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Validating the Process-Modelling Practice Model

The paper revises an existing model of process-modelling practice and uses it in an explorative survey of Norwegian model-based process-change projects. A central hypothesis is confirmed: there is a positive relationship between modelling processes and project outcome, where modelling process is measured in terms of management support, lack of resistance, in-project training and model types. In particular, management support and in-project training are robust predictors of project outcome. Practical and theoretical implications are presented and discussed. Important paths for further work include improving instrument validity and elaborating the research model by including other organisational and social dimensions of process-modelling behaviour and effects. Cross-national studies are also called for.

1 Background

Process modelling [CuKe+92] is today recognised as important for business process management ([Harm03], [Hilli05], [SmFi03]), although it was not considered central in the earliest publications on process change ([Hamm90], [HaCh93], [Dave93]). Since then, a number of modelling techniques and tools have been proposed. For example, process models are commonly used to document existing practice, analyse this practice and suggest future improvements. Process models are also used for structuring the vast amount of information that materialises in process-change projects.

Despite this, there are few theories and empirical studies available to guide practice of and research on process-modelling. The purpose of this paper is to revise and empirically test a *Process-Modelling Practice (PMP) model* that has been developed by the authors ([IdEi+06], [EiId+08]). It has been used to suggest that Norwegian practice differs from the prescriptions and descriptions in the predominantly Anglo-American literature [IdEi+06], thus advocating an explorative research perspective on process modelling that takes differences in national culture into account. It has also been used to investigate the relative importance of modelling-related and project-specific factors [Iden+07], indicating that the latter tend to be more important. The revised PMP model presented in this paper focuses on how the *Modelling process* and the organisation's *Process competence* are related to *Project outcome* in our unit of analysis, *model-based process-change projects*. Our research question is therefore

How does the organisation's process competence and choice of modelling process affect the outcome of model-based process-change projects in Norwegian enterprises?

The next section presents theory of process change and development of the a priori PMP model, whereas Section 3 presents the revised research model and our hypotheses. Section 4 then describes the research design, before Section 5 presents our results. Finally, Section 6 discusses the results and offers paths for further work.

2 Theory

2.1 Empirical Studies of Process Modelling

Considering the large interest in process modelling for process change, there are relatively few empirically-based theories and models of process-modelling practice. One group of studies has surveyed process modelling users and report on the utility of process modelling. [Iden95] interviewed BPR-consultants, finding that they were not well acquainted with available process-modelling techniques and tools. [KuKa97] interviewed participants in process modelling projects, reporting that process models were considered very useful for facilitating communication between users and IT experts. [KeCh+03] interviewed 12 consultants about their views on the advantages and disadvantages of process modelling, and found process modelling to be useful for understanding, documenting and implementing business processes. The major downside, they report, was risk of over-analysis. [Wiet06] surveyed levels of process orientation in Germans top firm's financial processes, receiving 103 responses and finding that, although overall level of process documentation was low, there was a positive correlation between documentation degree and financial chain satisfaction by CFOs: the better the documentation the better the process. [ReIn+06] conducted an ontological and empirical analysis of the BPMN notation, and identified a number of critical issues related to modelling practice, for example that interviewees indicate ambiguities in the specification of the Lane and Pool constructs.

Another group of studies reports on case studies of process modelling in enterprises. [DaJe+05] studied how enterprise modelling and, more specifically, process modelling was used in different parts of an engineering organisation. [KaLi+99] studied process modelling in three different Swedish wood-working enterprises, and found that process modelling gives a detailed and structured understanding of the relations between the business process and the problems in the enterprise. [DjCh+02] demonstrated, from a case study at the emergency department of an Australian Hospital, how a semi-conceptual modelling methodology can be used to address the needs of process and information modelling within an emergency care context. [MeMa+03] applied a self-developed modelling framework in an experiment in the Portuguese Army, showing how process models may facilitate organisational change. [BeFi+07] demonstrated the capability of business process management, including as-is and to-be process modelling, in a case study within a health care facility in the U.S. [KiKi98] introduced the enterprise process reverse engineering (EPRE) method for process analysis and redesign, and applied the method in a real BPR-project, and found the method to contribute to an efficient understanding and redesign of business processes. [PhSh00] proposed a quantitative approach to aid the analysis and comparison of process models, and found through multiple case studies that quantitative measures may be useful in the analysis of static process models.

In both groups of studies there is little or no use of established theories for developing research frameworks or for interpreting or discussing the results (with [ReIn+06] as a notable exception, see also the review of Sedera/Bandara et al's work in Section 2.2 below). Instead, much of the existing process-modelling literature is limited to demonstrating the usefulness and the benefits of process modelling through surveys, interviews and case studies. The surveys and interviews tend to be open and explorative. Their purpose is often to investigate what the respondents think about process modelling, what they use it for, which techniques and tools they use and what effects they observe. The case studies are often limited to a particular modelling technique or to an extension of an existing one. In either case, generality tends to be low and conclusions must be carefully interpreted in relation to the particular context. Also, there are few critical studies. The researchers appear positive to process modelling from the start. The theoretical contributions are confined to lists of advantages and possible pitfalls, backing up on the argument that process modelling is worth the effort. In consequence, developing a common knowledge base of process-modelling theory has been a slow, non-cumulative process brought forward by loosely coupled initiatives.

A third group of studies aims to remedy this situation by developing empirically-grounded theories of process modelling from the ground up. This group includes the Process-Modelling Success model (e.g. [RoSe+01], [ChRo02], [SeRo+02], [SeRo+03], [SeGa+04], [BaGa+05a], [BaGa+05b], [BaGa+06]) and the authors' Process-Modelling Practice (PMP) model ([IdEi+06], [EiId+08]). Another example is [ReIn+06], although this line of research has a slightly different focus. Hence, only the two former are discussed below.

