



COVER SHEET

This is the author version of article published as:

Bandara, Wasana and Gable, Guy G. and Rosemann, Michael (2007) Critical success factors of business process modelling.

Copyright 2007 The Authors

Accessed from <http://eprints.qut.edu.au>

This is an early version of a paper that is to be submitted. An updated version will be loaded to QUT e_prints after acceptance notification.

TITLE:

‘Critical Success Factors of Business Process Modeling’

AUTHOR DETAILS:

Wasana Bandara, School of Information systems, Queensland University of Technology,
w.bandara@qut.edu.au

Guy Gable, School of Information systems, Queensland University of Technology,
g.gable@qut.edu.au

Michael Rosemann, School of Information systems, Queensland University of Technology,
m.rosemann@qut.edu.au

CRITICAL SUCCESS FACTORS OF BUSINESS PROCESS MODELING

Keywords: Process modeling, survey method, success factors, moderating variables

Introduction

Process modeling is an approach for codifying, visually depicting, analyzing and improving how businesses conduct their operations by defining the entities, activities, enablers and 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.

Organizations are increasingly reliant on process modeling, the consequences of which are often substantial and can result in the implementation of new processes, organizational structures, and subsequently IT systems. Concomitantly, the successful execution of process modeling initiatives is of increasing importance, yet there is a dearth of research reported on the post-hoc evaluation of process modeling project outcomes (e.g. Bandara et al, 2006), and even less on the critical success factors of process modeling projects. This study aims to address this knowledge gap, by seeking answers to the research question - *What are the antecedent factors of process Modeling success?* This research question can be further analysed by the following sub-questions:

- *How can these antecedent factors be operationalised?*
- *What is the relative importance of these antecedent factors for Process Modeling success?*
- *Are there any contextual variables that influence the effects of these antecedent factors?*
- *How may contextual variables influence the effects of these antecedent factors on success?*

The study unit-of-analysis is the 'process modeling project', encompassing both the models (the output) and the process of deriving the models. It is believed that this is the *first* published study to empirically and quantitatively measure and validate the antecedent factors of process modeling success.

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

Background

Past studies have described and justified the use of process modeling at various stages of business and systems engineering (Kesari et al., 2003). Process modeling is used for (1) model-based identification process deficiencies, (2) adapting global practices in specific domains (e.g. SCOR, ITIL), (3) the design of a new business blueprint (as a form of documentation and communication), (4) specification of the process-view 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), the design of corresponding modeling tools (e.g. Scheer 1998), or 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. Bandara et al. (2005) present a conceptual model of process modeling success factors and measures. Subsequently, Bandara et al. (2006) report results from empirical testing of the dependent variable in their model; the only known study to report an empirically tested model for process modeling success measurement. In summary, literature related to process modeling tends to focus on the specific factors of process models (e.g. modeling techniques, model quality), paying little attention to the overall process of modeling and corresponding factors which determine modeling success. Empirical studies on process modeling projects are scarce and, to the authors' best knowledge, there have been no studies that empirically identify and test those antecedent elements that should exist in a process modeling project. Addressing this gap has been the motivation for this study.

Research Methodology

This paper describes a study which entailed a search for success factors of process modeling projects, which was *exploratory* in nature, conducted in an *area not previously researched*. There was little theory to guide the research process. A multi-method approach involving a relatively more exploratory model building phase, and a relatively more confirmatory model testing phase was followed, combining case study and survey methods (adapted from Gable 1994).

This paper is based on a larger study which focused on both the independent and dependent variables of process modeling success where data gathered over a period of 4 years (from 2001 to 2004). Exhibit 1 depicts the main phases of this research and its progressive outcomes.

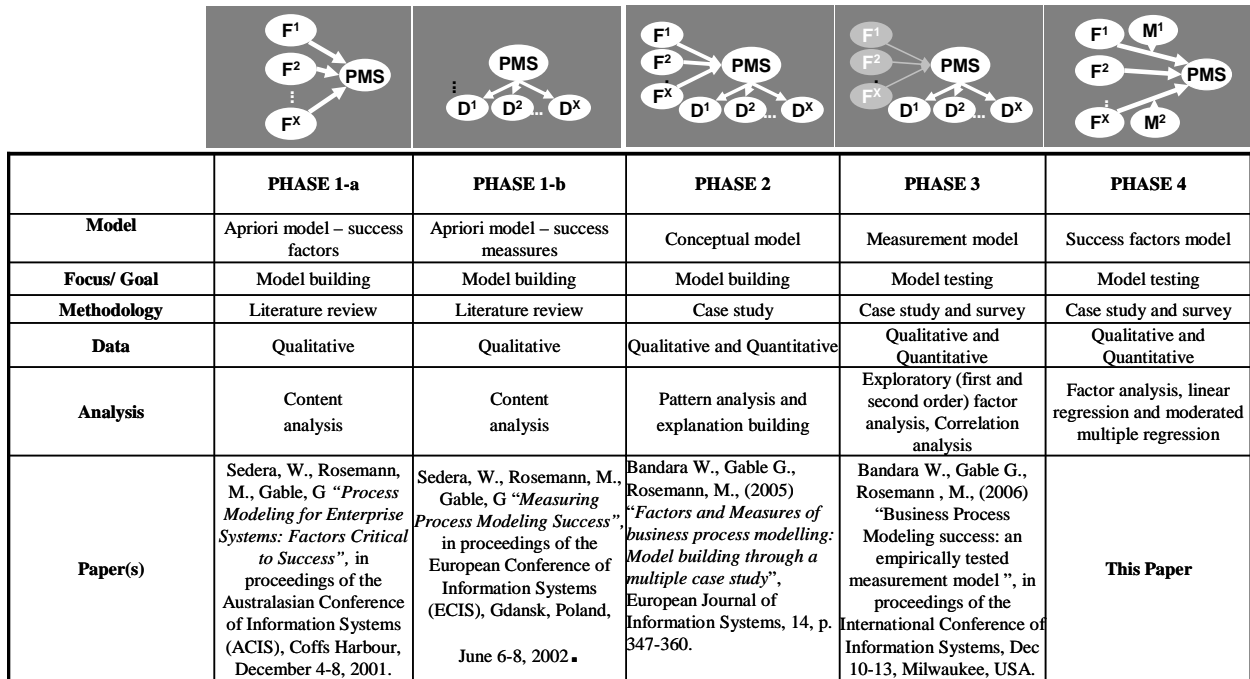


Exhibit 1: Progressive Study Outcomes of the Process Modeling Success Research

First, an apriori process modeling success factors model (henceforth referred to as PM-SFs) was derived from the literature (see Column 2- Phase 1a of Exhibit 1) followed by an apriori process modeling success measures model (henceforth referred to as PM Success; see Column 3- Phase 1b of Exhibit 1). The a-priori model was then adapted and extended through a multiple case study entailing 9 case studies across three large Australian organizations (see Column 4- Phase 2 of Exhibit 1). The resultant conceptual model constructs were then operationalised as a survey instrument employed to gather empirical data for model testing. First the dependent variable; PM-Success, was validated (see Column 5 - Phase 3 of Exhibit 1) which employed 15 measures within the 3 dimensions - Model Quality, Process Impacts and Project Efficiency. The model was empirically tested with 290 responses to a global survey of process modelers. 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 3 dimensions of success, and the completeness of the resultant overarching second-order measure of PM-Success.

The purpose of this paper is to validate the independent variables of the study. The following sections briefly describes the process of identifying, re-specifying and validating the independent variables of the Process Modeling success model.

Deriving the A-Priori Process Modeling Success Factors (PM-SFs) model

Critical success factors within the context of this research can be defined as those key areas where ‘things must go right’ in order for the process modeling initiative to proceed efficiently and complete successfully (following McNurlin & Sprague, 1989 p. 97). Due to the lack of theoretical and empirical evidence of process modeling critical success factors, a review of relevant literature was conducted, to identify those factors that were directly or indirectly suggested as important, as a tentative early start to identifying process modeling success factors.

Selecting Analogous Domains from Which to Identify Candidate Success Factors

The initial objective was to develop a list of candidate process modeling success factors that was as complete as possible. Given the dearth of directly related research to process modeling success factors, literature in several referent and analogous domains was reviewed: (a) software engineering success, (b) conceptual modeling success,

(c) information modeling (model quality), (d) Business Process Management (BPM) success, (e) Enterprise Systems (ES) success and (f) information system success.

Historical analysis of the emergence of process modeling suggests it originated from within the software engineering community (Curtis et al., 1992; Scheer, 1998b). The close link that process Modeling has with other conceptual modeling domains (such as data and object-oriented modeling) is evident, both within the literature and in the design of popular process modeling tools and practices (J. Becker et al., 1997; Levin, 1996; Scheer, 1998a, 1998b). Given the lack of theoretical or empirical evidence on process modeling critical success factors, a review of relevant literature within the traditional domains of software engineering and conceptual modeling was conducted.

A review of literature on ‘important elements’ of an information model (often under the banner of information-model quality) revealed that typically only ‘*quality*’ elements are described and not *success* factors (i.e. Lindland, Solvberg and Sindre, 1994; Moody 2005). The typical focus in these studies are on the general quality of the final *product* (the model) rather than overall *project* success (which is the unit of analysis of this study). However, the researcher perceived a substantial correspondence between these model-quality elements and potential success measures. Furthermore, means of achieving these model qualities were often described within the studies analyzed, these means were sometimes perceived as analogous to candidate process modeling success factors.

