18:6), 1990, pp. 605-613.

Ives, B. M. & Olson, M. H. "User Involvement and MIS Success: A Review of Research", *Management Science* (30:5), 1984, pp. 586-603.

Khalifa, M. & Liu, V. "The State of Research on Information Systems Satisfaction", *Journal of Information Technology Theory and Application (*5:4), 2004, pp. 37-49.

Kanellis, P., Lycett, M. & Paul, R. J. "An Interpretative Systems Success: From Concept to Practical Application", Information Systems Success Measurement, *Series in Information Technology Management*, Idea Group Publishing, 1998.

Kerliger, F. N. *Foundation of Behavioral Research*, Holt Rinehart and Winston, New York, 1988.

Kesari, M., Chang, S. & Seddon, P.B. "A Content Analysis of the Advantages and Disadvantages of Process Modeling", in *Proceedings of the Australasian Conference of Information Systems*, Lethbridge, N. (Ed.), Web Centre, School of Management and Information Systems, Edith Cowen University, Perth, Australia, 2003.

Law, K.S., Wong, C.-S., and Mobley, W.H. "Towards a Taxonomy of Multidimensional Constructs," Academy of Management Review (23:4) 1998, pp 741-755.

Lee, A. S. "A Scientific Methodology for MIS Case Studies", *MIS Quarterly*, March 1989, pp. 32-50.

Miles, M.B., Huberman, A.M. *Qualitative Data Analysis: A Source Book of New Methods*, Sage Publications, 1984.

Miller J. & Doyle, B. A. "Measuring the Effectiveness of Computer-based Information Systems in the Financial Services Sector", *MIS Quarterly* (11:1), 1987, pp. 106-124.

Myers, B. L., Kappelman, L. A. & Prybutok, V. R. "A Comprehensive Model for Assessing the Quality and Productivity of the Information Systems Function: Toward a Theory for Information Systems Assessment", in Information Systems Success Measurement, *Series in Information Technology Management*, Idea Group Publishing, 1998, pp. 94-121.

Nunnally, J. O. *Psychometric Theory*, New York, McGraw-Hill, 1978.

Palvia, "A Model and Instrument for Measuring Small Business User Satisfaction with Information Technology", *Information and Management* (31), 1996, pp. 151-163.

Parr, A. N., Shanks, G. & Darke, P. *Identification of Necessary Factors for Successful Implementation of ERP Systems in New Information Technologies and Theoretical Organizational Processes: Field Studies and Theoretical Reflections on the Future of Work*, IFIP Publications, 1999.

Peristeras, V. & Tarabanis, K. "Towards an Enterprise Architecture for Public Administration Using a Top-down Approach", *European Journal of Information Systems* (9), 2000, pp. 252-260.

Rai, A., Lang, S. S. & Welker, R. B. "Assessing the Validity of IS Success Models: an Empirical Test and Theoretical Analysis", *Information Systems Research* (13:1), 2002, pp. 50-69.

Rosemann, M. "Using Reference Models Within the Enterprise Resource Planning Life Cycle", *Australian Accounting Review* (3:22), November 2000, pp. 19-31.

Rosemann, M. & Chan, R. "Structuring and Modeling Knowledge in the Context of ERP", in *Proceedings of the 4th Pacific Asian Conference of Information Systems*, Hong Kong, 2000.

Rosemann, M. & zur Mühlen, M. "Evaluation of Workflow Management Systems - A Meta Model Approach", *Australian Journal of Information Systems* (6:1), 1997, pp. 103-116.

Scheer A.W. *ARIS -Business Process Modeling*, 2nd Edition. Springer-Verlag, Berlin et al., 1998.

Scheer A.W., Abolhassan, F., Jost, W. & Kirchmer, M. "Business Process Excellence: ARIS in Practice", Springer-Verlag, Berlin et al., 2002.

Seddon, P.B. "A Re-specification and Extension of the De Lone and Mclean Model of IS Success", *Information Systems Research*", (8:3), 1997, pp. 240-253.

Seddon, P.B., Staples, S., Patnayakuni, R. & Bowtell, M. "Dimensions of Information Systems Success", *Communications of the Association for Information Systems (CAIS) (*2:20), November 1999.

Seddon, P. "A Re-specification and Extension of the DeLone and Mclean Model of IS Success", *Information Systems Research* (8:3), September 1997.

Sedera, D. & Tan, F.T.C. "User Satisfaction: An Overarching Measure of Enterprise Systems Success", in *Proceedings of the Pacific Asian Conference on Information Systems (PACIS),* Bangkok, Thailand, 2005, pp. 963-976.

Sedera, W., Rosemann M., Gable, G., "Measuring Process Modeling Success". in *Proceedings of the tenth European Conference of Information Systems*, Gdansk, Poland, 2002, pp. 331-341.

Smith, H. & Fingar, P. "Business Process Management. The Third Wave", Meghan-Kiffer, 2003.

Tabachnick, B.G. & Fidell, L. S. *Using Multivaraint Statistics*, 4th Edition, New York: HarperCollins, 2001.

Wreden, N. "Model Business Processes", *Information Week*, September 1998, pp.1A-8A.

Yin, R. K. *Case Study Research Methods*, 2nd Edition, Sage Publications, 1994.