2.2 The Process-Modelling Success Model

In its re-specified form, after validation, ([SeRo+03], [SeGa+04]) Process-Modelling Success (PM-Success) model has two main variables ([BaGa+05a], [BaGa+06]), success factors and success measures, in addition to a selection of moderating variables acting as controls. The success factors are divided into project-specific and modelling-related factors. Project-specific success factors are stakeholder participation (degree of input from process roles), management support (level of commitment by senior management), information resources (resources available to inform the modelling project), project management (management of the process modelling project) and modeller expertise (experiences of the process modellers). Modelling-related success factors are modelling methodology (instructions for the process of modelling), modelling language (grammar or the syntactic rules) and *modelling tool* (software that facilitates design, maintenance and distribution of process models). The success measures are *model quality*, *user satisfaction*, *individual impacts* (how process modelling has influenced project stakeholders), *process impacts* (overall effect of modelling on the process) and *project efficiency* (ability to maximise obtained outcomes in relation to the invested

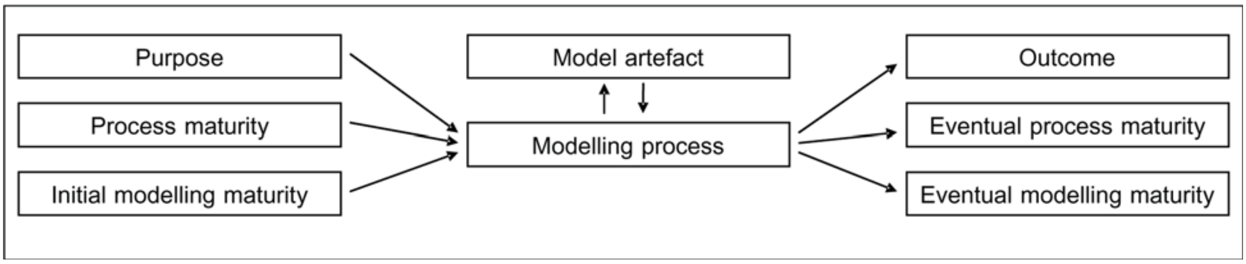

Figure 1: The a priori Process-Modelling Practice (PMP) model [IdEi+06]

resources). The relationship from the success factors to the success measures is moderated by two additional variables, *importance* and *complexity*.

2.3 The Process-Modelling Practice Model

The Process-Modelling Practice (PMP) model ([IdEi+06], [EiId+08]) aims at describing *model-based process-change projects*. The scarcity of available theories and instruments at the time (2004) made us take an explorative approach to complement the emerging PM-Success model. Furthermore, our Norwegian context was characterised by relatively *high worker involvement* (e.g., worker representation in executive boards mandated by law) and *low power distance* [Hofs97], suggesting that process-modelling practice in Norway might differ from the prescriptions and descriptions in the predominantly Anglo-American literature, as supported by early evidence [IdEi+06]. We therefore chose to emphasise worker involvement and power distance and other *organisational and social aspects* in our research. For example, we included *competence* and *learning* as prerequisites for and consequences of process modelling, assuming that, to have an impact, process-change projects across the world need to handle organisational and social issues differently because of differences in culture.

Development and validation of the PMP model is described in detail in [EiId+08]. We first developed an *a priori model* based on a review of empirical studies of process-modelling projects, review of appropriate theory, considerations about the Norwegian cultural context and the researchers' experiences from participating in numerous process- and enterprise-modelling projects.

The a priori PMP model has two central variables, as shown in Figure 1: *Modelling process* and *Model artefact,* reflecting the activity-artefact dichotomy emphasised by many IS authors, e.g. [Floy99], and in Activity Theory ([Vygo86], [Enge99]). Their relevance is corroborated by [DaJe+05] central distinction between modelling and models, and the distinction in the PM-Success model between *project-specific* and *modelling-related* factors. We selected a set of candidate issues from the literature for use in our interview guide, since no developed instruments existed for either variable at the time. We reviewed the relevant dimensions of the PM-success model and supplemented them by adapting ideas from the Technology Acceptance Model [Davi89] and the IS Success Model ([DeMc92], [DeMc03]). The resulting issues were grounded in literature, practical experience or data from the pilot interviews.

The a priori PMP model introduced *Purpose* as a variable that referred to the anticipated outcomes of process modelling, consistent with theories that emphasize the *intentionality* of human activity (e.g. [Vygo86]) and open for purposes not described in the literature. The model separated the *intended artefacts produced* from the *intended effects of process modelling*, following the project-management literature (e.g. [AnGru+04], [Fram95]). *Outcome* was introduced as a dependent variable, subdivided into *attainment of purpose* and the *actual effect of process modelling* on processes. The *Purpose* and *Outcome* variables are consistent with [DaJe+05] *Process Model Value Model*.

Competence and *learning* are inspired by the Capability Maturity Model (CMM) [PaCu+93]. The a priori PMP model included *process* and *(process-)modelling maturity*, inspired by the maturity levels in the original CMM. Organisational learning was included through *initial* and *eventual maturities*, i.e., changes in *process-* or *process-modelling maturity* resulting from the process-change project. We expected particular types of *Modelling purpose*, along with an organisation's *Initial process* and *process-modelling maturities*, to be associated with particular types of *Modelling processes*. Particular types of *Modelling processes* were expected to produce and use particular types of *Model artefacts*. Together, we expected particular types of modelling processes and model artefacts to be associated with particular *Outcomes* and produce the organisation's *Eventual process* and *modelling maturity*. [Ham07] also recognises *process maturity* as distinct from *enterprise maturity*.

We developed a semi-structured *interview guide*, which was iteratively improved through 8 *pilot* *interviews*. The research model and interview guide were then *initially validated* in a study of 34 projects [EiId+08]. The results indicated that several aspects of the *Modelling process* were positively related to *Outcome*. On the other hand, the study was not able to establish the importance of the *Model artefact*.