Factors influencing the effectiveness of a system (or a system development and supporting methodology) are difficult to separate clearly from external contextual factors (Kanellis et al., 1998; Smyth, 1999). Thus, with the objective of gaining insights to the external social elements influencing the evaluation of process modeling success, the literature that related to the specific *application areas* of process modeling was studied. The literature that specifically described how process modeling is applied within Business Process Re-engineering projects (e.g. Amoroso, 1998; Scheer, 1998a, 1998b), Enterprise Systems (ES) initiatives (e.g. Forsberg et al., 2000; Gulla & Brasethvik, 2000; Wreden, 1998) and general Information Systems projects (e.g. Curtis et al., 1992; Levin, 1996), were incorporated into this study. Thus, the domain areas of Business Process Management success, ES success and IS success studies were included in this review, in the search of a tentative list of success factors pertaining to process modeling.

Synthesized Extraction of Candidate Process Modeling Success Factors

Table 1 summarizes findings from review of the literature; cross-referencing originating studies with candidate factors that were specifically (S) identified as critical to success, and with those implied (I) to benefit the related initiative.

Study	Area / Domain	Candidate Process Modeling CSFs									
		Methodology	Tool	Language	Developer's expertise *	Team orientation	Project management	User participation	Top management support	User training	Project championship
		1	2	3	4	5	6	7	8	9	10
Raymond et al., (1995)	Business Process Management Success	I						I			
Grover et al, (1998)	Business Process Management Success		I				S			I	
Clemons, (1995)	Business Process Management Success	I	I				I	I	I		
Evans (1994)	Business Process Management Success							I			
Larsen and Myers (1998)	Business Process Management Success					S			S		
Murphy and Staples (1998)	Business Process Management Success	I	I				S		S		
Davenport (1993)	Business Process Management Success		S								
Kettinger and Teng (1997)	Business Process Management Success		S								
Carr and Johanson (1995)	Business Process Management Success		S								
Hammer and Champy (1993)	Business Process Management Success	S				S	S				
Amoroso (1998)	Business Process Management Success										
Smyth (1999)	Conceptual Modeling success		I								
Burkhard (1990)	Conceptual Modeling success	S					S	S	S	S	
Brash (1999)	Conceptual Modeling success							S			
Lindland et al. (1994)	Conceptual Modeling success		S	S				S	I		
Batini et al. (1985)	Conceptual Modeling success			I							
Bingi et al. (1999)	Enterprise Systems Success				I	I	I		S	S	
Sumner (1999)	Enterprise Systems Success					I			S	S	
Holland et al., (1999)	Enterprise Systems Success	I				S	S	S	S		
Constantinos (1999)	Enterprise Systems Success					S			S	I	S
Moody and Shanks (1997)	Information Modeling- quality						I	S			
Moody (1996)	Information Modeling- quality				S			S			
Krogstie et al (1995; 1995)	Information Modeling- quality										
Delone and Mc Lean (1992)	Information Systems success							S			
Bailey and Pearson (1983)	Information Systems success							S			
Ginzberg (1981)	Information Systems success							S			
Ives and Olson (1984)	Information Systems success							S			
Lucas (1981)	Information Systems success							S			
Lucas et al (1998)	Information Systems success							S			
Raymond (1995)	Information Systems success							S			
Fisher (2000)	Information Systems success							S			
Davis (1989)	Information Systems success							S			
Warne and Hart (1996)	Information Systems success								I		
Inchusta et al. (1998)	Information Systems success		I					S	S	S	
Srivihok (1999)	Information Systems success							S		I	
Rainer and Watson (1995)	Information Systems success							S			
Chuang and Shaw (2000)	Information Systems success				S	I	I		S		
Rosemann (1998)	Process Modeling		I	I			I	I			
Green and Rosemann (2000)	Process Modeling			S							
McClure (1979)	Software Engineering success		S		S	S			S		

S = factor was 'specifically' mentioned as critical to succes; I = factor was 'implied' to benefit the initiative

* Developer's expertise was extracted as an analogous to modeler expertise

Table 1: Cross Reference Literature Review of Candidate Process Modeling Critical Success Factors

Review of the literature identified 11 candidate success factors, namely: (1) Modeling Methodology, (2) Modeling Tool, (3) Modeling Language, (4) Modeler Expertise, (5) Modeling Team Orientation, (6) Project Management, (7) User Participation, (8) User Training, (9) Top Management Support, (10) Project Championship and (11) Communication.

Modeling Methodology is defined as a detailed set of instructions that describe and guide the process of modeling. It includes activities such as the definition of the model architecture, the modeling procedure, model lifecycle management and model quality assurance. In example, it should clearly define the modeling scope and the different levels of the model abstractions, and specify layout standards and naming conventions (e.g. Bancroft, 1998; Hammer & Champy, 1993; Rosemann, 1998).

Modeling Tool is the software application (e.g. ARIS, System Architect, ABC Flowcharter) that facilitates the design, maintenance and distribution of process models (e.g. Carr & Johannson, 1995; Davenport, 1993; Kettinger et al., 1997). The importance of a tool for process modeling derives from its ability to assist achieving the expected levels of model quality. In example, automatic syntax checks, consistency checks, integrated repository, layout placements, animations and filtering features that most modeling tools offer, aid in obtaining syntactic and pragmatic quality more efficiently (Curtis et al., 1992; Lindland et al., 1994).

Modeling Language is the grammar or the “syntactic rules” of the selected process modeling technique [e.g. Petri Nets, Event-driven Process Chains (e.g. J. Krogstie et al., 1995; J. Krogstie et al., 1995; Lindland et al., 1994).

Modeler Expertise describes the experience of the person conducting the modeling, in terms of conceptual modeling in general and process modeling in particular (Holland & Light, 1999; Lindland et al., 1994; Moody, 1996; Sumner, 1999). Ideally the Modelers should have *business knowledge* (understand the processes that are being modeled), *company-specific knowledge* (understand the individual issues pertaining to the process), *product knowledge* (understand the components and functionality of the software which will support the process), *technical knowledge* (understand how to apply the functionality of the selected tool within the existing system infrastructure and be able to interface with other systems), *project management knowledge* and *communication knowledge* (understand how to exchange ideas and communicate within the modeling team) (following Rosemann, 2000).

Modeling Team Orientation captures the 'infrastructure' that should exist in a successful process modeling team, such as an appropriate mix of internal and external members and representation from all core modeled processes (e.g. Bancroft, 1998; Hammer & Champy, 1993; Rosemann et al., 2000; Sumner, 1999).

Project Management refers to the formal definitions of the project scope, milestones and plans (e.g. Bancroft, 1998; Grover et al., 1998; Holland & Light, 1999; Murphy & Staples, 1998; Rosemann et al., 2000).

User Participation describes the degree (in terms of time and quality) of input from users (e.g. Brash, 1999; Burkhard, 1990; Holland & Light, 1999; Moody, 1996; Moody & Shanks, 1997). This input can be participation at modeling workshops or active process modeling. In the context of the a-priori model, ‘Users’ are defined as those involved with a business process, including process owners (those who overlook an entire process area in a company), and operational level employees who will use the process models derived from the process modeling project.

User Training describes how much knowledge was given to the users about the modeling tool and modeling procedures, so that they can understand the models, provide useful interpretations, and maintain the models after the project (e.g. Constantinos, 1999; Grover et al., 1998).

Top Management Support is the level of commitment by senior management in the organization to the process modeling project, in terms of their own involvement and the willingness to allocate necessary organizational resources (e.g. Holland & Light, 1999; Rosemann et al., 2000).

Project Championship (a.k.a Leadership) is the existence of a high level sponsor who has the power to steer the project, by setting goals and approving legitimate changes (e.g. Constantinos, 1999; Inchusta et al., 1998).

Communication describes the exchange of information (feedback and reviews) amongst the project team members and the analysis of feedback from users (e.g. Holland & Light, 1999; Murphy & Staples, 1998).

It was observed that these factors can be broadly grouped under two categories. Those success factors that are common to most projects such as (User participation, Top management support etc) were identified as ‘project

specific factors', and those that were specific to process modeling projects were identified as 'modeling specific factors'. With the above list of a priori factors; modeling methodology, modeling tool, and modeling language were classified as modeling specific factors while all others were treated as project specific factors.

Re-specifying the Process Modeling Success Factors (PM-SFs) 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 an accepted approach to researching an emerging area in which there has been little prior study (Lee 1989; Yin 1994).

Case Study Methodology

A single pilot-case study and 9 subsequent (a total of 10) case studies were conducted, with the primary goal of instantiating 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 multiple case 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 factors 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 9 independent process modeling projects (the process modeling project is the unit of analysis) in three large Australian organizations, namely - Queensland Rail (QR) (4 case studies), Queensland Treasury (QT) (1 case study) and Telstra (4 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 4 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 4-week period (Apr-May 2003), 4 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 eleven 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 9 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 (antecedent factors of process modeling success), and (b) to evaluate the necessity of each model construct. When new constructs were identified from a case site, these were integrated into the protocol of subsequent cases. Since case study analysis was completed on a within-site basis (hence in 3 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 16 antecedent success factors (F1-F16). F1-F11 are the starting eleven success factors of the a-priori model, while F12-F16 are new factors identified through the case studies. The column between the factors and measures (titled ‘Case/Project Respondent’) depicts the stakeholders who were interviewed within each project.

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-citations¹) and conducted redundancy checks with ‘matrix intersection and difference’ searches and proximity searches using NVivo. *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. A proximity search finds passages with specific features which are close to each other. NVivo has five different types of *Proximity searches*;

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.

Co-occurrence, Sequence, Inclusion, Matrix *Co-occurrence*, *Matrix Sequence* and *Matrix Inclusion*². A mixture of these was used based on the context of the constructs that were tested for (Bandara 2006).

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.

Comparison of citations that merely mentioned a construct (general-citations) with instances that specifically stated its importance (specific-citations) 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.

² [Co-occurrence](#) finds places where text referred to by the first item is near text referred to by the second item.

