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Repeated use of process models: The impact of artifact, technological, and individual factors

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ABSTRACT

Business process modeling has received a lot of attention from practitioners and researchers alike. Organizations make significant investments into process modeling in terms of training, tools, and resources. Yet, having invested into creating large process model collections, process models often fall into disuse, provoking the impression that the initial investment has been lost. While previous work has aimed at exploring model re-use as a design principle, our work examines repeated use of a model as a behavior and thus aims at identifying factors that facilitate or hinder the repeated use of process models by individual users. We develop a conceptual model of factors that can influence an individual's intention to repeatedly use process models. We evaluate this model through a cross-sectional survey of process model users from a large European financial institution. Our results indicate the importance of quality and ease of understanding of process models to repeated use, alongside individual factors, such as motivation and individual expertise. We identify means that help organizations to promote the repeated use of process models, which can assist them to increase the benefits of process modeling.

1. Introduction

Process models provide information about the tasks, data, resources, and actors of a business process [1]. They are used for describing business requirements for organizational, technical systems design, or redesign decisions [2]. Many organizations commit ongoing and substantial investments in process modeling and the creation of process model collections [3]. For example, a manufacturing company that we are in contact with has a core modeling team of more than 20 people and over 1000 casual modelers in different lines of business who create new process models or maintain existing ones.

After having invested in the creation of process models, organizations often face the problem that models fall into disuse, which means that investments in process modeling are at risk of being lost [4]. In order for process modeling to be beneficial, the *repeated use* of models by end users has been identified as a key challenge [5]. With repeated use, we mean using an existing model again at a different *point in time* for the *same* or a *different task*. This notion of repeated use is broader than continued use because it includes using a model beyond its original context in terms of task or time. Repeated use thus requires a post hoc decision to use a model again, while in continued use, this decision has been taken earlier. Moreover, our understanding of repeated use is not limited to the use of models for one purpose (e.g., process documentation) or one task (e.g., creating new models based on existing fragments) only but explicitly includes the use for multiple purposes (e.g., process improvement or software development). Understanding this notion of repeated use is important because key benefits of process modeling can only materialize if models are repeatedly used for multiple purposes [6].

Understanding repeated model use is also different from understanding successful modeling. Various studies into modeling success have identified factors that relate to project-specific and modeling-related characteristics [7], or the level of flow orientation in the models themselves [2]. These studies, however, do not explain why certain organizations manage to stimulate repeated use of process models while others suffer from models only being rarely used, or why some users repeatedly use models while others do not. We try to answer this question. We make three main contributions:

1) We developed a conceptual model that explains user intentions for repeatedly using process models. The model integrates different categories of factors and explicates their connection with intentions for repeated use.
2) To test our model, we developed an instrument to assess users' intentions for repeated use.

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3) Using this measurement instrument, we conducted the first empirical study on individual users' intentions to repeatedly use process models.

Our findings suggest that individual and artifact (i.e., model)-related factors are substantially more important than organizational or technological factors. This implies that any initiative for improving repeated use has to focus on the interaction of individuals with process models in the context of specific work tasks.

We proceed as follows. Section 2 positions our work in the literature on process modeling research. Section 3 defines our theoretical model based on four categories of factors relevant for repeated use we identified in literature. Section 4 describes our survey design. Section 5 presents the obtained data and results from our statistical analysis. Section 6 discusses our findings and highlights implications for research and practice. Finally, Section 7 closes with concluding remarks.

2. Background

Our research question is an empirical one. Empirical research in process modeling, broadly, is concerned with a) model creation, b) model interpretation, and c) scenarios of model use.

Model creation refers to the act of constructing a model. Overall, this stream of research is not densely populated. Model creation as a behavior has been studied through using specific tools that track and mine the interaction of a modeler with a modeling tool [8,9]. This work shows that good modeling outcomes are correlated with certain behavioral patterns during modeling. This implies that appropriate tool support for modeling is likely to result in better models [10–12].

Model interpretation focuses on the understanding of process models and the factors influencing it. Studies in this stream relate to characteristics of modeling grammars, of individual models, and of model readers. For instance, ontological deficiencies of modeling grammars appear to be a hindrance for understanding, since certain matters cannot be represented in a concise and clear way [13]. Notational deficiencies also affect understanding [14], as do model characteristics such as size and complexity [15]. Finally, personal differences such as cognitive abilities [16], education, and modeling knowledge [17] also explain variations in model understanding.