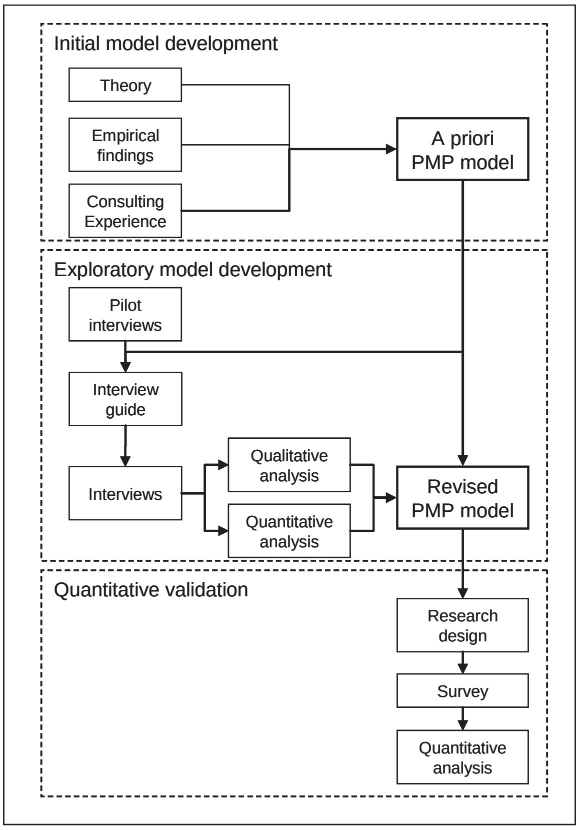

Figure 2: The overall research design

Figure 2 provides an overview of our overall research design, comprising three distinct phases, *Initial model development*, *Exploratory model development* and *Quantitative validation*. The first two phases were essential in securing content validity, as will be discussed in Section 5.2. An overview of these two phases, up to revising the PMP model, is given in [EiId+08]. The lower part depicts the quantitative validation covered in the present paper, along with revising the PMP model. Hence, the present paper augments our earlier qualitative contributions ([IdEi+06], [IdOp+07], [EiId+08]) with a quantitative hypothesis-testing study.

3 Research Model and Hypotheses

3.1 Revising the Process-Modelling Practice Model

Based on the initial qualitative validation [EiId+08], the a priori PMP model was revised, as shown in Figure 3. The three boxes *Process modelling*, *Process competence* and *Project outcome* in this Figure represent *variables* (or *top-level construct)*, which are abstractions that describe phenomena of theoretical interest for our study [PeSt+07]. Furthermore, these three variables are *multi-dimensional*, meaning that each of them has several *dimensions* (or *sub-constructs*), each of which represents some portion of the overall latent construct [PeSt+07]. Hence all our variables are formative.

The revised model retains Modelling process of Figure 1 as an independent variable, defining it as “the activities carried out within the project to improve the organisation's processes.” The following sub-constructs from the initial study are included as dimensions. Management support describes how extensively and visibly management gave its support to the process-modelling project. Employee participation describes how broadly and deeply the various stakeholders and roles in the organisation were involved in the project. In-project training reflects the extent to which training in process orientation and process modelling was given as part of the project. Lack of resistance describes to which extent the project met resistance within the organisation. Model type describes whether modelling was systematic and thorough, i.e., based on a standard notation, covering both present and future situations and using a more elaborate swim-lane based notation. We will motivate and explain each of them further in the hypothesis Section below.

The revised model introduces *Process competence* as an independent variable that accounts for initial maturities with respect to process and process-modelling. *Process competence* is defined as “the organisation's ability to manage, model and improve its processes” and is formed by the following two dimensions. *Process-orientation competence* reflects the organisation's ability to manage and improve its processes independently of model use (corresponding to *Initial process maturity* in Figure 1). *Process-modelling competence* reflects the organisation's ability to model its processes and effectively using the resulting models (corresponding to *Initial process-modelling maturity* in the initial study). Again, each of them will be motivated and explained further in the hypothesis Section.

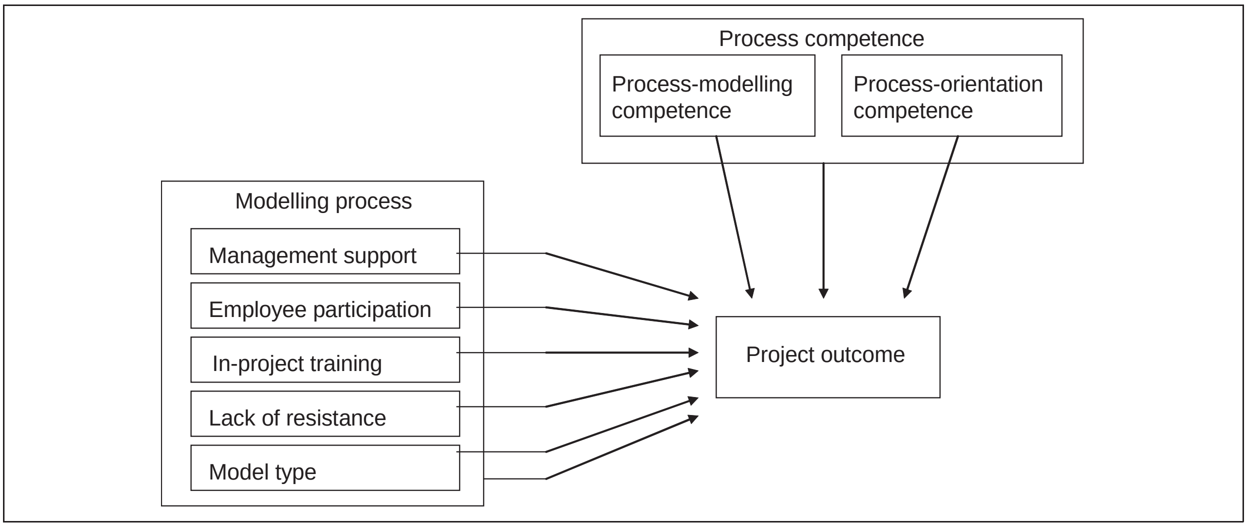

Figure 3: The revised Process-Modelling Practice (PMP) model

The dependent variable, *Project outcome*, is defined as "the results of the project to the organisation, including achievement of project goals, effected organisational changes and learning." It comprises the following dimensions: *Goal achievement* describes the extent to which the project met the goals that were set at its initiation. *Organisational impact* reflects the extent to which the process was changed after the project, using the criteria from the literature that were most prominent in the initial study. *Process-orientation learning* describes to what extent the organisation and its people have increased their competencies in process orientation. *Process-modelling learning* describes to what extent competencies in process modelling have increased.

3.2 Hypotheses

In the revised model, *Process competence* and *Modelling process* are considered independent variables determining the dependent variable *Project outcome*. The causal effect of *Modelling process* on *Project outcome* reflects relationships in the initial model that were validated in the initial study. The causal effect of *Process competence* on *Project outcome* differs from the initial model, where the relationship between initial maturities and outcome was *indirect* through the modelling-process construct. The initial study found some indications of direct effects of competence on outcome and eventual maturity, explaining the revision of the model. In each case, the direction of causality can be justified by a temporal precedence: *Process competence* reflects the state of the organisation *before* the *Modelling process* was initiated, whereas *Project outcome* reflects the organisation's state *after* the *Modelling process*.