[Sequence](#) finds places where text referred to by the first item is before text referred to by the second item.

[Inclusion](#) finds places where text referred to by the first item surrounds text referred to by the second item.

[Matrix Co-occurrence](#) finds places where text referred to by items in the first group is pairwise near text referred to by items in the second group.

[Matrix Sequence](#) finds places where text referred to by items in the first group is pairwise before text referred to by items in the second group.

[Matrix Inclusion](#) finds places where text referred to by items in the first group pairwise surrounds text referred to by items in the second group (extracted from NVivo online help).

Table 2: Summary Case Study General-Citations (presented chronologically top-down)

A-Priori Factors											New Factors					
F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	Case / Project	F12	F13	F14	F15	F16
											Respondent					
Top mgmt Support	Leadership	Project mgmt	Team structure	User competence	Modeler expertise	User participation	Communication	Modeling language	Modeling method	Modeling tool		Need	Culture	Complexity	Importance	Information Resources
P1: Work request automation project: Technical Services Group (TSG)																
6	2	2	4	3	2	6	2	2	5	3	Internal Modeler	3		4		
P2: Freight booking system project: Infrastructure Services Group (ISG)																
6	2	2	2	2	4	6	1	0	2	4	Internal Modelers		3	2		
P3: Train control transition project : across Queensland Rail																
3	2	3	2	3	3	2	2	1	1	2	Internal Modeler					
3	8	2	4	1	7	7	6	0	3	5	Project sponsors					
P4: Rail Supply Chain Optimization (SCOR) Project: supply division																
2	0	4	1	1	2	2	3	2	1	2	Internal Modelers			1		
4	3	1	0	1	2	1	1	2	0	1	Project sponsor		1			
24	17	14	13	11	20	24	15	7	12	17	Queensland Rail	3	4	7	0	0
P1: K-economy project																
7	4	7	1	-	1	2	5	5	1	6	External Modeler 1		3	2	2	1
2	2	12	2	2	3	3	2	2	6	5	External Modeler 2		2	2	3	-
1	3	5	3	1	5	9	2	4	3	2	Internal Modeler 3		1	3	3	-
4	2	17	7	1	2	6	4	3	4	5	Project sponsor		1	5	-	-
14	11	41	13	4	11	20	13	14	14	18	Queensland Treasury	0	7	12	8	1
P1: IP Telephony Assurance project																
4	2	7	0	2	2	2	3	2	4	4	Internal Modeler1		2	2	1	9
P2: Interim Mini-Stats Ordering Project																
7	4	11	1	1	7	2	5	2	2	2	Internal Modeler1		2	2	2	12
P3: Payphone Faults Detection Project																
3	2	4	0	0	7	7	4	2	3	6	Internal Modeler1		1	5	2	8
P4: Supplementary Worker Project																
2	4	7	2	1	7	2	5	0	0	1	Internal Modeler1		0	0	0	6
16	12	29	3	4	23	13	17	6	9	13	Telstra Queensland	0	5	9	5	35
54	40	84	29	19	54	57	45	27	35	48	Total	3	16	28	13	36

Re-specifying the Success Factors

This section describes the overall construct re-specification process that occurred during the case study phase. Each construct was carefully revisited and most a-priori constructs were re-specified and redefined. Table 3 depicts the summary resulting constructs and their definitions.

Top Management Support (F1) was consistently cited across interviewees (Modelers and project sponsors), across projects, and across case sites. However, overlap was perceived across the case sites with other a-priori constructs such as Leadership. Detailed analysis of the interview data suggested that aspects of management support, such as funding and management participation, played a substantial role in successful modeling projects. Thus, Top Management Support was kept as a separate construct, and the overlap with other constructs was noted to guide subsequent construct operationalization.

Respondents too consistently cited Leadership (F2), arguing its relevance and importance as a success factor of process modeling projects. However, as suggested, there was substantial overlap with the data coded under Top Management Support (this became evident after a matrix intersection search through NVivo), respondents often referring to the ‘need to have support for the initiation of the

project' and 'support within the major decision making of the project'. Though Leadership was at times referred to as Management Support; the phrases coded under leadership simultaneously referred to other sub-constructs of Management Support such as availability of funding, resources etc. Consistent with the views of (Meade et al., and Colvard, 2003) it was concluded that Top Management Support is a multi-dimensional construct that should be included in the model, and that Leadership is a sub-construct of Top Management Support that relates to the participation and decision-making power shown by managerial staff on the process modeling project. Thus, Leadership was removed from the model and, to compensate for this, appropriate sub-constructs were included within the Top Management Support construct.

Project Management (F3) was the most cited success factor across all three case sites (a total of 84 general-citations). The multi-dimensional nature of the data became apparent, with different respondents referring to Project Management sub-constructs such as Scope and Objective Definitions, Quality Management, Knowledge Management, Time Management, and Communication Management. However, there was substantial overlap between Project Management and other constructs of the a-priori model (such as Team Structure and Communication). Following detailed analysis of this overlap, and considering those citations that specifically stated the importance of Project Management (a total of 20 specific-citations), Project Management remained in the model.

While the **Team Structure (F4)** construct was mentioned within the interview data, there were only two citations that specifically (specific-citations) stated its importance, these two also overlapping with the project management citations. Furthermore, this construct substantially overlapped with Communication. Given weak evidence of its separate existence, Team Structure was removed from the model. Similar to Team Structure, **User Competence (F5)** had relatively few general-citations (19) or specific-citations (6) suggesting its relatively lesser relevance as a success factor for process modeling. Consequently, it was removed from the model.

Modeler Expertise (F6) was consistently cited as an important element of success in process modeling (16 specific-citations), and remained. However, Modeler Expertise, overlapped with other constructs – e.g. Communication and Getting Information (Information Resources). This suggested a possible overlap with the Modeler Expertise sub-constructs, which included the 'required skills', 'knowledge' and 'experience' the Modeler ought to have in order to succeed in a process modeling project. The specific-citations (??) on Modeler Expertise convincingly evidenced its importance as a separate construct. Thus, it remained in the model and the other overlapping constructs were further analyzed with care.

User Participation (F7) had consistent supporting citations across all projects and perspectives, a strong indication of its importance as a success factor. However, the data suggested that respondents were referring to participation in general and more specifically to the participation of the process stakeholders, rather than the model users. Process stakeholders have a role in the processes being modeled and may or may not be model users, and hence this construct was redefined as **Stakeholder Participation**. It was also noted that Participation overlapped to some extent with Communication, and Getting Information (Information Resources) (evident after a matrix intersection search through NVivo). Data coded under each of these were reviewed carefully to remove these potential redundancy issues. Participation remained in the re-specified model, due to the relatively many specific-citations (19) of its importance.

While the importance of **Communication (F8)** was specifically mentioned several times (45 general-citations and 16 specific-citations), there seemed to be a high level of overlap with the data coded under other constructs, especially Participation and Modeler Expertise. A closer analysis of the Communication construct indicated that there were two types of communication processes within a modeling project: (a) Information sharing - communication among the modeling team members for sharing information, and (b) Feedback - communication between the Modelers and the users to confirm the correctness of the models. The content coded under 'Feedback' was identical to the intersection between Communication and User Participation. Thus, this segment was identified as a sub-construct of User Participation rather than a separate construct of its own.

Information Sharing was perceived to be an aspect that should be planned for and addressed within a good project management plan. Thus, this was included under Project Management. A matrix differences search conducted between Communication and the two re-located sub-constructs of Communication (Feedback and Information Sharing) supported the conclusion that the core aspects of communication are captured under Participation (the 'Feedback' sub-construct) and Project

Management (the 'Information Sharing' sub-construct). Hence, there was no need for a separate Communication construct in the re-specified model.

All three initial modeling specific constructs, the Modeling Tool (F11), the Modeling Technique (a.k.a. Modeling Language) (F9) and the Modeling Guidelines (a.k.a. Modeling methodology) (F10), remained in the model. Although these constructs all had citations in support of their relevance and s in a process modeling project, they all had fewer overall general-citations than the project specific factors Participation, Project Management, Modeler Expertise and Top Management Support (see Table 2 – last row). This may suggest the relatively greater importance of project specific factors within a process modeling project.

Five new success factors were identified across the case studies (see Table 2 Columns F12 to F16). The first three of these were identified from case studies in the first case site (Queensland Rail), and the latter two from the 2nd case site (Queensland Treasury).

The 1st new factor - **Need (F12)** - captured 'how important the overall initiative is' (in other words, what motivated the process modeling project). With some reference to past literature (e.g. Seddon, 1997), the Need construct was later redefined as 'Importance' (F15), or 'the criticality of the process modeling project to the organization' (the 4th new factor). This new Importance construct was further justified in the succeeding case studies and was ultimately included in the modified model (superseding 'Need').

The 2nd new factor – **Culture (F13)** – was tentatively defined as 'the organizational readiness to accept and participate in a modeling initiative'. However, no strong evidence was collected from any of the case studies to justify having Culture as a separate construct in the modified model (only 4 specific-citations had mentioned its importance). The data suggested that culture would be influential for the "initiation of a modeling project rather than for the 'success' of the project". Furthermore, Culture, was a reflection on the Leadership and Top Management Support constructs. Thus, it was not included as a separate construct in the modified model.

The 3rd new factor - **Complexity (F14)** - was initially defined as 'the complexity of the processes being modeled as well as how the detailed modeling was to be done'. This construct was further justified in the succeeding case studies and was later re-specified and re-defined as 'the many different features of the processes modeled' (such as the number of inputs, outputs, variants, involved stakeholders of a process, etc.), capturing the complexity of the processes being modeled.