The stream on *scenarios of model use* investigates how process models are used in practice and which issues might hamper their effective use. For example, zur Muehlen and Recker [18] show that only few constructs of BPMN are used in practice. Other case studies emphasize guidance, communication, and coordination as positive effects stemming from model use [7,19,20]. Pitfalls of process modeling appear to be, among others, lack of top management support, lack of tool support for process visualization, and lack of connection between process design and execution as the most urgent, which might be rooted in the different mindsets of practitioners, researchers, and tool vendors [21].

In sum, these studies do not explicitly address the repetition or continuation of process model use. In fact, knowledge about what happens after the creation and initial use of a model overall is limited. As insights into the factors that influence repeated use will help to increase the organizational impact of process modeling, more empirical research in this area is needed.

2.1. Repeated use versus re-use of process models

It is important to understand that repeated use of models is not the same as re-use of models. Re-use of process models has been extensively studied from a technical perspective under the umbrella of "design for re-use." In this line of work, re-use is understood as applying some fragments of a model or an entire existing model [22] in the creation of a new or revised model. Discussions include, for instance, various types of re-use patterns [23].

Several techniques support model creation based on re-usable fragments. Their goal is to guide business users in understanding and adopting the concepts of a specific fragment [24]. This requires corresponding querying techniques [25] and the automatic identification of recurring fragments [26].

The re-use of complete process models has partially overlapping requirements. Respective solutions are built based on ontological reasoning [27] and information retrieval concepts [28]. This requires similarity measures [29] and matching concepts [30], amongst others.

Research in this area is rich in terms of technical concepts and techniques that support the re-use of process models for the purpose of creating new ones. However, these contributions clearly focus on the technical component and do not cover an understanding of peoples' intentions to repeatedly use models, e.g. to regain knowledge about a processes. In particular, questions of when and why a particular act of repeated model use is happening remain unanswered. Also lacking are insights into factors promoting or hindering repeated use, not for the sake of creating new models but for application in different tasks and initiatives. We take this step and discuss repeated use as a behavior next.

2.2. Repeated use and re-use as behaviors

Due to the lack of empirical research on repeated process model use and on intentions for repeated model use in particular, we set out to deduce a broader set of relevant factors influencing intentions for repeated use from other fields. We therefore extended our literature review to fields involving information artifacts and information seeking behaviors. For instance, seeking information about processes from models is similar to seeking knowledge about products when intending to repurchase them, which brought us to the field of marketing. Our review also included literature on knowledge re-use as well as more technology-centered scenarios such as software re-use, code re-use, and database query re-use. Results from our literature review and the implications our study are summarized in Table 1.

Based on our review, we derived the following four conjectures, which inform our conceptual model of repeated process model use behavior:

- Repeated use will be dependent on the *properties of the artifact*. This conjecture has been found in the context of model re-use [33] as well as in research on re-use of software, [34] software code [35,36], and repurchase intentions [40]. While re-use is potentially influenced by the fit of the artifact to the task a user aims at re-using it for [33,34,38,39], the perception of the quality of an artifacts has been found to be another determinant in the context of code re-use [35,36] and repurchase intentions [40]. This indicates that repeated use will vary depending on an individuals' perceptions of the properties of an artifact (e.g., its quality).
- *Individual factors* should also play a decisive role in a person's intention to repeatedly use an artifact as indicated by research on knowledge re-use [31], code re-use [35,37], query re-use [39], and repurchase intentions [40]. There is, however, no consensus when it comes to which individual factors influence repeated use. Some studies identified motivation as one important factor [31,37], while others focus more on how familiar a user is with an artifact and the domain [31,35,39].
- *Organizational factors* might also promote or hinder repeated use as has been found in the context of knowledge [31,32], software code, and database query re-use [34,35,38,39]. Identified factors are support by colleagues [32] or the existence of re-use processes [34,35].
- Accessibility also has been identified as a factor influencing repeated use, especially in the context of knowledge re-use [31,32] and repurchase intentions [41]. Since access mainly happens through IT systems, *technological factors* such as usefulness, ease of use [41], and ease of access [31] may impact repeated use.

Table 1
Forms of re-use behavior studied in different fields.