We state hypotheses both at the top-level between the three multi-dimensional variables and at the decomposed level, between their dimensions. Following [PeSt+07], if it is possible to show that both the (first order) variables and (second order) dimensions are related, analysing both levels gives the most complete and accurate picture. Nine hypotheses were thus derived, as summarised in Table 1, each corresponding to a relation between two main variables or dimensions in Figure 3.

Hypothesis H1: Modelling process is positively related to project outcome.

In the qualitative study we found more *extensive outcomes* in projects that were characterised by elaborate *modelling processes* in terms of management support, employee participation, in-project training and presence of resistance. Hypothesis H1 thus assumes a positive correlation between the two variables *Modelling process* and *Project outcome*. The *Modelling process* variable comprises five dimensions as explained in hypothesis H1.1-H1.5 below, whereas the *Project outcome* variable has four dimensions, *Goal achievement*, *New process-orientation competence*, *New process-modelling competence* and *Organisational effects*.

Hypothesis H1.1: Management support is positively related to project outcome.

In the qualitative study, one of the aspects of modelling processes that appeared to have impact on project outcome was *Management support* ([IdOp+07], [EiId+08]), operationalised as whether high-level managers actively and explicitly supported the project and to what extent they were actively involved. *Management support* was therefore chosen as the first dimension of the multi-dimensional *Modelling*

	Hypotheses
H1	Modelling process is positively related to project outcome
H1.1	Management support is positively related to project outcome
H1.2	Employee participation is positively related to project outcome
H1.3	In-project training is positively related to project outcome
H1.4	*Presence of* resistance is positively related to project outcome
H1.5	Model type is positively related to project outcome
H2	Competence in process orientation and process modelling is positively related to project outcome
H2.1	Competence in process orientation is positively related to project outcome
H2.2	Competence in process modelling is positively related to project outcome

Table 1: Hypotheses derived from the relationships in Figure 3

process variable. Hypothesis H1.1 assumes a positive correlation between this dimension and the *Project outcome* variable.

Hypothesis H1.2: Employee participation is positively related to project outcome.

Another aspect of modelling processes that appeared to have impact on project outcome in the qualitative study was *employee participation* ([IdOp+07], [EiId+08]), operationalised in terms of how many people and which different roles were involved in process modelling and how, i.e., whether they were all drawing models or just commenting on models presented by modelling experts. *Employee participation* was therefore chosen as another dimension of the *Modelling process* variable. Hypothesis H1.2 assumes a positive correlation between this dimension and *Project outcome*.

Hypothesis H1.3: In-project training is positively related to project outcome.

In-project-training also appeared to lead to extensive project outcomes in the initial study ([IdOp+07], [EiId+08]), including both training in process orientation and in process modelling. It was therefore chosen as the third dimension of *Modelling process*. Hypothesis H1.3 states that *In-project training* is positively correlated to *Project outcome*.

Hypothesis H1.4: Presence of resistance is positively related to project outcome.

Somewhat surprisingly, the initial qualitative study indicated that projects with *presence of resistance* had more extensive project outcomes than projects with little or no resistance. [IdOp+07] suggest that resistance is addressed early in the project when they can still be resolved, instead of postponing conflicts to a later stage where they may limit outcome more severely and that “those projects that have encountered resistance may have put more effort into change management, information and motivation and, thereby, managed to lead the project towards an extensive outcome.” On the other hand, the study did not include many projects with high resistance and the differences between high- and low-resistance projects were not large. Nevertheless, we chose to include *presence of resistance* as a dimension of *Modelling process*, and hypothesis H1.4 assumes a positive correlation between *Presence of resistance* and *Modelling process.*

Hypothesis H1.5: Model type is positively related to project outcome.

In the qualitative study, *Model artefact* was one of the *a priori* analysis categories, but we could not demonstrate a clear impact of model artefacts on project outcome ([IdOp+07], [EiId+08]). However, a few aspects of model artefacts appeared to be more common in the most successful projects [EiId+08], such as using a well-defined notation, using (presumably more advanced) swim-lane notations and drawing both as-is and to-be models. We wanted to investigate these issues more closely in the quantitative study. *Model type* was therefore chosen as the last dimension of the multi-dimensional *Modelling process* variable, operationalised in terms of whether a well-defined notation was used, whether the notation used swim lanes, and whether as-is and to-be models were created. In consequence, *Model type* becomes a formative, as opposed to reflective, dimension [PeSt+07]. Hypothesis H1.5 thus assumes a positive correlation between this dimension and the *Project outcome* variable.

Hypothesis H2: Competence in process orientation and process modelling is positively related to project outcome.

Although the initial study could not demonstrate a clear impact of competence (or initial maturity) in process orientation and process modelling on project outcome ([IdOp+07], [EiId+08]), we did not want to drop this as a hypothesis, because of the demonstrated usefulness of maturity frameworks like CMM and SPICE in software development and the broad current interest of quality frameworks for other types of processes. Also, our initial study did show a clear relationship between competence/maturity before and after the process-change projects. Including hypotheses about competence could therefore be justified because our revised *Project outcome* variable included eventual competences in both process orientation and process modelling as dimensions. Hypothesis H2 thus assumes a positive correlation between the two variables *Process competence* and *Project outcome*. The *Process competence* variable comprises two dimensions as explained in hypothesis H2.1 and H2.2 below, whereas the *Project outcome* variable has four dimensions as before.

Hypothesis H2.1: Competence in process orientation is positively related to project outcome.

In the qualitative study, one of the aspects of process competence dealt with process orientation in itself ([IdOp+07], [EiId+08]), operationalised in terms of whether processes were described and standardised, process ownership established, process goals set and goal achievement monitored. *Competence in process orientation* was therefore chosen as the first dimension of the multi-dimensional *Process competence* variable. Hypothesis H2.1 assumes a positive correlation between this dimension and *Project outcome*.

Hypothesis H2.2: Competence in process modelling is positively related to project outcome.

In the qualitative study, one of the aspects of process competence dealt with process modelling ability ([IdOp+07], [EiId+08]), operationalised in terms of whether process modelling was much used in the organisation, a standard notation defined, the models themselves much used and continually updated. *Competence in process modelling* was therefore chosen as the second dimension of the multi-dimensional *Process competence* variable. Hypothesis H2.2 assumes a positive correlation between this dimension and *Project outcome*.