Based on these analyses, both Complexity and Importance (previously known as 'Need') were included in the re-specified process modeling success model, as moderating variables. "A moderating variable affects the direction and/or strength of the relationship between an independent and dependent variable. Thus, moderator variables provide information as to the conditions in which we would expect a relationship between two variables to exist" (Chin, Marcolin, & Newsted, 1996, p.21). Complexity and Importance were hypothesized as moderating variables (as opposed to direct independent variables – in this case; critical success factors) for several reasons. First, while case study evidence did not suggest any direct impact of Complexity and Importance on process modeling success, they seemed to influence how other success factors such as Top Management Support, Project Management, Modeler Expertise, Modeling Tool and Modeling Technique etc. related to process modeling success. This was evident through Matrix Intersection search results [see Bandara (2006) for further details on how the NVivo tool was used for this purpose], which provided evidence that Complexity and Importance influenced the relationship between certain success factors and the proposed success measures, but there was rarely any evidence that denoted a direct influence on process modeling success from these variables³. Furthermore, neither the Complexity of the process

³ The different kinds of search capabilities of NVivo that were applied within this study were briefly introduced earlier. Quotations extracted from the different matrix intersection and proximity searches were analyzed in determining the moderating effects of the variables. While it is accepted that moderation is a phenomena that is best tested through quantitative analysis techniques, careful analysis of qualitative data can assist in identify 'potential' moderation relationships. In this case, a variable was hypothesized/ specified as a moderating variable when (i) it was mostly only mentioned in association with an identified independent variable (IV) (tested with proximity searches), (ii) no data (i.e. quotes and literature) supported any direct relationship to the dependent variable (DV) (tested through matrix intersection searches), and (iii) some quotes described how the relationship between the IV and DV were somewhat influential on the existence of the variable under

nor the Importance of the projects, are elements that one can influence or change once the project is approved, whereas all other critical success factors of the model are prone to intervention and are manageable to some extent. Hence, in a model that attempts to capture the critical success factors as the ‘things that one must do right in order to succeed’ (which assumes some level of intervention and control), those factors that had an indirect influence on success but did not have any capacity to be controlled and managed in anyway, seemed more appropriate to be denoted as moderating variables.

The 5th new factor in relation to ‘Getting Information’, was raised in data gathered within the second and third case sites. This new concept was identified as a success factor because of the relatively high number of citations (a total of 34 general-citations and 14 specific-citations). After careful analysis of the data gathered within the case study, this construct was re-specified as **Information Resources (F16)** and defined as ‘those resources available to inform the modeling project’. This new construct substantially overlapped with the Participation construct, where quotes often referred to the type of information that was made available to the Modelers during stakeholder participation (i.e. documents, procedure manuals, access to organization/ process specific details like through the intranet). This can be explained by the fact that Participation, in the context of process modeling initiatives is important, mainly to gather relevant information to undertake the modeling and for reviewing the completed models. However, it was made evident from the data that reference to Information Resources emphasized the state of information available, while reference to Participation emphasized the process of gathering information. Thus, both constructs remained in the re-specified model.

RE-SPECIFIED CONSTRUCT	DEFINITION
Information Resources	Information resources refer to those resources available to inform the modeling project.
Stakeholder Participation	Process stakeholders are those who have a role in the processes being modeled (they may or may not be model users). Stakeholder participation refers to the activities performed by the Process stakeholders during the modeling phase.
Top Management Support	Top management support refers to the involvement and participation of senior management, and their ongoing commitment and willingness to devote necessary resources and time of senior managers to oversee the process modeling efforts.
Project Management	Project management is the management of activities and resources throughout all phases of the process modeling project, to obtain the defined project outcomes.
Modeler Expertise	Modeler Expertise describes the experiences of the person conducting the modeling, in terms of conceptual modeling in general and process modeling in particular
Modeling Tool	Modeling tool refers to the software application that facilitates the design, maintenance and distribution of the process models.
Modeling Technique	Modeling technique refers to the set of symbols and the related rules that specify the usage of the symbols (sometimes referred to as the ‘modeling language’).
Modeling Guidelines (Methodology)	Modeling guidelines refers to a detailed set of instructions that describes and guides the process of modeling (sometimes referred to as the ‘modeling methodology’ or ‘modeling conventions’).

investigation (tested through matrix intersection searches). Complexity and Importance that were specified as moderating variables in this analysis fulfilled these ‘rules’/ ‘guidelines’.

RE-SPECIFIED CONSTRUCT	DEFINITION
Importance	Importance, is defined as the criticality of the process modeling project to the organization.
Complexity	Complexity captures the many different features of the processes modelled (such as the number of inputs, outputs, variants, involved stakeholders of a process, etc.), capturing the complexity of the processes being modelled.

Table 3: Definitions of the re-specified model constructs after case study analysis

Operationalization of the Process Modeling-Success Factors

The next step was to operationalize the derived 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 factors. Separate log books were maintained for each construct, each documenting (a) prior established definitions for the constructs, (b) an inventory 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.

Operationalization of constructs involved two main phases, largely in accord with the two-step approach advocated by (Burton-Jones and Straub, 2006). They emphasize the importance of considering ‘structure’ and ‘function’ of measures (a.k.a items, instrument questions), where structure refers to the selection of elements (factors) that are most relevant for the research model and context; and function refers to the selection of measures for the chosen elements that tie to the constructs in a nomological network. It is noted that few studies elaborate the rationale for their choice of success constructs and measures employed.

The first phase, akin to the ‘function’ phase of the Burton-Jones et al. (2006) approach, sought, from review of the literature and the case studies, to identify a comprehensive set of relevant sub-constructs for each success factor, the related aim being to adequately account for the context of contemporary process modeling, and to ensure model completeness.

The second phase was to derive survey questions (here after referred to as ‘items’) for the constructs, to measure 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).

Results from a series of joint meetings of the three main researchers over a period of 9 months were presented to two separate groups; one of experts in process modeling, and another of experts in survey instrument design. Their feedback was also incorporated into this process. Columns 2-5 of Appendix A, summarize this effort, depicting the sub-constructs derived for each success factor, the final survey question, and the origin and rationale of each question. A total of 34 items (for both the success factors and moderating variables) were included. The validated instrument to measure Process Modeling success (PM- Success) presented in Bandara et al., 2006 was borrowed and used in the survey (as is) as the dependent variables in the factor study.

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 (integrating the case study and survey methods as per 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, 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 (typically, they 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 breadth of exposure were discouraged from participating).

Survey questions employed to measure the success factors are presented in Appendix A. All questions, except those that measured Modeler expertise and the modeling-specific constructs, employed a 7 point likert-scale with the end values (1) strongly disagree and (7) strongly agree. With the objective of minimizing potential bias from modelers scoring themselves (see section below for further details), the Modeler Expertise construct included four demographic items (items #19-#22 in Appendix A), and a single scale item (#23) as a cross-check. Modeling-specific constructs - modeling tool, modeling technique and modeling guidelines – employed dichotomous questions that merely recorded the existence or not of these three modeling aids (#24-#26).

The finalized survey instrument was pilot tested in three stages. First, the research team requested that 6 candidate survey respondents complete the survey while ‘thinking out loud’. Modifications were made to the instrument based on feedback gathered. A second round of pilot testing targeting 100 candidate respondents was next conducted (using the paper-based version). 19 responses were received, that suggested several minor adjustments to the layout and presentation. A third and final round of pilot testing was conducted, whereby 120 process modeling practitioners were contacted and 17 responses received. These 17 responses were analyzed similarly to those from the second pilot testing round, results evidencing 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. The survey was also distributed as a web link, targeting membership forums of professional societies and user communities with potential process modelers (e.g. BPMG org⁴, Australian Computer Society⁵, New Zealand Computer Society⁶). A web link was included in user group newsletters of leading process modeling tool vendors’ who showed interest in supporting the study (i.e. IDS Scheer, Ultimus).

The overall data collection phase extended over 6 months (from March 2004 to August 2004) until sufficient responses were collected (~300 was the target). Table 4 summarizes the origins of responses. The responses were collated, cleansed and codified. All fields were mandatory, thus there

4 The Business Process Management Group (BPMG.org) is a global business club exchanging ideas and best practice in process and change management. They have over 16,000 global members in 155 countries across all business sectors and support their members through case studies, seminars, education and research (see <http://www.bpmg.org/> for further details, last accessed Nov 22nd, 2006)

5 The Australian Computer Society (ACS) is the recognised association for Information & Communications Technology (ICT) professionals, attracting a large and active membership from all levels of the ICT industry. ACS members work in all areas of business and industry, government and academia, and are qualified and experienced ICT professionals (see <http://www.acs.org.au/> for further details, last accessed June 22nd, 2007).

6 NZCS is the professional institution for Information and Communication Technology people in the New Zealand Region. Their goal is to achieve ongoing improvement in the quality of the delivery of ICT by organisations and individuals (see <http://www.nzcs.org.nz/> for further details, last accessed June 22nd, 2007).

were no missing values. Records were analyzed for perceived frivolity and none identified. A total of 290 responses remained in the database after this initial cleaning phase.

Table 4: 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 within Australia.	24
2	Web	Responses from a process-modelers database derived by amalgamating each research-team member's personal contacts and contacts within their research centre databases. Data was collected globally, via the <i>web version</i> of the instrument.	160
3	Web	Responses from advertising the study in related, specialized associations and forums. Data was collected globally via the <i>web version</i> of the instrument.	106
		TOTAL	290

Findings

The purpose of the survey was to re-specify the success factors and moderating variables as previously described (exploratory) and to validate the result (confirmatory). As discussed above and depicted in Appendix A, most of the constructs were measured with multiple item Likert scale items, except for the *Modeler expertise* (ME – which were measured by 3 continuous variables and an overall measure of self evaluated Modeler expertise) and modeling-specific constructs (which included *Modeling tool*, *Modeling technique* and *Modeling guidelines*); which were measured as dichotomous variables.