Context	Relevant literature	Key findings	Implications for understanding repeated process model usage
Knowledge re-use	Watson and Hewett [31] Markus [32]	Re-use is dependent on ease of access, incentives, support by intermediaries, and users' trust in the information source and domain familiarity.	Facilitating conditions and support determine individual intentions for repeated use.
Model re-use	Irwin [33]	Similarities between artifact and task have an influence on whether or not the artifact is re-used.	Characteristics of a model influence people's perception about its re-usability for a certain task.
Software re-use	Frakes and Kang [34]	Re-use is dependent on the re-usability of the software as well as the integration of re-use into organizational structures.	Characteristics of a model as well as organizational support are key for repeated use.
Corporate code re-use	Frakes and Fox [35]; Morisio et al. [36]	Re-use is dependent on code quality as well as training, monetary incentives, and re-use processes within the organization.	Model quality and organizational processes influence repeated use.
Open source code re-use	Hars and Ou [37]; Haefliger et al. [38]	Re-use is dependent on personal factors: intrinsic and extrinsic motivation, altruism, and personal need for a software solution.	Motivational and resource-related drivers are key to understanding repeated use of a model.
Database query re-use	Allen and Parsons [39]	Successful re-use is dependent on domain familiarity and opportunity to re-use.	Users consciously explore opportunities for repeated use in different task settings.
Repurchase intention	Hellier et al. [40]; Loiacono et al. [41]	Repurchase intention is dependent on previous satisfaction with, timeliness of information about, and usefulness of an object. The role of trust in an object and the object's quality is ambiguous.	Characteristics and information about a model and peoples' attitude toward it may influence repeated use.

3. A framework of factors relevant to intentions for repeated use

To structure our empirical examination of repeated model use, we started by defining our phenomenon of interest—repeated process model use—as "*the extent to which a process model is employed again by an individual user to perform a task*" [42]. In this context, repeated use describes an information seeking behavior rather than a modeling task. Thus, repeated use is different from other streams of research such as design for re-use (Section 2.1) or other forms of re-use behaviors (Section 2.2).

To clarify our conceptualization, Table 2 distinguishes our understanding of repeated use from related behaviors, such as initial model use, continued model use, and use for revision. Our definition stresses the *repeated use* of a process model at *different points in time* for the *same* or a *different task*. Repeated use is thus different from *initial use* as it requires the repeated use of a model rather than using it once. Additionally, our view of repeated use focuses on an end-user other than the creator of a process model as the key actor. While this conceptualization is similar to the differentiation between repeated use and *revision*, revision is limited to altering or extending the content of a model by the creator or a co-creator. Repeated use, however, covers users engaging with the model for one or multiple purpose across multiple work tasks, such as using a model in order to gain knowledge about the process it depicts and later using it again to identify improvement potentials.

Thus, repeated use may or may not involve a change in purpose of model use. For instance, we may repeatedly use a model to refresh our descriptive knowledge about a process while at some other time we repeat model use with the view to finding bottlenecks or other issues within the process. Thereby, repeated use is also different from *continued use*: repeated use requires a new decision to use a model *again* while for continued use, the decision to use a model again has been taken before and the use of the model for said purpose is merely sustained, i.e., continued.

Thus, our study focuses on individual repeated use behavior as

- The same person deciding at a later point in time to use a process model for the same task *in the future* (time).
- The same person deciding at a later point in time to use a process model for a *different task* in the future (purpose).

3.1. A framework of determinants for repeated process model use

Following our definition of repeated process model use, we developed a conceptualization of factors determining an individual's intention to repeatedly use process models. In developing this framework, we draw on socio-technical systems theory [43] to recognize that potentially relevant factors may fall into four categories [44]: *technology*, *person*, a person's *task*(*s*), and the organizational *structure*. We added the *artifact* category to capture relevant characteristics of the process model as an informational rather than technological artifact. We built an initial conceptualization based upon a literature review structured along these categories (c.f. Section 2.2). Afterwards, we conducted a pretest by surveying 35 process model users from a large Australian retail company. Results from that pretest were incorporated into the model (c.f. Fig. 1).The most significant change to the original model was the removal of organizational factors as the measures we developed show bad factor loadings and/or reliability issues and thus proved unsuitable. We however kept organizational factors as a category for our qualitative analysis to potentially identify organizational factors that might influence intentions for repeated use.

We thus arrived at the framework depicted in Fig. 1, which suggests that three main categories directly influence intentions for repeated model use: *individual*, *artifact-related*, and *technological factors*. In what follows, we describe the three factor categories in more detail. Additional information about the specifics of the model determinants is available in [self-reference].

Table 2
Definition of process model repeated use compared to other forms of model use.