4 Research Methods

4.1 Research Design

To test our research model and hypotheses, we conducted a cross-sectional field study with individual model-based process-change projects as the level of analysis. A questionnaire was administered by regular mail to a selection of Norwegian enterprises in June 2007, targeting personnel who had been actively involved in one or more process-development projects, e.g. quality managers, process owners, IT managers, process developers, system developers and consultants. Our sampling frame comprised the participants at a national industrial IT conference, the largest enterprises in western Norway and the members of a regional interest group for process development. Hence sampling was convenient, using available address lists, as well as self-selected. In total, 460 questionnaires were administered. The informants were asked to answer the questionnaire based on a self-chosen project in which they had been involved during the past 5 years.

4.2 Operationalisations and Measurements

We operationalised the theoretical constructs in the refined research model in Figure 3 based on questions from the interview guide for the initial validation. The resulting survey instrument [SuIn08] comprised 69 questions. Indicators of the dimensions of *Modelling process* (21 indicators), *Process competence* (8 indicators) and *Project outcome* (17 indicators) were measured using response formats of a 5-point Likert-type scale, with three-to-six indicators for each dimension. There were exceptions for two of the *Modelling process* dimensions: *Management support* comprised a pair of multiple-choice indicators, and *Employee participation* was operationalised by combining a multiple-choice indicator with three Likert-type indicators. By combining information from these indicators, variable indicators were created as new ordinal indicators. In addition, the survey instrument controlled for the *Context* of the project, organisation and individual informant (18 questions). The *Individual context* describes central characteristics of the informant, his/her current position, experience with process change and with process modelling, and in what roles. The *Project context* describes the project from which the informant responds, including its size in terms of people involved and *Purpose*, in the form of delivery and organisational goals. The *Organisational context* describes the setting for the project, including business sector and organisation size. Finally, the instrument contained 5 indicators to be answered only by respondents from organisations that had *not* used process modelling in their projects. These respondents were asked to give their reasons for *not* using process models. But because our unit analysis in the present paper is *model-based* process-change projects, we have not included responses from the respondents who had not used process modelling, ignoring these final 5 indicators.

5 Results

5.1 Responses

We received 90 responses, giving a response rate of 19.6%. On average, the respondents had worked with process improvement for 5 years and process modelling for 3 years. The largest respondent groups were process developers and external consultants, as shown in Figure 4a. Other important respondent groups were IT managers, consultants, quality managers and department heads. Figure 4b shows that organisations in the public, telecom/media and IT sectors had the highest numbers of respondents. Organisation sizes ranged from 12 to 18.000 employees, with an average of 2343. Project sizes ranged from 4 to 350 people involved, with an average of 29. Within the project they reported from, most respondents had acted as project leaders, process developers (facilitators) and process modellers. Other common roles were department manager, IT advisor, role representative and external consultant.

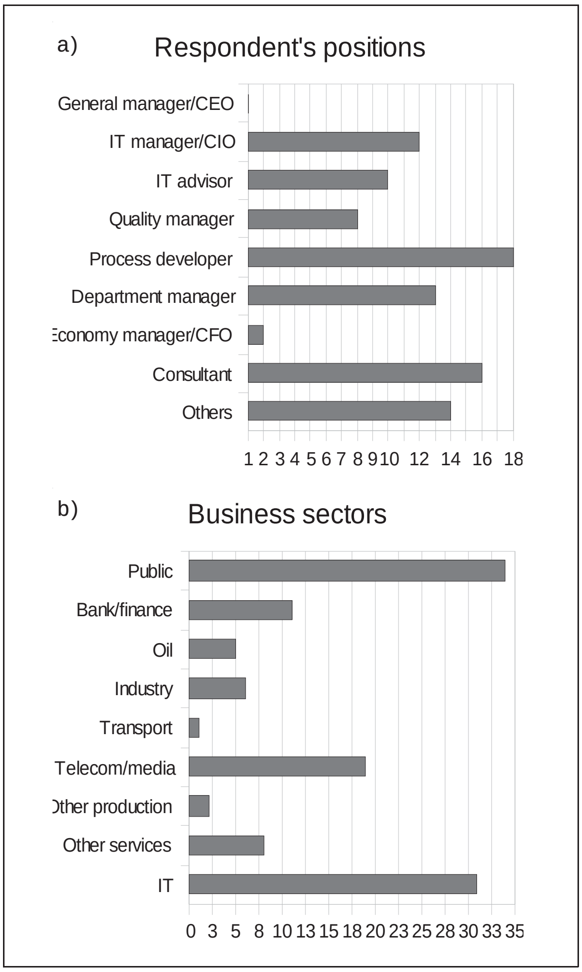

Figure 4: The positions of the 90 respondents and the business sectors of their organisations (the y-axes show numbers of respondents)

5.2 Content Validity

Our goal is to develop a relevant and useful theory of process modelling practice, where content validity forms the basis for the construct validity and predictive validity of our model. We have therefore followed the guidelines of [StBo+04], who describe content validity as the sine qua non of theory building and subsequent instrumentation in a research process. The purpose of securing content validity is to make sure that the phenomenon of interest is correctly described in the constructs that are developed and, furthermore, that the instruments used to measure these constructs have the right content. We have ensured content validity first by building our study on a comprehensive review of available literature, as reported in Section 2.

Because the Scandinavian context is special and theories describing process modelling practice are scarce and developed in other contexts, there is a risk that important aspects of this phenomenon are not sufficiently represented in the existing literature. We therefore highlighted, assessed and improved content validity further through several stages of interviews, as described in Section 2.3. In addition, the authors' experiences from industrial process- and enterprise-modelling projects contributed to the process. Hence, several of the standard methods for securing content validity were used in our study, both in combination and iteratively, as recommended in [StBo+04].

5.3 Construct Validity

Construct validity was assessed in terms of discriminant and convergent validity in a two-step procedure. The first step assessed *discriminant validity* through exploratory factor analysis. We considered an exploratory approach sufficient at this stage because of the early stage of theory development and the likelihood that characteristics of our research context were not described in theory. All the dimensions measured using reflective indicators and Likert-type scales were included in the factor analysis. *Management support* and *Employee participation* were included, after transforming the three multiple-choice indicators into ordinal scales (1-6, 1-13 and 1-4, respectively). As a result, the factor analysis covered 42 indicators. The scores for all indicators were normalised into the 0-1 range.