A total of 25 items (see Appendix A – all listed items except those pertaining to the moderating variables) were included in an exploratory factor analysis which used varimax rotation. Over several analyses, 6 items were dropped (ME3, IR3, PM1, PM5, PM6 and PM8), their having loaded across multiple factors and not having loaded above 0.5 on any single factor. Scree plots, Eigen values and parallel analysis (Horn, 1965) using Monte Carlo PCA (Watkins, 2000), all suggested a 5 factor solution, results of which are reported in Table 5 (67.6% variance explained). A Kaiser-Myere-Olkin measure of .833 and a Bartlett's test of sphericity with a significance level of .000 supported the appropriateness of factor analysis. The ratio of subjects (290) to items (25) also satisfied various heuristics suggested in the literature (Tabachnick and Fidell, 2001).

	Component				
	1	2	3	4	5
* Approximately, how many process modeling projects had you been involved in prior to this project?	ME1			0.861	
* Approximately, how many years of experience did you have in process modeling, when the project commenced?	ME2			0.833	
*Overall, how experienced are you as a process modeler?	MEoverall			0.509	
*Top management made a commitment to provide stable funding for the Modeling activity	TMS1	0.756			
*Top management made a commitment to provide all the other necessary resources for the Modeling activity	TMS2	0.796			
*Top management was involved in the key decisions of the Modeling project (e.g. in the selection of which processes to model)	TMS3	0.771			
*Top management actively participated in the process Modeling project (e.g. attended	TMS4	0.807			

key project meetings)						
* Process stakeholders provided input to the design of the models	SP1	0.881				
*Process stakeholders carefully reviewed the models	SP2	0.851				
*Process stakeholders were responsible for approving the models	SP3	0.740				
*Relevant process stakeholders were available from whom to gather information	IR1	0.830				
*These available process stakeholders were knowledgeable about the processes	IR2	0.834				
*A formal procedure was used to determine the level of detail of the models	PM2			0.849		
*A formal procedure was used to determine which processes to model	PM3			0.828		
*A time management strategy was utilized in the process Modeling project	PM4			0.680		
*A formal quality control strategy was applied within the process modeling project	PM7			0.771		
Modeling Tool existence	Mte					0.753
Modeling Technique existence	Mteche					0.732
Modeling Guideline existence	Mge					-0.622

Table 5: Factor Analysis of Success Factors

While all Stakeholder Participation (SP) items loaded together, in all rounds of Factors analysis, they combined with the Information Resources (IR) items (IR3 having been dropped⁷). The close relationship and potential overlap between Stakeholder Participation (SP) and Information Resources (IR) was observed in the multiple case study. They were regardless included in the conceptual model as separate constructs, as case study data indicated that Information Resources emphasized the state of information available, while Stakeholder Participation emphasized the process of information gathering. Factor analysis results suggest however that, as operationalized, these are not easy for respondents to differentiate. It is acknowledged that two of the three Information Resources (IR) measures included the term “stakeholder”. (i.e. IR1 – ‘Relevant process stakeholders were available from whom to gather information’, and IR2 – ‘These available process stakeholders were knowledgeable about the processes’). IR3 (‘Available documentation was highly useful for the project’) was dropped during factor analysis and was the only IR item that did not include the word ‘stakeholder’, perhaps explaining why it did not load along with the others. One might conclude that the Information Resources construct is a dimension of a higher-order, multidimensional Stakeholder Participation construct. This view is supported by case data (as well as factor analysis results) which indicated that Stakeholder Participation, in the context of process modeling initiatives, was important only to gather relevant information to undertake the modeling (and for reviewing the completed models). Alternatively, Information Resources (IR) may not have been operationalised well, and thus we see poor evidence of divergence from Stakeholder Participation⁸. Thus, a new variable was defined as “Stakeholder Input” (SI) - “the amount of quality input from the project stakeholders for the design, approval and maintenance of the models”.

The four Top Management Support (TMS) items loaded as predicted. The four Project Management (PM) items also loaded together as anticipated (four other PM items having earlier been dropped - PM1, PM5, PM6 and PM8).

⁷ Cronbach Alpha showing significant improvement when this item was dropped.

⁸ The placement in the questionnaire of the Information Resources items immediately following the Stakeholder Participation items too may have influenced respondents’ ratings.

The modeling-specific factors (MTe, MTEche and MGe) loaded together. This is not surprising considering that Tools, Techniques and Guidelines have been conceptually perceived as closely related. For example, sometimes modeling tools and techniques are described with the ‘chicken and egg’ scenario; where one’s existence is not possible without the other. Data gathered on these variables within the case studies and survey also indicated that tools and techniques are not always clearly differentiated⁹ in the mind sets of people. Modeling guidelines and techniques are not differentiated clearly either, as guidelines often also consist of how the techniques are applied in practice, and hence are interwoven together. Recent literature also supports this observation (Rosemann, 2006a & 2006b). Thus, a new variable was defined as “Modeling aids” (Ma) - “the existence of modeling specific elements which included the modeling tool, technique and modeling guidelines”

The nine measures of the hypothesised moderators; Importance and Process Complexity, were included in an exploratory factor analysis (see Table 6), yielding a Kaiser-Meyer-Olkin Measure of .847 and a Bartlett’s test of sphericity with a significance level of .000, both justifying the appropriateness of factor analysis.

		Component	
		1	2
*The process modeling project was <i>important</i>	IMP1		.856
*The process modeling project was <i>relevant</i>	IMP2		.886
*The process modeling project was <i>needed</i>	IMP3		.904
*The processes that were modelled entailed a high volume of transactions	PC1	.680	
*There were many stakeholders involved in the processes modelled	PC2	.803	
*There were many inputs and outputs involved in the processes modelled	PC3	.891	
*There were many alternative options (i.e. process paths/ process variants) within the processes that were modelled	PC4	.774	
*The processes that were modelled had many activities (functions)	PC5	.901	
*The processes that were modelled had many dependencies within their activities	PC6	.867	

Table 6: Factor Analysis of the Moderating Variables

All items loaded as predicted across a two factor solution, thus evidencing the construct validity of the Importance (IMP) and Process Complexity constructs. None of the items were removed as they all loaded above 0.5 on a single factor.

Table 7 illustrates the reliability scores of the final items of the model. Ideally, the Cronbach’s alpha coefficient of a scale should be above .7 (Pallant, 2005, p. 90). All constructs except Modeler Expertise (ME) reported a Cronbach’s alpha of more than 0.8. Modeling Expertise reported a Cronbach’s alpha of .603. While it is noted that care must be taken when using the ME scale and interpreting the results, the lower Cronbach’s alpha value could also have been caused by combining the varying types of scales (continuous scale for ME1 and ME2, and an interval scale for MEoverall) that were used to measure the construct.

⁹ In the analysis of the different types of tools and techniques reported to be used, some ‘vague statements’ that supposedly described the tools used were actually describing modeling techniques and vice versa.

ID	Item	Alpha
IMP1	*The process modeling project was <i>important</i>	.852
IMP2	*The process modeling project was <i>relevant</i>	
IMP3	*The process modeling project was <i>needed</i>	
PC1	*The processes that were modelled entailed a high volume of transactions	.901
PC2	*There were many stakeholders involved in the processes modelled	
PC3	*There were many inputs and outputs involved in the processes modelled	
PC4	*There were many alternative options (i.e. process paths/ process variants) within the processes that were modelled	
PC5	*The processes that were modelled had many activities (functions)	
PC6	*The processes that were modelled had many dependencies within their activities	
TMS1	*Top management made a commitment to provide stable funding for the modeling activity	.877
TMS2	*Top management made a commitment to provide all the other necessary resources for the modeling activity	
TMS3	*Top management was involved in the key decisions of the modeling project (e.g. in the selection of which processes to model)	
TMS4	*Top management actively participated in the process modeling project (e.g. attended key project meetings)	
SP1	* Process stakeholders provided input to the design of the models	.913
SP2	*Process stakeholders carefully reviewed the models	
SP3	*Process stakeholders were responsible for approving the models	
IR1	*Relevant process stakeholders were available from whom to gather information	
IR2	*These available process stakeholders were knowledgeable about the processes	
PM2	*A formal procedure was used to determine the level of detail of the models	.843
PM3	*A formal procedure was used to determine which processes to model	
PM4	*A time management strategy was utilised in the process modeling project	
PM7	*A formal quality control strategy was applied within the process modeling project	
ME1	*Approximately, how many process Modeling projects had you been involved in prior to this project?	.603
ME2	* Approximately, how many <i>years</i> of experience did you have in process Modeling, when the project commenced?	
ME overall	* Overall, how experienced are you as a process modeler?	
Mte	Modeling Tool existence	Single Item measure - Alpha value not relevant
Mteche	Modeling Technique existence	Single Item measure - Alpha value not relevant

Mge	Modeling Guideline existence	Single Item measure - Alpha value not relevant
-----	------------------------------	--

Table 7: Final Independent Constructs/Items of the Process Modeling Success Model and Related Alpha Scores

Summary

This above section discussed in detail the re-specification and validation of the process modeling success factors and moderating variables.

User Participation (UP) and Information Resources (IR) were consolidated into one construct named stakeholder Input (SI). Top Management Support, Project Management and the two moderating variables: Process Complexity and Importance remained in the model unchanged. Reliability of the resulting measures was tested by deriving alpha values.

The tests presented above were repeated (with original data *and* normalised data) and for the different segments of the data based on demographic segregations of the datasets. The observations presented above were observed consistently in all instances, with no evidence of data bias. Figure 2 depicts the resulting process modeling success factor model after construct validation.