Type of use	Purpose	User	Point in time	Decision to use again
(initial) Use	Creation of the model as an artifact (e.g. to document a work process).	Creator	t = 1	–
Revision	Revision or extension of the content of a process model.	(Co-)creator	t = 2 to n	On demand
Continued use	The sustained use of a process model in support of one particular work task (e.g., continued use in a process improvement project).	Model end-user	t = 2 to n	Chosen upon initial use
Repeated use	*Repeated use of a model for original or novel purposes across multiple work tasks (e.g., in multiple projects).*	*Creator or model end-user*	*t = 2 to n*	*On demand*

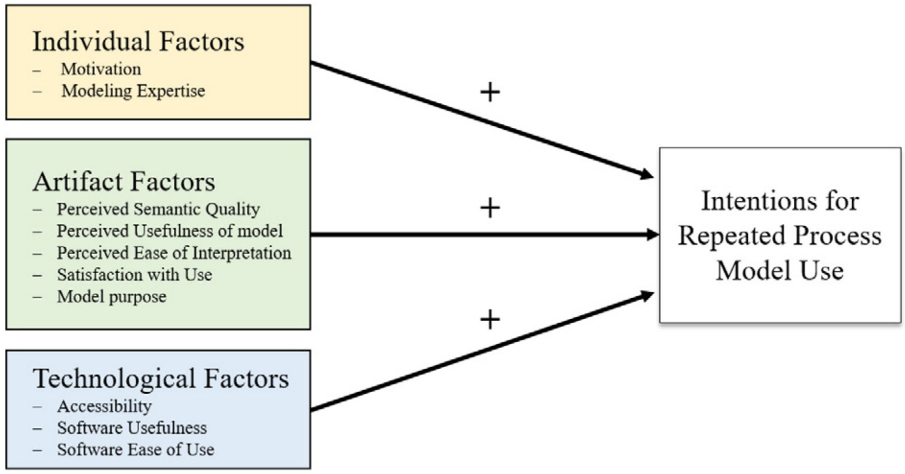

Fig. 1. Framework of factors influencing intentions for repeated process model use.

3.1.1. Artifact factors

These factors describe properties of a process model as an *artifact*. As we focus on an individual's intentions to repeatedly use a process model, and as these intentions will vary dependent on whether a user perceives a model to be good rather than any objective attribution of quality or usefulness, we consider users' perceptions of model attributes. We expect these factors to have an immediate impact on an individual's intention to repeatedly use a process model, because they are informational artifacts, for instance, about how certain procedures are conducted in an organization. The accuracy and relevance of information that a model provides is important if users want to retrieve and apply this information. This can be measured as the *perceived semantic quality* of a model [45]. We thus state:

H1. The perceived semantic quality of a process model will be positively associated with the intention to repeatedly use a process model.

A model should be *easily interpretable* [46], even for readers who are not aware of the context that a particular model was created in. This is because information acquisition is a cognitive task. The easier this cognitive task, the more likely a user is to consult the model for future tasks. Therefore:

H2. The perceived ease of interpretation of a process model will be positively associated with the intention to repeatedly use a process model.

Furthermore, the intention to use a model after creation can also be positively influenced by an individuals' perception of its *usefulness* to assist in work tasks [47]. The more useful a model turns out to be in a task, the more likely a user is to repeatedly use the model for another task in the future:

H3. The perceived usefulness of a process model will be positively associated with the intention to repeatedly use a process model.

Users' *satisfaction* [48] with a model will also positively influence intentions for repeated use of a model. This is because satisfaction captures the affective response of a user after completion of a model-based task. The more satisfied a user, the more likely the repeated use:

H4. Perceived satisfaction with process model use will be positively associated with the intention to repeatedly use a process model.

Finally, we also take into account the *purpose* of a model [49]. This includes both the *original purpose* of a model and the *purpose for which the model is repeatedly used*, such as obtaining information or analyzing the process it depicts in order to improve it. We expect the fit of a models' repeated use purpose to the original purpose to positively influence an individual's intention for repeated use:

H5. A fitting purpose of a process model will be positively associated with the intention to repeatedly use a process model.

3.1.2. Individual factors

The goal of our work is to explore and understand the determinants of individual intentions for repeated use. Thus, it is reasonable to include *individual factors* as they play a vital role in understanding a person's *intention to use*—and subsequently *repeatedly use*—an object [48]. One main aspect of using an artifact is the user's *motivation*—usually distinguished between *extrinsic* and *intrinsic motivation*—to perform a task for which the model can be used. We only consider intrinsic motivation because typically employees will not receive explicit compensation for repeatedly using process models. In line with research on self-determination [50], we expect that the higher levels of intrinsic motivation are, the more likely a user will seek to engage in the task. Therefore:

H6. The intrinsic motivation of an individual will be positively associated with the intention to repeatedly use a process model.