Factors were extracted from the normalised indicators for all 90 respondents using Principal Component Analysis and Varimax-rotated using Kaiser Normalisation. Analysis was iterative, with indicators dropped in each iteration according to the following criteria: all items were dropped that did not load on the same factor as the other indicators in the same dimension (unless the dimension was *formative)*. Also, all items were dropped that loaded on multiple factors. In the end, 33 indicators remained, as shown in Appendix 1. In this final rotated matrix, all factor loadings were > 0.5, described by [HaBl+06] as “very significant”.

4 out of the 33 indicators had loadings that were between .2 and .3 greater than the second highest loading. 7 out of the remaining 29 indicators had loadings that were between .3 and .4 above the second highest loading. All of the remaining 22 indicators loaded only on one factor. Cumulatively, the 7 factors explained 72.6% of total variance in the 33 indicators.

Appendix 1 shows that the *reflective indicators* (indicators EC2, EC3, P1, P3 and P4 in Appendix 1 and 2) all loaded on different factors, each relating back to a different dimension in Figure 3. Indicator P5 (*Model type*) in Appendix 1 also loaded on factors that were distinct from the other dimensions, but this indicator loaded on three *different* factors, which is acceptable for a *formative indicator* that combines multiple underlying factors. In the end, all remaining indicators of the four dimensions of *Project outcome* loaded onto the same distinct factor. *Project outcome* was therefore treated as a uni-dimensional variable in the rest of the analysis.

The next step assessed *convergent validity* in terms of Cronbach's coefficient alpha of the set of indicators within each dimension. See Appendix 2 for an overview of the variables, their reliability and retained indicators. The final measure for each variable was calculated as an index based on the retained indicators, weighing the contribution of each indicator to its dimension with the indicator's component scores from Appendix 1. Alpha coefficients were calculated for all the revised measurement scales containing reflective indicators. All alpha coefficients were above 0.7 for the reflective indicators, indicating sufficient convergent validity/reliability for our explorative, validation study. Appendix 2 provides an overview of the variables used, their reliabilities as well as the remaining indicators used in their final measurement.

5.4 Testing the Hypotheses

Pearson's correlations were chosen to test our hypotheses. Pearson's correlation assumes normally distributed data and measurements at the ratio or interval level. Kolmogorov-Smirnov tests confirmed that the two main variables *Modelling process* and *Project outcome* were normally distributed, as were dimensions P1 (*Management support)* and P4 (*Lack of resistance)* in Appendix 1 and 2. On the other hand, dimensions CE2, CE3, P3 and P5 were not normally distributed and the corresponding results should be used with some caution. Also, the Likert-type measurement scales with 5 response categories used deviate from the assumptions behind Pearson's correlation. However, simulation studies have documented that Likert-type scales with 5 or more response categories are similar to measurements at the ratio or interval level, thus suitable for Pearson's correlation (e.g. [JoCr83]).

Four of the eight hypotheses were supported as shown in Figure 5. *Management support*, *In-project training* and *Model type* are all significantly correlated to *Project outcome*. In addition, one hypothesis was confirmed in the opposite direction of what we had expected. *Lack* (and not *Presence) of resistance* is significantly and positively correlated to *Project outcome.* All indicators for *Employee participation* had to be dropped during factor analysis, so this variable could not be considered further in the analysis. No significant correlations were found from *Process competence* or its two dimensions to *Project outcome*.

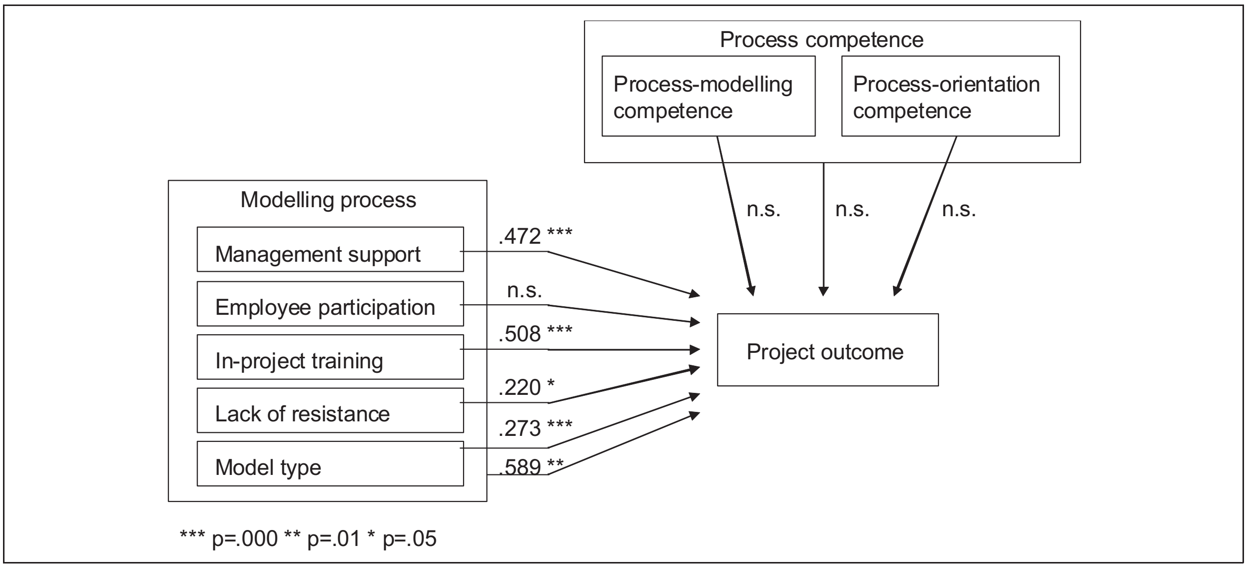

Figure 5: One-tailed Pearson's correlations

5.5 Statistical Control

We performed independent correlation analyses (partial tables) for each of the three largest business sectors in our sample, i.e., public administration, telecoms and IT. In each independent analysis, we calculated the Pearson's correlations between all the variables and dimensions in our model, using data from all the projects in our sample that took placewithin that business sector. For the public sector companies, all the correlations were higher than shown in Figure 5, except for modelling type. For the telecoms/media companies, all the correlations were higher. Competences in process orientation or process modelling were not significant for either sector. For the IT companies, the correlations tended to be weaker, and competences were negatively correlated with outcome. However, few of the correlations were significant, because the broken-down samples were small, and we found no patterns of significant cross-sector differences. We therefore conclude that our main findings from Section 5.4 were robust across business sectors.