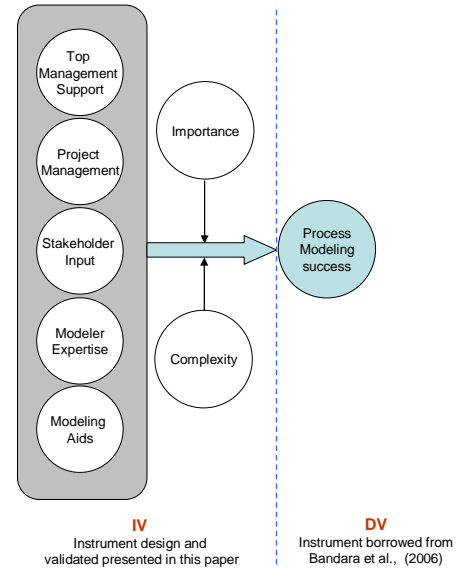


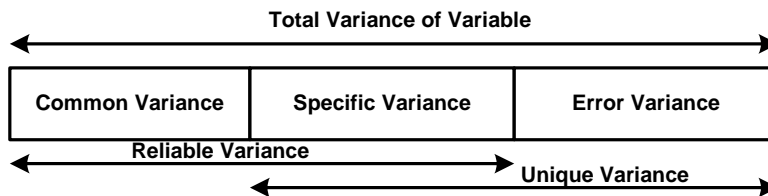
Figure 2: Process Modeling Success Factor Model (after construct validation)

Testing for the Predictive Power of the Success Factors

A simple standard regression was conducted to identify how much of the variance of the dependent variable– Process Modeling Success (instrument borrowed and used from Bandara et al. 2006), the success factors identified herein (namely Top Management Support, Stakeholder Input, Project Management, Modeling Aids and Modeler Expertise) were able to predict as a group.

With uncorrelated independent variables, the partial regression coefficients (Beta values) depict how much unique variance¹⁰ a particular independent variable (in this case, each success factor) is capable of explaining for a given dependent variable (in this case, process modeling success) (following

¹⁰ The figure below illustrates the components in the variance of a variable.



Unique variance is that variance of a variable which is not explained by common factors. The uniqueness of a variable is $(1-h^2)$. Unique variance is composed of specific and error variance. Specific variance is the component of unique variance which is reliable but not explained by common factors. Error variance is unreliable and inexplicable variation in a variable. Common variance is variance in a variable shared with common factors (extracted from <http://www.siu.edu/~epse1/pohlmann/factglos/>, last accessed 25th June, 2006).

Tabachnick & Fidell, 2001, p, 139). Squared semi partial correlation coefficients are recommended as a useful measure of importance of an independent variable, especially if the independent variables are correlated (Tabachnick & Fidell, 2001, p, 140). When reporting this section, the correlations between the independent variables (in this case, the success factors) are first tested (see Table 8a and 8b). The Beta values and the semi partial correlation coefficients are presented side by side for interpretation. In all instances of this analysis, the semi partial correlation coefficients supported observations made from the Beta values, the betas thus being used as the primary form of evidence to describe the predictive power of the independent variables.

The factors scores (resulting from the analysis depicting in Table 5 and 6 were saved and used in this regression analysis. Thus, only 5 independent measures were used in model testing; the sample size meeting the requirement specified in the literature. Based on the Tabachnick & Fidell (2001, p.72) formula ($N > 50 + 8m$), a minimum of 90 cases is required. This dataset had 290 valid cases.

		Correlations				
		Stakeholder Input (SI_FAC)	Project Management (PM_FAC)	Top Management Support (TMS_FAC)	Modeler Expertise (ME_FAC)	Modeling Aids (MA_FAC)
Stakeholder Input (SI_FAC)	Pearson Correlation	1	.322**	.309**	-.064	-.073
	Sig. (2-tailed)		.000	.000	.277	.216
	N	289	289	289	289	289
Project Management (PM_FAC)	Pearson Correlation	.322**	1	.260**	-.117*	.038
	Sig. (2-tailed)	.000		.000	.047	.525
	N	289	289	289	289	289
Top Management Support (TMS_FAC)	Pearson Correlation	.309**	.260**	1	.008	-.023
	Sig. (2-tailed)	.000	.000		.892	.693
	N	289	289	289	289	289
Modeler Expertise (ME_FAC)	Pearson Correlation	-.064	-.117*	.008	1	.017
	Sig. (2-tailed)	.277	.047	.892		.776
	N	289	289	289	289	289
Modeling Aids (MA_FAC)	Pearson Correlation	-.073	.038	-.023	.017	1
	Sig. (2-tailed)	.216	.525	.693	.776	
	N	289	289	289	289	289

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 8A: Correlations between the Success Factors

Table 8B: Testing for Multi Collinearity between the Success Factors

	Collinearity Statistics	
	Tolerance	VIF
Stakeholder Input (SI_Fac)	.835	1.197
Project Management (PM_Fac)	.854	1.171
Top Management Support (TMS_Fac)	.873	1.145
Modeler Expertise (ME_Fac)	.983	1.017
Modeling Aids (MA_Fac)	.990	1.010

Data was checked for correlation and multicollinearity. As Table 8A depicts, the largest correlation coefficient was only .322¹¹. Collinearity diagnostics tests (see Table 8B) indicated Variance Inflation Factors (VIF) less than 10 and Tolerance values greater than 0.1 for all variables, both indicating that the data did not have any multicollinearity to be concerned about (Pallant, 2005, p.150).

Inspection of the normal probability plot identified no major deviation from normality. Inspection of the residual scatter plot and subsequent calculations

of Mahalanobis distance and Cook's distance statistics, indicated that the dataset had no outliers of concern.

An adjusted R square of **0.533** was reported with this regression analysis, indicating that **53.3%** of the variance in process modeling success is explained by the success factors. Table 9 illustrates (with the beta values and significance values), that while all the success factors make a significant unique contribution (with reported significance levels of less than 0.05), Stakeholder Input (SI) makes the strongest unique contribution to explaining process modeling success. (i) Stakeholder Input (Beta = 0.575), (ii) Top Management Support (Beta = 0.344), (iii) Project Management (Beta = 0.272), (iv) Modeling Aids (Beta = 0.098) and (v) Modeler Expertise (Beta = 0.093) in descending order of importance, all contribute to predicting process modeling success. An analysis of the squared semi partial correlations [as depicted in the last column (column 5) of Table 9], further supports these interpretations of the Beta coefficients.

	Standardised Coefficients	t	Sig.	Part
	Beta			
Stakeholder Input (SI_Fac)	.575	14.266	.000	.575
Project Management (PM_Fac)	.272	6.756	.000	.272
Top Management Support (TMS_Fac)	.344	8.534	.000	.344
Modeler Expertise (ME_Fac)	.093	2.309	.022	.093
Modeling Aids (MA_Fac)	.098	2.423	.016	.098

Table 9: Model Summary Data of Regressing Success Factors on PM-Success

¹¹ It is said that independent variables are highly correlated at a correlation coefficient (r) of .9 and above (Tabachnick & Fidell, 2001).

Testing for the Existence of Moderator Effects

As Figure 2 illustrates, the derived conceptual model proposed two moderating variables: Process Complexity (PC) and Importance (IMP). This section reports on the detailed analysis of the entire process modeling success model, including the effects of these moderating variables.

“A moderator variable affects the direction and/or strength of the relationship between an independent and dependent variable. Thus, moderator variables provide information as to the conditions in which we would expect a relationship between two variables to exist”

(Chin, Marcolin, & Newsted, 1996, p.21).

Moderator variables have been widely used across many disciplines for many years, including IS. Chin et al. (1996) report on a critique of more than seventy articles extracted from leading IS research outlets till 1995 and conclude that the ability to accurately estimate moderating effects is difficult, which is mainly due to measurement error and low statistical power that can result from such error (Chin et al., 1996, p.21). This reported analysis conducted a Moderated Multiple Regression method (a.k.a MMR approach) as recommended by Stone & Hollenbeck (1984) and followed the procedures outlines in Frazier, Tix & Barron (2004).

Most studies that discuss moderator effects, prescribe procedures to follow when there is only one moderator variable (e.g. Chin et al., 1996; Stone & Hollenbeck, 1984). However, some research contexts may require testing models with more than one moderator variable, as it is the case in this study. Frazier et al. (2004, p.122) warn researchers that *“performing a large number of statistical tests in this manner will lead to an inflated Type 1 error rate”*. In order to help control for this type of error, they propose to: (a) first run the analysis with all the moderator effects being considered (after controlling for the main effects of the predictor and moderator variables), (b) identify the interaction terms that result with a significant result (hence determine which one to include and exclude in the model) and (c) re-run the identified moderating effects individually to further analyse the moderator effects. These guidelines were followed when testing for the moderator effects of the proposed process modeling success model.