Process models are not everyday artifacts and we thus cannot assume that every person is able to use them in the same way. Extracting knowledge about a process from a model depends on the individual's ability to read and understand it. Therefore, it can be expected that individuals with *modeling expertise*, i.e., that are skilled in modeling, understand their use and value more than those with a lower modeling skill [17]. We thus expect:

H7. The modeling expertise of an individual will be positively associated with the intention to repeatedly use a process model.

3.1.3. Technological factors

Organizations that create and use process models typically have software-based tools in which the models are stored. Therefore, we assume that repeated use of process models will mainly take place through information systems, viz., process modeling software [51] or process repositories [10]. In turn, intentions for repeated use will be impacted by users' perceptions about *technological factors*, viz., the interaction with a system as well as the system's provided access to models in general. Thus, *accessibility*—the effort of finding a model and having access to the right tools to use it—will influence an individual's intention to repeatedly use a process model [52]. Furthermore, previous research has shown that technology use strongly depends on perceptions of *usefulness* and *ease of use* of that technology [53]. We consequently expect all three factors to have a positive effect on an individual's intention to repeatedly use models since access as well as perceived usefulness and ease of use of technology may provide better and more ready access to a model and in turn positively influence an individuals' preposition toward repeatedly using models:

H8. Accessibility of software and models will be positively associated with the intention to repeatedly use a process model.

H9. Perceived software usefulness will be positively associated with the intention to repeatedly use a process model.

H10. Perceived software ease of use will be positively associated with the intention to repeatedly use a process model.

4. Research method

We used a cross-sectional survey to examine repeated use behavior and its determinants across a large sample of individuals, tasks, and process models within one representative large organization [54]. We did so because survey methods are especially suitable for research that focuses on behaviors [55]. An alternative strategy would have been to conduct a qualitative case study; however, we felt that through the development of the research model from literature and the pilot study, we had a sufficiently mature theoretical model that would benefit from statistical evaluation rather than further exploration. In such scenarios, quantitative research designs are preferred. Choosing a survey as a method also increases the robustness of the findings by gathering data from respondents across departments and backgrounds. We chose a cross-sectional over a longitudinal survey because we are interested in antecedents that influence the decision for repeated use rather than the evolution of repeated use behavior.

We deliberately focused on a single organization, as this allowed us to assume a similar background for all participants. In doing so, we rule out a number of intervening factors that could compromise our results such as different conventions and policies while maintaining a sufficient variety with respect to the factors studied in the model. It also allowed us to gain a deeper understanding of the inner workings of that organization, as well as linking the results of our analysis to specific characteristics of that organization (which we will explore through our qualitative findings in Section 5.4).

Our population of interest included but was not limited to analysts who work with process models regularly. As we defined repeated use as a knowledge-seeking activity, we expanded our population to all people that have access to process models such as process participants and people responsible for process outcomes. We only expected people with prior exposure to process models to participate in the survey, as process models are difficult to interpret without any knowledge about modeling grammars. We also ruled out any tasks that involve creating new process models or model parts, or refining existing models. Instead, we relied on the tasks that correspond with our understanding of repeated model use. In particular, we encouraged the participants to pick a specific situation, in which they repeatedly used an existing model, describe the repeated use context, and answer questions relating to the factors of our research model in relation to that context.

4.1. Measurement

Wherever possible, we relied on established measures and adapted them to fit our study. Table 3 provides an overview of constructs from literature as well as our (adapted) definitions and sample measures. The complete survey instrument is available in Appendix A. We altered the self-determination scale by Mullan et al. [50] by combining it with a similar scale by Sheldon et al. [56] to ensure that we obtain an appropriately contextualization of self-determination. According to our definition of repeated use (Section 3), we developed a scale aiming at identifying intentions for repeated use.

In addition to the scales mentioned in Table 3, we also included questions that would allow us to gain a deeper understanding about the *organizational context* an individual works in and the *individual* itself. Questions about the *individual* participant included basic demographics such as gender and age but also measures for their *intensity* of process model use [16] and their *experience* with process models [17]. We captured these variables using single-item measures because the measures had been shown in experimental studies to influence how people understand process models and we thus deemed them important control variables [15,17]. We further included open-ended questions focusing on the organizational context to mitigate potential bias from our exclusion of organizational factors in the quantitative measurement. In this survey part, we also included measures of the time an individual has been a member of the organization and which organizational unit the person belongs to. Furthermore, we were interested in identifying the purpose for which an individual generally uses process models during her work, as this might affect the individual's perception and subsequent model use. We provided a list of potential use purposes derived from literature [57] (e.g., process execution, analysis, improvement, and gaining knowledge about a process) and allowed for additional responses.