We then performed partial correlation analyses between the *Process modelling* and *Project outcome* variables and their dimensions, while controlling for process-orientation and process-modelling competence. The results confirmed that *Management support* and *In-project training* remained significantly correlated to *Project outcome*, although *Lack of resistance* and *Model type* were no longer significant. Multiple regression for all dimensions CE2-CE3, P1, P3-P5 confirmed that *Management support* and *In-project training* were the most robust independent predictors of Outcome. It is no surprise that the influence of resistance is smaller in projects that take place in highly competent organisations, because resistance can in some cases be attributed to lack of knowledge about process orientation and process modelling. Likewise, it is no surprise that the influence of in-project training is smaller in such organisations, because the effect of training may be greater in organisations where competence is low.

	Hypotheses	**Results**
H1	Modelling process is positively related to project outcome	p ≤ 0.000
H1.1	Management support is positively related to project outcome	p ≤ 0.000
H1.2	Employee participation is positively related to project outcome	-
H1.3	In-project training is positively related to project outcome	p ≤ 0.000
H1.4	*Lack of* resistance is positively related to project outcome	p ≤ 0.028
H1.5	Model type is positively related to project outcome	p ≤ 0.009
H2	Competence in process orientation and process modelling is positively related to project outcome	n.s.
H2.1	Competence in process orientation is positively related to project outcome	n.s.
H2.2	Competence in process modelling is positively related to project outcome	n.s.

Table 2: The results of testing the main hypotheses in Table 1

6 Discussion and Conclusion

The paper has revised a model of process-modelling practice developed in an earlier study and tested it empirically in a survey of Norwegian model-based process-change projects. Due to the scarcity of theories and instruments on process modelling practice, our research has been exploratory in nature, albeit informed by our earlier studies and by the existing literature. A central hypothesis of our research model was confirmed: a positive correlation exists between *Modelling processes* and *Project outcome*. Among the dimensions of the *Modelling process* variable, management support and in-project training are the most robust predictors of project outcome. Our other central hypothesis could not be confirmed: higher organisational *Process competence* was not positively correlated to *Project outcome*. Our study also contradicts a suggestion from our initial study [IdOp+07] that *presence*, as opposed to *lack*, of resistance is beneficial for model-based process-change projects.

Another central outcome of our study is the validated process-modelling practice model itself, which indicates that the outcome of model-based process-change projects is explained by a combination of technological (i.e., *Model type)*, social (i.e., *Lack of resistance)*, organisational (i.e., *Management support)* factors. Through its consideration of social and organisational issues in addition to technology, this model will hopefully be sensitive to differences in national culture, as explained in the introduction and in Section 2.3.

The implications for practice are straightforward: both *Management support* and *In-project training* are critical for effective model-based process-change projects. Organisational culture and project-execution strategies that avoid and defuse *resistance* are also beneficial. Furthermore, there is a benefit in using more elaborate models, modelling techniques and tools, as evidenced by the significant correlation between *Model type* and *Project outcome*. The study thereby confirms the dimensions of our *Modelling process variable* (except for *Employee participation*, which had to be dropped after factor analysis).

Surprisingly, *Process competence* was not related to *Project outcome*, as could be expected from the demonstrated usefulness of maturity frameworks like CMM and SPICE in software development and the broad current interest of quality frameworks for other types of processes. Possible explanations are low content validity of the instrument, or that *Process modelling* can indeed be used effectively by organisations with or without *Process competence.* A third explanation is that most organisations with high *Process competence* will already have reaped the largest benefits from past process-change projects, resulting in diminishing returns on further projects.

The study has several methodological limitations. Sample size was low, the sample was convenient and the response rate low (<20%). The survey instrument needs to be further refined and validated with data from other contexts. For example, none of the indicators for *Employee participation* and only one indicator for *In-project training* was retained after factor analysis. The breadth, depth and quality of the measurements for these dimensions need to be improved in further work. The correlation analysis should also be supplemented by second generation statistical analysis, using structural equation modelling (SEM). Partial Least Squares (PLS) is a second generation technique recommended for research models that combine reflective and formative constructs [PeSt+07]. Our findings are also primarily generalisable to SMEs and to the Nordic cultural sphere. Although the partial tables and other statistical controls presented in Section 5.5 indicate that our results are relatively robust, further studies are needed to improve the external validity of our findings. Cross-national studies could even investigate the impacts of differences in national culture on process-development projects, along the lines of [IdEi+06]. Cross-cultural aspects of process development and process modelling will become increasingly important in the global economy, e.g., when coordinated process change is sought within international organisations that combine a management-driven, top-down approach in some national offices with a more bottom-up or middle-out approach elsewhere.

As already mentioned, our analysis indicates that the outcome of model-based process-change projects is explained by a combination of technological (i.e., *Model type)*, social (i.e., *Lack of resistance)*, organisational (i.e., *Management support)* factors. But the present study cannot exclude the importance of additional dimensions of *Modelling process*. For example, further studies should investigate the effects of *resources*, i.e., whether adequate budget, personnel and time was available for carrying out the project. Also, *Lack of resistance* is only weakly (albeit significantly) related to outcome. The research model should therefore investigate the effects of *organisational culture* [Brow98] in a broader sense. The relation of *Model type* to *Project outcome* is also weak (though significant), so *Model type* might exploratively be split into several dimensions. The re-specified Process-Modelling Success (PM-Success) model [BaGa+05a] distinguishes between *modelling methodology*, *modelling language* and *modelling tool*. However, our initial study did not provide support for such detailed dimensions of *Model artefact* having an impact on *Outcome.* A possible explanation is that, unlike the PM-Success model, our measure of *Project outcome* does not include *Model quality* as a dimension of the dependent variable.

Now that the PM-Success model has been finalised [BaGa+06], it is possible to compare the two with the aim to improve the research models and share instruments. Besides differences in model artefacts, both models confirm the importance of *Management support.* The significance of *Employee participation* could not be validated in the study. The PMP model emphasises *Lack of resistance* and *In-project training*, whereas the PM-Success model emphasises *Information resources* and *Project management*. Further studies should seek to increase content validity of the PMP model's *Process modelling* variable by including dimensions from the PM-Success model. Further studies should also seek to increase instrument reliability and validity by adopting and adapting some of the PM-Success model's measures.