Zmud B., "Survey Measures and Instruments in MIS: Inventory an Appraisal", in *Information Systems Research Challenge: Survey Research* (3), Harvard Business School, Boston, 1991, pp. 149-180.

APPENDIX A

Table A.1: Survey Questions, Codes Used and their Origins

	Col 2	Col 3	Col 4	Col 5
Row #	**ID used**	**Actual Question**	**Related sub-constructs**	**Origin**
	Model Quality measures			
1	MQ1	* The model users found the process models easy to use	Ease of Use	Adapted from; Davis(1989) Doll and Torkzadeh (1998) Palvia (1996)
2	MQ2	* The process models met the model user requirements	Realization of user requirements	Case data and expert feedback /input
3	MQ3	* The process models accurately depicted the modeled processes	Information accuracy	Adapted from Doll and Torkzadeh (1998)
4	MQ4	* The process models were easily modifiable	Flexibility	Adapted from Doll and Torkzadeh (1998)
5	MQ5	* Information available from the process models was important	Information Relevance (a)	Adapted from Miller and Doyle (1987)
6	MQ6	* The process models provided relevant and complete information	Information Relevance (b)	Adapted from Miller and Doyle (1987)
7	MQ7	* The process models were easy to understand	Understandability	Adapted from Miller and Doyle (1987)
8	MQ8	* The process models were concise	Conciseness	Doll and Torkzadeh (1998)
	Satisfaction measures			
9	SAT1	* The model users were satisfied with the information conveyed by the process models	Information Satisfaction	Adapted from Palvia (1996)
10	SAT2	* The model users were satisfied with the graphical design of the process models	Satisfaction with model presentation	Adapted from Palvia (1996)
11	SAT3	* The model users enjoyed using the process models	Enjoyment	Adapted from Doll and Torkzadeh (1998)
	[10] *Individual Impacts measures*			
12	II1	* The process modeling facilitated learning about the modeled processes	Learning	Case data and expert feedback /input

[10] In search of suitable items to be adapted, 26 potential Individual Impacts items (e.g. Davis, 1989; Palvia, 1996; Doll and Torkzadeh, 1998) and 36 potential Process Impacts items (e.g. Palvia, 1996; Miller and Doyle, 1987; Doll and Torkzadeh, 1998; Bailey and Pearson, 1983) reported in IS studies were reviewed. None were found suitable for this study context, hence our resort to case study evidence and expert input (as discussed earlier) to derive measures ultimately employed.

NB: when posing these (II) questions, the target respondent group – modelers, were asked to respond with regard to how they felt the model users were impacted by the models.

13	II2	* The process modeling increased awareness of the importance of business processes	Information Awareness	Case data and expert feedback /input
14	II3	* The process modeling helped to identify problems and issues within the modeled processes	Problem Identification	Case data and expert feedback /input
	[12]*Process Impacts measures*			
15	PI1	* The process modeling resulted in cost effective processes	Cost effectiveness	Case data and expert feedback /input
16	PI2	* The process modeling improved our understanding of personnel requirements of the modeled processes	Staff management	Case data and expert feedback /input
17	PI3	* The process modeling helped to identify improvements to the quality of products and services resulting from the modeled processes	Increased product/ service quality	Case data and expert feedback /input
18	PI4	* The process modeling helped to reduce the processing time of the modeled processes	Reduced processing time	Case data and expert feedback /input
19	PI5	* The process modeling resulted in improved business processes	Improved business processes	Case data and expert feedback /input
	[11]*Project Efficiency measures*			
20	PE1	* The project was efficient in terms of the invested person days of effort	Man-day efficiency	Case data and expert feedback /input
21	PE2	* The project was efficient in terms of the overall project duration	Time efficiency	Case data and expert feedback /input
22	PE3	* The project was efficient in terms of the overall resources required	Efficiency in relation to other resources	Case data and expert feedback /input
	Criterion measures			
23	Effi	* Overall, the process modeling project was *efficient*	Efficiency	Case data and expert feedback /input
24	Effec	* Overall, the process modeling project was *effective*	Effectiveness	Case data and expert feedback /input
25	CV	* Overall, the process modeling project was *successful*	Overall Process Modeling Success	Case data and expert feedback /input

[11] This was a new construct that was identified through the case study phase, hence the final measures were derived from case data (which were validated through expert feedback and pilot testing).

TABLE A.2: Overall Correlation Matrix of Success Dimension Averages and Criterion Measures

	MQ	SAT	II	PI	PE	OF	FAC_O	Effi	Effec	CV
MQ	1.00	0.88	0.79	0.67	0.69	0.80	0.82	0.72	0.80	0.78
SAT		1.00	0.74	0.64	0.67	0.79	0.80	0.72	0.78	0.76
II			1.00	0.66	0.58	0.73	0.75	0.62	0.75	0.74
PI				1.00	0.63	0.73	0.75	0.63	0.74	0.75
PE					1.00	0.85	0.84	0.84	0.77	0.76
OF						1.00	0.99	0.94	0.95	0.89
FAC_O							1.00	0.90	0.96	0.95
Effi								1.00	0.79	0.77
Effec									1.00	0.91

* All values are significant at $p < 0.05$