Next, we asked the participants to describe a certain process model that they had repeatedly used recently during a work task. This includes the original purpose for which that particular model was used as well as the repeated use purpose which served as a basis for our subsequent analysis of whether or not a fit between the task a model was initially developed for and the repeated use task influences and individuals' intentions for repeated use (c.f. Section 5.1.1). The model the participants

Table 3
Key construct definitions.

Category	Construct	Study definition
Artifact factors	Perceived semantic quality [45]	The degree of correspondence between the information conveyed by a process model and the domain that is modeled.
	Perceived usefulness of model [53]	The degree to which a person believes that (re-) using a particular process model will be effective in achieving an intended goal.
	Perceived ease of interpretation [53]	The degree to which a person believes that interpreting a process model would be free of effort.
	Satisfaction with model use [58]	The level of approval when a person compares her/his expected performance when using process models with the actual performance.
Individual factors	Self-determination [50,56]	The experience of freedom in using process models.
	Modeling expertise [17]	The degree to which an individual is informed and an expert on the matter of process modeling.
Technological factors	Accessibility [52]	The ease with which a process model can be accessed or extracted from a modeling software.
	Software usefulness [53]	The degree to which a person believes that using a modeling software will be effective in (re-) using a process model.
	Software ease of use [53]	The degree to which a person believes that using a modeling software for (re-) using a process model would be free of effort.
Repeated process model use	Intention to repeatedly use model [48]	The strength of one's intention to repeatedly use a process model.

described served as a basis for all other model-related questions (c.f. process model factors in Table 3). Focusing the participants' attention in this manner allowed us to draw more comprehensive conclusions, as all answers relate to a single model. With respect to this model, we asked the participants if they have an active role in the process it depicts. We also asked them to assess its size and complexity.

Adding to the technological factors described in Table 3, we asked the participants how they usually access that particular process model by providing them with a list that includes printed form, electronic form (e.g. PDF, JPG, PNG, XSL), a modeling software, or a corporate process model repository. We also asked the participants to provide ideas for improving model access and the models themselves.

4.2. Procedures

The population of interest to our study included people that occasionally or regularly use process models as part of their work. While not limiting the study to a specific use task, we explicitly ruled out the initial creation of a model and its refinement. Furthermore, we only included individuals that had previous experience with process models, as they are difficult to use without any modeling knowledge. It was also important for our study to capture repeated use data in relation to one specific process model (c.f. Section 4.1).

In order to evaluate our research model and the factors that influence repeated use behavior, we chose a large European bank as a target organization. This organization met our study criteria, as processes and process models are an important aspect of many areas of work within this organization—working with models is a well-established practice (e.g., to use them to analyze processes or to use them for decision-making). The organization maintains a large repository, which contains several thousand models. Overall, the business processes are organized in three main categories covering core, governance, and support activities of the company. These categories are split into three to seven subcategories. Moreover, process models are tied to a corporate knowledge base, which is accessible to every person within that organization. The knowledge base provides additional information, such as textual descriptions and other process-related documents. There were also other means of accessing models and information about processes such as textual process documentation, presentations, models in local repositories of different departments, and printouts. These factors alongside with the possibility to gain deeper insights into their technological infrastructure made for a suitable target audience for our study.

The study itself lasted for 1 month. A total of 406 people were invited to participate. Our study had the support of the organization's manager responsible for processes, who distributed the study in several business units. We received 121 completed and 107 incomplete responses, which we excluded from further analysis. Participation was anonymous and voluntary.

5. Data analysis

In reporting our results, we proceed in three steps. First, we screened the data and performed a number of exploratory analyses. We report on each of these in turn, starting with data cleansing and an exploration of descriptive survey data. Second, we report on measurement and structural model estimation using PLS-based structural equation modeling [59]. Third, we report on selected supplementary qualitative analyses to examine parts of our results in more detail. We report on each of these in turn, starting with data cleansing and an exploration of descriptive survey data.

5.1. Data screening

During data cleansing, we prepared the 121 valid and complete responses for data analysis by removing any data points that lacked appropriateness (e.g., a person voting in a certain pattern) or that contained data by participants that had not used process models before. In the end, we arrived at 86 usable data points (an effective response rate of 21.2%) for further analysis.