On the dependent-variable side, our *Project outcome* variable resembles the *PM-Success measure* [BaGa+06] in that they both distinguish *attainment of purpose* (*Goal achievement* in our study, *Process efficiency* in the PM-Success measure) from the *actual effect of process modelling* on processes (*Organisational impact* in our study, *Process impacts* in the PM-Success measure).

On the other hand, the match between the two pairs of dimensions is not exact. The items in the PMP model tend to be spread more broadly, as reflected by the lower alpha coefficients they produce. Unlike the PMP model, the PM-Success model does not address organisational learning. On the other hand, [BaGa+06] include *Model quality* in their success measure. It is not obvious that model quality is a dimension of the dependent rather than the independent variable. Indeed, different process-change projects may develop models of various quality depending on context, and a research model of such projects should incorporate the effects of choosing a higher or lower quality model on project outcome. For this purpose, in terms of the PMP model, we therefore argue that process-model quality should be a dimension of *Modelling process* and not of *Project outcome*.

Further comparing and combining elements from the PMP and the PM-Success models is a promising research path. Research based on the Theory of Reasoned Action [FiAj75] and the Theory of Planned Behaviour [Ajze91] illustrates how additional technological, social and organisational perspectives could be included in behavioural models. Now that the PMP model has been empirically validated, it is time to revisit some of the theories and instruments that inspired us initially, such as the Technology Acceptance Model [Davi89], the IS Success Model ([DeMc92], [DeMc03]) and the Capability Maturity Model [PaCu+93], as well as others.

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Appendix 1: Factor analysis results

	Factor								
	1	2	3	4	5	6	7	8	9
Process-Orientation Competence (EC2)									
EC2a: processes described and standardised		,419	,736						
EC2b: process ownership well established			,794						
EC2c: explicit process goals			,754						
EC2d: systematic monitoring of goals		,415	,646						
Process-Modelling Competence (EC3)									
EC3a: process modelling much used		,720	,339						
EC3b: standard modelling notation established		,829							
EC3c: process models much used		,817							
EC3d: process models kept up-to-date		,777							
Management Support (P1)									
P1a: explicit top management support					,637	,424			
P1b: top management participated in modelling					,919				
P1c: top management actively followed-up	,349		,310		,771				
In-project Training (P3)									
P3a: adequate process training offered							,872		
Lack of Resistance (P4*)									
P4a: employee resistance to process modelling				,821					
P4b: top management resistance to proc. modelling				,847					
P4c: resistance has reduced organisational effects				,731			,425		
P4d: resistance has reduced project results				,729			,452		
Model Type (P5)									
P5a: well-defined process model notation						,693			
P5b: explicit models of current situation								,896	
P5c: explicit models of future situation	,334								,761
P5d: swimlanes to show actors/roles	,322					,674			
Goal Achievement (O1)									
O1a: project has improved the processes	,793								
O1b: planned deliverables produced	,699								
O1c: project effect goals achieved	,556							,333	
Process Change (O2)									
O2a: processes described and standardised	,752								
O2b: process ownership well established	,763								
O2c: explicit process goals	,704								
Process Use (O3)									
O3a: process modelling much used	,736								
O3c: process models much used	,756								
O3d: process models kept up-to-date	,693								
Organisational Change (O4).									
O4a: productivity gains	,697					,356			,332
O4b: quality improvement	,818								
O4c: increased efficiency	,749					,363			
O4d: clearer responsibility distribution	,689								

Extraction Method: Principal Component Analysis. Varimax rotation with Kaiser Normalization converged in 9 iterations

Appendix 2: Indicators used in the final analysis

Process-Orientation Competence (EC2). Scale reliability (Coeff. alpha): 0.81
EC2a: Before the project, processes were described and standardised in the enterprise
EC2b: Before the project, process ownership was well established in the enterprise
EC2c: Before the project, explicit process goals were set in the enterprise
EC2d: Before the project, the goal achievement for the enterprise's processes was systematically monitored
Process-Modelling Competence (EC3). Scale reliability (Coeff. alpha): 0.82
EC3a: Before the project, process modelling was much used in the enterprise
EC3b: Before the project, a standard modelling notation was well established in the enterprise
EC3c: Before the project, the enterprise's process models were much used
EC3d: Before the project, one kept the enterprise's process models up-to-date whenever the organisation changed
Management Support (P1). Scale reliability (Coeff. alpha): 0.83
P1a: Top management has explicitly expressed to the whole enterprise that process modelling was important
P1b: Top management have participated actively in the process modelling
P1c: Top management have actively followed-up the process modelling during the project
In-project Training (P3). Scale reliability (Coeff. alpha): -
P3a: Adequate training in process orientation was offered in relation to the project
Lack of Resistance (P4*). Scale reliability (Coeff. alpha): 0.85
P4a: There has been expressions of resistance to process modelling from affected employees
P4b There has been expressions of resistance to process modelling from affected top managers
P4c: Resistance has made the project have more limited effect on the organisation than planned
P4d: Resistance has made the project deliver more limited results than planned
Model Type (P5). Scale reliability (Coeff. alpha): -
P5a: The project used a well-defined (standard or own) process-modelling notation
P5b: The project modelled the current situation explicitly for each process
P5c: The project modelled the future situation explicitly for each process
P5d: The project used 'swimlanes' to show process actors/roles
Goal Achievement (O1). Scale reliability (Coeff. alpha): 0.75
O1a: The enterprise's process have been improved because of the project
O1b: The planned deliverables have been produced
O1c: The project effect goals set for the project have been achieved
Process Change (O2). Scale reliability (Coeff. alpha): 0.84
O2a: Because of the project, processes are described and standardised in the enterprise today
O2b: Because of the project, process ownership is well established in the enterprise today
O2c: Because of the project, explicit process goals are set in the enterprise today
Process Use (O3). Scale reliability (Coeff. alpha): 0.81
O3a: Because of the project, process modelling is much used in the enterprise today
O3c: Because of the project, the enterprise's process models are much used today
O3d: Because of the project, one keeps the enterprise's process models up-to-date whenever the organisation changes
Organisational Change (O4). Scale reliability (Coeff. alpha): 0.85
O4a: Because of the project, one has achieved productivity gains
O4b: Because of the project, one has achieved quality improvement
O4c: Because of the project, one has achieved increased efficiency
O4d: Because of the project, one has achieved a clearer responsibility distribution