First, any potential interrelationships between the two moderating variables Process Complexity (PC) and Importance (IMP) were tested for, via a correlation analysis. The two variables did not have any significant correlation, which justified testing for the moderating effects with these two variables in a single regression test without having any hidden interaction effect caused by any relationship between these two variables. Table 10 depicts the summary results of this analysis. Step 1 (Model 1) consisted of all the predictor variables. Step 2 (Model 2) consisted of all the predictor variables and the moderating variables. In Step 3 (Model 3), all the interaction variables were included to the equation. As denoted by Table 10, the introduction of the interaction terms increased the R square value from 0.541 to 0.655, reporting an overall change of 0.091. In other words, 65.5% of the variance in process modeling success can be explained by the success factors and moderator variables, and the moderating effects alone account for 9.1% of the variance.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.735 ^a	.541	.533	.68193850	.541	66.639	5	283	.000
2	.751 ^b	.564	.553	.66672257	.023	7.532	2	281	.001
3	.809 ^c	.655	.633	.60411065	.091	7.127	10	271	.000

a. Predictors: (Constant), Ma_fac, Me_fac, Pm_fac, TMS_Fac, SI_fac

b. Predictors: (Constant), Ma_fac, Me_fac, Pm_fac, TMS_Fac, SI_fac, Imp_fac, PC_fac

c. Predictors: (Constant), Ma_fac, Me_fac, Pm_fac, TMS_Fac, SI_fac, Imp_fac, PC_fac, ImpXMa, PCXME, PCXMA, PCXTMS, ImpXPM, ImpXMe, PCXPM, ImpXTMS, ImpXSI, PCXSI

Table 10: Model Summary Data with All the Standardised Predictor and Moderator Variables, Including All Interaction Effects of Both Moderating Variables

Generally, effect sizes for interactions are small (a 0.02 value for the R square is considered as a small effect size with interaction effects) (Frazier et al., 2004, p.118). Thus, a .091 effect size is arguably a considerable interaction effect. The next step of the analysis was to identify which variable-interactions were significant enough to contribute to this overall interaction effect. Table 11 depicts regression coefficients of the analysis conducted with all the Standardised predictor and moderator variables, including all interaction effects of both moderating variables the regression coefficients and Beta values for the three models described above in Table 10. When analysing the interaction effects (Model 3), three (3) interaction effects stood out to be significant with a significant value of less than 0.05. These were:

1. The interaction effect between Stakeholder Input (SI) and Process Complexity (PC)
2. The interaction effect between Modeling Aids (Ma) and Importance (IMP)
3. The interaction effect between Top Management Support (TMS) and Importance (IMP)

These three moderating effects were further analysed in depth. As Frazier et al. (2004, p.122,125) suggest; first the significance of these interactions was analysed individually (by conducting separate MMR tests). Then, the nature of the moderating relationships was explored.

Coefficients ^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.005	.040		.135	.893					
	SI_fac	.573	.040	.575	14.266	.000	.575	.647	.575	1.000	1.000
	TMS_Fac	.271	.040	.272	6.756	.000	.272	.373	.272	1.000	1.000
	Pm_fac	.343	.040	.344	8.534	.000	.344	.452	.344	1.000	1.000
	Me_fac	.093	.040	.093	2.309	.022	.093	.136	.093	1.000	1.000
	Ma_fac	.097	.040	.098	2.423	.016	.098	.143	.098	1.000	1.000
2	(Constant)	.005	.039		.124	.901					
	SI_fac	.490	.046	.491	10.751	.000	.575	.540	.423	.744	1.344
	TMS_Fac	.219	.042	.219	5.239	.000	.272	.298	.206	.886	1.129
	Pm_fac	.284	.042	.284	6.727	.000	.344	.372	.265	.868	1.151
	Me_fac	.083	.040	.083	2.085	.038	.093	.123	.082	.971	1.030
	Ma_fac	.106	.039	.107	2.704	.007	.098	.159	.107	.996	1.004
	PC_fac	.179	.049	.180	3.654	.000	.534	.213	.144	.643	1.556
	Imp_fac	.067	.041	.068	1.637	.103	.155	.097	.064	.909	1.100
3	(Constant)	.098	.043		2.265	.024					
	SI_fac	.403	.045	.404	8.890	.000	.575	.475	.317	.617	1.621
	TMS_Fac	.189	.040	.189	4.771	.000	.272	.278	.170	.808	1.237
	Pm_fac	.265	.039	.265	6.804	.000	.344	.382	.243	.838	1.194
	Me_fac	.098	.038	.098	2.613	.009	.093	.157	.093	.897	1.115
	Ma_fac	.057	.037	.058	1.565	.119	.098	.095	.056	.939	1.065
	PC_fac	.096	.048	.096	2.019	.045	.534	.122	.072	.561	1.782
	Imp_fac	.129	.044	.129	2.965	.003	.155	.177	.106	.669	1.494
	ImpXSI	.084	.044	.082	1.930	.055	.329	.116	.069	.706	1.416
	ImpXTMS	.095	.035	.110	2.737	.007	.157	.164	.098	.782	1.279
	ImpXPM	.015	.035	.017	.440	.660	.128	.027	.016	.887	1.127
	ImpXMe	-.047	.042	-.042	-1.124	.262	-.026	-.068	-.040	.892	1.121
	ImpXMa	-.148	.038	-.146	-3.895	.000	-.103	-.230	-.139	.908	1.101
	PCXSI	-.222	.037	-.266	-6.008	.000	-.507	-.343	-.214	.650	1.540
	PCXTMS	-.042	.036	-.044	-1.174	.242	-.090	-.071	-.042	.906	1.104
PCXPM	.025	.038	.026	.667	.506	-.052	.040	.024	.826	1.210	
PCXME	-.034	.040	-.031	-.847	.398	.027	-.051	-.030	.935	1.069	
PCXMA	.055	.041	.050	1.332	.184	-.113	.081	.048	.918	1.089	

a. Dependent Variable: PMS

Table 11: Regression Coefficients of the Analysis Conducted with All the Standardised Predictor and Moderator Variables, Including All Interaction Effects of Both Moderating Variables

	Relationship tested	R square	R square change		Standardised		Unstandardised	
					Beta	Sig	Beta	std Error
Process Complexity (PC)	Stake holder Input (SI) with Process Complexity (PC)	0.416	.049	SI (Step 1)	.333	.000	.332	.051
				PC (Step 1)	.279	.000	.279	.050
				SI*PC (Step 2)	-.257	.000	-.215	.041
Importance (IMP)	Top management support (TMS) with Importance (IMP)	.078	.046	TMS (Step 1)	.261	.000	.261	.056
				IMP (Step 1)	.167	.005	.166	.058
				TMS*IMP (Step 2)	.229	.000	.197	.050
	Modeling aids (Ma) with Importance (IMP)	0.028	.006	Ma (Step 1)	.092	.114	.092	.058
				IMP (Step 1)	.159	.006	.159	.058
				Ma*IMP (Step 2)	-.098	.093	-.099	.059

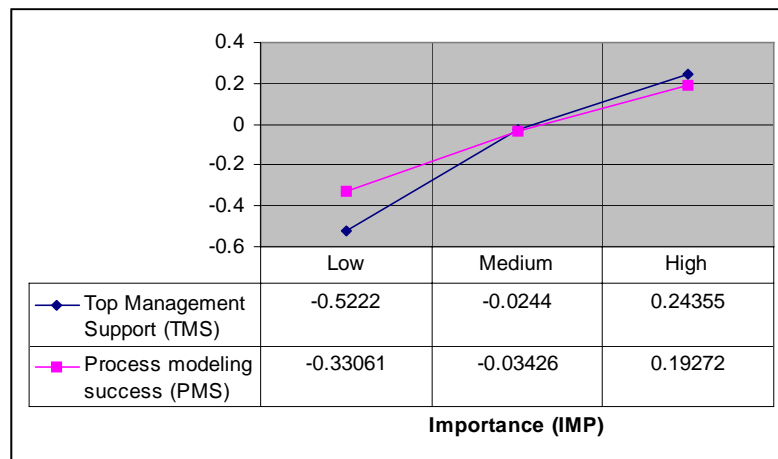
Table 12: Summary Data of Testing for Interaction Effects within Selected Individual Success Factor and Moderating Variables (with Standardised Variables)

Table 12 depicts the summary results of regression tests conducted to further analyse the interaction effects identified above from Table 11. Column 1 groups the table entries by the moderating variable tested. Column 2 describes the relationship that was tested. Column 3 illustrates the R square of the variables in the regression model. Columns 6 and 7 report on the individual Beta values and significance values for each variable tested within each round of regressions conducted. Standardised values were used for the moderator and predictor variables as recommended by Frazier et al. (2004) to run these second level tests.

It can be observed that while there is only a small incremental change in the R square value (0.049), Process Complexity (PC) acts as a moderating variable between Stakeholder Input (SI) and Process Modeling Success (PM-Success). Similarly, as Table 12 depicts, Importance (IMP) acts as a moderating variable between Top Management Support and Process Modeling Success (PM-Success) (with an R square increment of 0.046), but *not* between Modeling Aids (Ma) and Process Modeling Success (PM-Success). The reported degree of significance for the interaction effect between Modeling Aids (Ma) and Process Modeling Success (PM-success) was 0.093, greater than the accepted significance amount of 0.05. Thus, Table 12 confirms a significant moderating effect (1) between Stakeholder Input (SI) and Process Complexity (PC) and (2) between Top Management Support (TMS) and Importance (IMP). However, it contradicts the third identified moderating effect between Modeling Aids (Ma) and Importance (IMP).

When all the variables (especially when there are many) are entered into the regression equation (as depicted in Table 11), only those with a true significant interaction effect would be highlighted. This is why Frazier et al. (2004) propose to run the analysis with the entire variable set first and then to run individual interaction effects after they have been identified from the previous step. Thus, it is very unlikely that an interaction effect identified in the midst of all variables will be contradicted when tested for its effect size individually. The researcher acknowledges that this observation for potential error may be caused by the scale of measurement of the Modeling Aids (Ma) construct and notes this as a limitation of this analysis. Hence, this concludes that Process Complexity (PC) and Importance (IMP) have moderating effects with only Stakeholder (SI) and Top Management Support (TMS) respectively. Once this observation was made, the next step was to test for the *nature* of the moderating effect. The next section depicts this analysis in detail.