Next, we determined whether this sample is large enough to test our complex structural model. Marcoulides et al. [60] advise evaluating the number of predictors and the effect size of each multiple regression analysis of the structural model to calculate the statistical power. Following this method, we used GPower 3.1 [61], as suggested by Hair et al. [62], and calculated that, with $n = 86$ and a maximum of 7 predictors, we achieve a statistical power of 80% for effect sizes larger than or equal to 0.30, with an error probability of less than 2%. Therefore, our sample has sufficient statistical power for our conclusions to be valid for large effect sizes. In addition, we conducted a more rigorous test that takes additional parameters of the entire model into account (http://www.danielsoper.com, as proposed by Gefen et al. [63]). According to this evaluation, we achieve statistical power of 80% for effect sizes larger than or equal to 0.3 in our model with 29 observed and 8 latent variables.

Next, we discuss the descriptive data findings, by category.

5.1.1. Artifact factors

Reasons for using process models in general were diverse and almost evenly distributed. The major reason for using a process model is to *regain knowledge* about a process. Almost two thirds of the population (62.07%) quote this as a reason for using process models, while about half of the participants use process models to check whether or not a process is *up to date* (59.77%) and to identify means of *improving* the process (54.02%). Finally, 41.38% of the population use process models for *analyzing* the process, and 34.48% for carrying out tasks of that process (*execution*).

We also analyzed the *purposes* for which the models that the participants chose for were *originally developed* and compared them to the purposes they were then repeatedly used for. We identified a *clear fit between the original task and the repeated use task* for 13.79% of the models. For another 16.09% of the models, we found a *potential fit*. A potential fit in this context mostly means that models were created for general documentation purposes and then repeatedly used to e.g. regain knowledge about specific tasks. We also found models that were created for *documentation purposes* are then used for *process optimization* as well as models that were created for *optimization purposes* and then used to *regain knowledge* about a process. These findings lead us to reject hypothesis H5 since a fit between original task and repeated use task only partly influences intentions for repeated use.

5.1.2. Individual factors

We started our analysis of individual factors by comparing participants that repeatedly use process models to participants that never or only rarely repeatedly use them. We consider the first group to be *power users*, while the latter group is made up of *low users*. We determine these groups by comparing the weighted average of the repeated use factors in our research model. Participants that scored 3.5 or higher are considered power users. Over 80% of the participants are power users. In general, we noted that power users scored higher with respect to any factor measured. With respect to *job experience* (about 5 years on average) as well as *experience in using process models* (about 5 years on average), power and low users scored roughly the same. There are also almost no notable differences considering size and complexity of the models chosen by power and low users. Both groups chose small models that are easy to understand and of low complexity (2 on a scale of 1–5 for all three measures).

There are, however, a number of notable differences between the two groups (c.f. Fig. 2). Power users were slightly more *motivated* to repeatedly use process models (3.7 on average compared to 2.6), perceived the *semantic quality* of the models to be higher (5.5–4.3), and perceived models to be more *useful* (4.6–2.9) and *easier to use* (5.1–3.8). Power users also felt more *satisfied* when using process

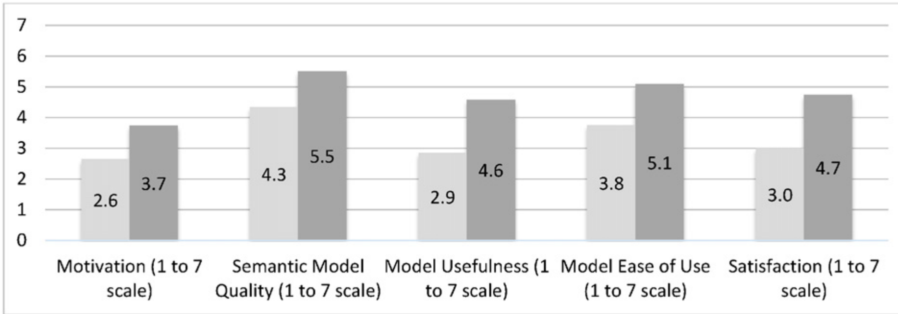

Fig. 2. Comparison between power (dark gray) and low users (light gray).

models (4.7–3.0). These findings indicate that artifact-related factors are relevant for an individual's intentions for repeated use. Furthermore, individual factors, such as motivation and previous satisfaction with models, also seem to influence an individual's intention to repeatedly use a model.