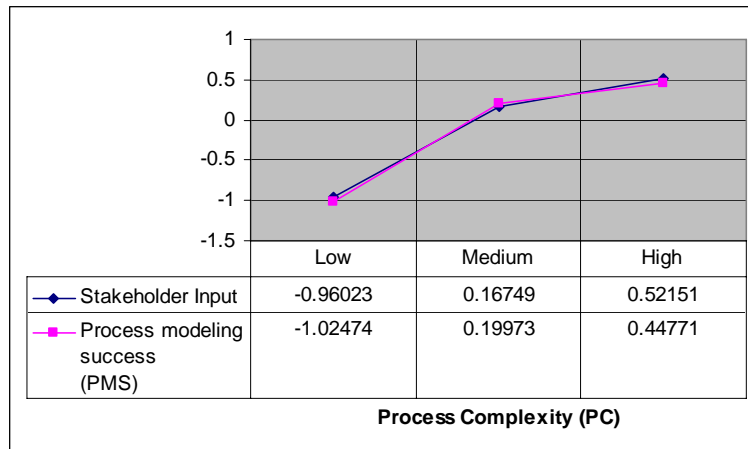
Figure 3: The Moderation Effect between Top Management Support (TMS) and Importance (IMP)



Frazier et al. (2004) describe how the form of the moderation effects can be identified by plotting the predictor values for groups of the moderating variables. Following their recommended procedure, (a) the standardised moderator values were grouped into three categories for both moderating variables; 'low' (all values less than -1 standard deviations from the mean), 'moderate' (all values between ± 1 standard deviations from the mean) and 'high' (all values greater than +1 standard deviations from the mean). (b) The mean value of the predictor variables(s) was derived for each interaction that was identified. (c) These values were then plotted for each individual interaction effect with the moderator variable as the X-axis and the predictor variable as the Y-axis, to graphically analyse the nature of the moderating effects. The Figures 3 and 4 depict the resulting graphs.

The moderating relationship between Top Management Support (TMS) and Importance (Imp) was relatively linear (see Figure 3). When the perceived importance was low, the amount of Top Management Support received was also low and the degree of Process Modeling Success was low too. As the degree of perceived importance increased, the amount of Top Management Support and the degree of Process Modeling Success increased. This can be justified by the fact that the management is willing to provide more support when the perceived degree of importance of the process modeling project to the organisation is high.

Figure 4: The Moderating Effect between Stakeholder Input (SI) and Process Complexity (PC)



The moderating relationship between Stakeholder Input (SI) and Process Complexity (PC) was also relatively linear (see Figure 4). When Process Complexity was low the resources made available were low in comparison to when the complexity was higher and Stakeholder Input increased as Process Complexity increased. This may be due to the fact that people tend to document and maintain details more (hence information/ input is ready available) when things are complex as compared to when it is relatively simple.

Figure 5 depicts the final process modeling success model resulting from the detailed analysis presented here.

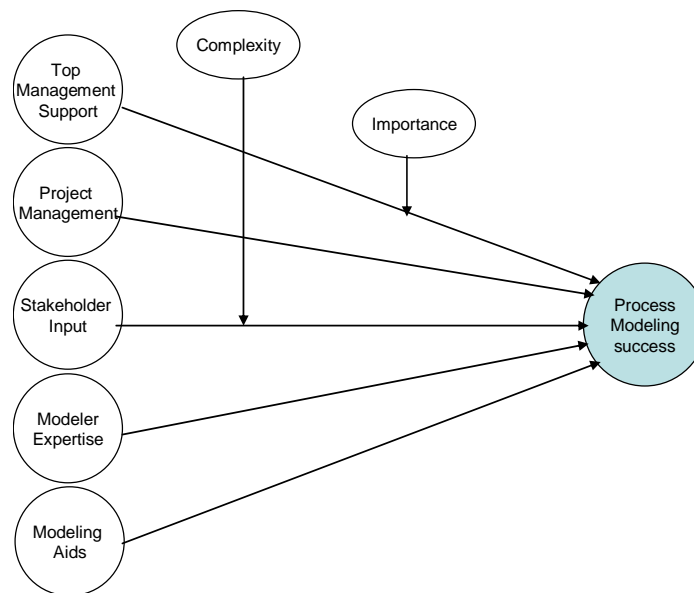


Figure 5: Final Process Modeling Success Model

Study Limitations, conclusions and outlook

The increasing prevalence and magnitude of process modeling projects demand appropriate means for planning modeling efforts. This paper presented a validated success factor model and instrument for capturing antecedent process modeling success factors. This is the *first* study to empirically validate a process modeling success factors model. No relevant, existing theory was identified. There were no extant, validated, quantitative instruments for identifying and measuring process modeling success factors. The overall study design consists of an exploratory model building phase - the trialing of analogous success factors from referent domains (from the literature) in a multiple case study - followed by an exploratory model testing phase. The study drew heavily on referent domains to identify the initial set of candidate success factors. These were trialed in a series of case studies, resulting in modifications to the constructs. The instrument was empirically tested with 290 responses to a global survey of process modelers. Analysis of the survey data revealed

Related future work would benefit from identification of underpinning theory on the relationship and nature of the proposed measurement dimensions.

Reference

Available upon request

APPENDIX A - Survey questions, codes used and their origins¹²

#	Actual Question	Code	Related Sub-Construct(s)	Adopted/ adapted from
Top Management Support items				
1	Top management made a commitment to provide stable funding for the Modeling activity	TMS1	Funding	Doll (1987)
2	Top management made a commitment to provide all the other necessary resources for the Modeling activity	TMS2	Provide other resources	Doll (1987)
3	Top management was involved in the key decisions of the Modeling project (e.g. in the selection of which processes to model)	TMS3	Decision making	Thong, Yap, Raman (1996)
4	Top management actively participated in the process Modeling project (e.g. attended key project meetings)	TMS4	Active participation	Thong, Yap, Raman (1996)
Stakeholder Participation items				
5	Process stakeholders provided input to the design of the models	SP1	Provide input <support in information gathering>	Case data and literature
6	Process stakeholders carefully reviewed the models	SP2	Review the models	Mc Keen et al., (1994)
7	Process stakeholders were responsible for approving the models	SP3	Approve the models	Mc Keen et al., (1994)
Information Resources items				
8	Relevant process stakeholders were available from whom to gather information	IR1	Stakeholders availability	Case data
9	These available process stakeholders were knowledgeable about the processes	IR2	Stakeholder competence on the processes	Case data
10	Available documentation was highly useful for the project	IR3	Information available through documentation	Case data
Project Management items				
11	The objectives of the process Modeling project were carefully defined in advance	PM1	Defined objectives	Powers and Dickson (1973)
12	A formal procedure was used to determine the level of detail of the models	PM2	Scope 1 – Determining the level of detail to model	
13	A formal procedure was used to determine which processes to model	PM3	Scope 2 – Determining which processes to model	Adopted from case study data
14	A time management strategy was utilised in the process Modeling project	PM4	Time management	Powers and Dickson (1973)
15	The Modeling team included people with appropriate skills	PM5	People management	
16	The project status was systematically communicated amongst the project stakeholders	PM6	Communication management	Powers and Dickson (1973)
17	A formal quality control strategy was applied within the process Modeling project	PM7	Quality management	
18	The costs of the Modeling project were carefully accounted for	PM8	Cost management	Powers and Dickson (1973)
Modeler Expertise items				
19	Approximately, how many process Modeling projects had you been involved in prior to this project?	ME1	Process Modeling skills-1	Modeling experts
20	Approximately, how many years of experience did you have in process Modeling, when the project commenced?	ME2	Process Modeling skills-2	Modeling experts

¹² There wasn't any item that we could directly adopt. However there were items that were useful, and they are presented below

- Mc Keen et al. (1994) Users define system controls and security procedures
- Mc Keen et al. (1994) Users create system procedure manuals
- Hartwick and Barki (1994) I created the user procedure manual for this system, (Yes / No)
- Doll and Torkzadeh, (1998) Developing input forms/screens
- Mc Keen et al. (1994) Users define I/O forms, screen layout, report formats
- Hartwick and Barki (1994) For this system, I defined / helped define input / output forms (Yes / No)
- Hartwick and Barki (1994) For this systems, I defined / helped screen layouts (Yes / No)
- Mc Keen et al. (1994) Users are interviewed by IS staff
- Mc Keen et al. (1994) Users respond to questionnaire administered by staff

21	Approximately, how many <i>years</i> of experience did you have in the modelled business area(s) that was/were modelled, when the project commenced?	ME3	Business knowledge	Modeling experts
22	Overall, how experienced are you as a process modeler?	MEOverall	Overall self evaluation	Modeling experts
Modeling tool item				
23	Were Modeling tools used in the process Modeling project? (Yes/No)?	MTe	Modeling tool existence	Modeling experts
Modeling technique item				
24	Were Modeling techniques used in the process Modeling project (Yes/No)?	MTeche	Modeling technique existence	Modeling experts
Modeling guidelines item				
25	Were Modeling guidelines used in the process Modeling project (Yes/No)?	MGe	Modeling methodology existence	Modeling experts
Importance items				
26	The process Modeling project was <i>important</i>	IMP1	Importance Relevance Need	Seddon and Kiew (1994)
27	The process Modeling project was <i>relevant</i>	IMP2		
28	The process Modeling project was <i>needed</i>	IMP3		
Complexity items				
29	The processes that were modelled entailed a high volume of transactions	PC1	Volume of transactions	Case data and experts
30	There were many stakeholders involved in the processes modelled	PC2	Number of stakeholders	Case data and experts
31	There were many inputs and outputs involved in the processes modelled	PC3	Amount of Inputs and outputs	Case data and experts
32	There were many alternative options (i.e. process paths/ process variants) within the processes that were modelled	PC4	Number of process variants	Case data and experts
33	The processes that were modelled had many activities (functions)	PC5	Number of functions	Case data and experts
34	The processes that were modelled had many dependencies within their activities	PC6	Amount of dependencies	Case data and experts