Another major difference between the two groups was the perception of the modeling software (c.f. Fig. 3). Power users found the software to be more *useful* (3.2–1.2), *easier to use* (3.4–1.3), and more *accessible* (3.4–1.7). This indicates the relevance of an accessible and easy way to use the modeling software for promoting repeated use.

On the basis of these data, we believe we have reason to reject hypothesis H7: we expected an individual's modeling expertise to directly influence that persons' intentions for repeated use. However, the exploration of the data suggests that expertise rather seems to be a moderating factor.

5.1.3. Technological factors

Most of the participants mainly access process models through a *corporate process repository* (81.65%). About two thirds (68.98%) used other *electronic representations* of process models, such as spreadsheets and graphics, which are spread across various electronic systems such as shared drives that are internal to a specific department. These representations include e.g. self-created documents that are not part of the official process documentation and presentations from teaching sessions. Over a half of the population also used *printed process models* (57.48%), and about a quarter used a *modeling software* (24.14%). Process models were also accessed via a newsletter that contains process-related information. Some participants also stated that they *ask colleagues* about processes instead of using models. These findings indicate a variety of means of accessing and repeatedly using process models.

5.1.4. Correlations

Next, we examined item correlation statistics (c.f. Appendix B for a complete overview). In the interest of brevity, we only discuss correlations of items that are not part of the structural model we estimate below. We found a weak correlation between the *size* of a process model and its *repeated use* ($r = 0.218$, $p < 0.05$), indicating that larger models might be repeatedly used more often than smaller ones. We also found that models used for *knowledge-intensive tasks* are *larger* ($r = 0.278$, $p < 0.01$) and more *complex* ($r = 0.296$, $p < 0.01$), and that *repeated tasks* correlate with repeated use ($r = 0.278$, $p < 0.05$). Furthermore, all factors related to the artifact (*perceived semantic quality*, $r = 0.438$, $p < 0.01$; *perceived usefulness*, $r = 0.550$, $p < 0.01$; *perceived ease of use*, $r = 0.537$, $p < 0.01$; and *satisfaction*, $r = 0.472$, $p < 0.01$) as well as the individual factor *motivation* are correlated with repeated use ($r = 0.252$, $p < 0.05$). Considering the technical factors, only *model accessibility* is correlated with repeated use ($r = 0.315$, $p < 0.01$).

5.2. Scale validation

In our second step of data analysis, we evaluate the adequacy and validity of our measurement scales. Each scale item was modeled as a reflective indicator of its theorized latent construct, and the measurement model included all eight latent constructs that are depicted in Fig. 4. The constructs were allowed to co-vary.

The analysis was done using SmartPLS Version 2.0 [64]. Our main reason to use PLS was because our data violated some normality assumptions, which favors the use of PLS [63]. Also, our research included new self-developed constructs (e.g., model accessibility, intentions for repeated model use). PLS with its relaxed assumptions is often viewed as more appropriate to that end [59,63].

Table 5 reports item cross-loadings and Table 4 reports statistics to assess reliability, convergent, and discriminant validity. Unidimensionality of scales as demonstrated by Cronbach's α for all scales were 0.7 or above [65]. Composite reliability scores ranged from 0.90 to 0.96. All scale items had factor loadings exceeding 0.70 ($p < 0.001$). AVE for all scales were 0.70 or above. Hence, Fornell and Larcker's [66] three conditions of convergent validity were met. Discriminant validity is assured where the AVE for each construct exceeds the squared correlation

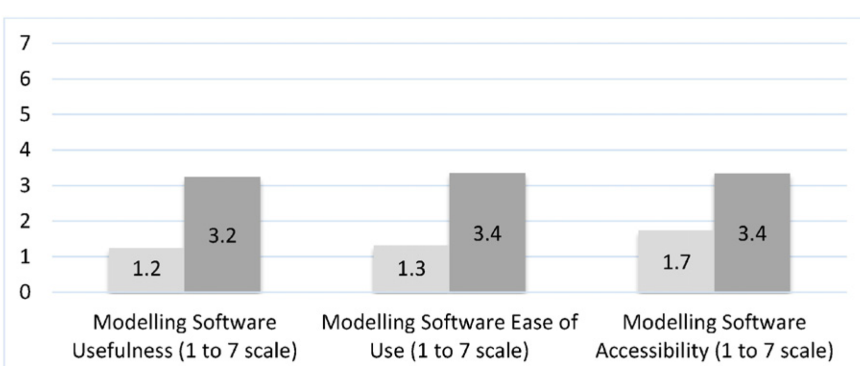

Fig. 3. Comparison between power (dark gray) and low users (light gray).

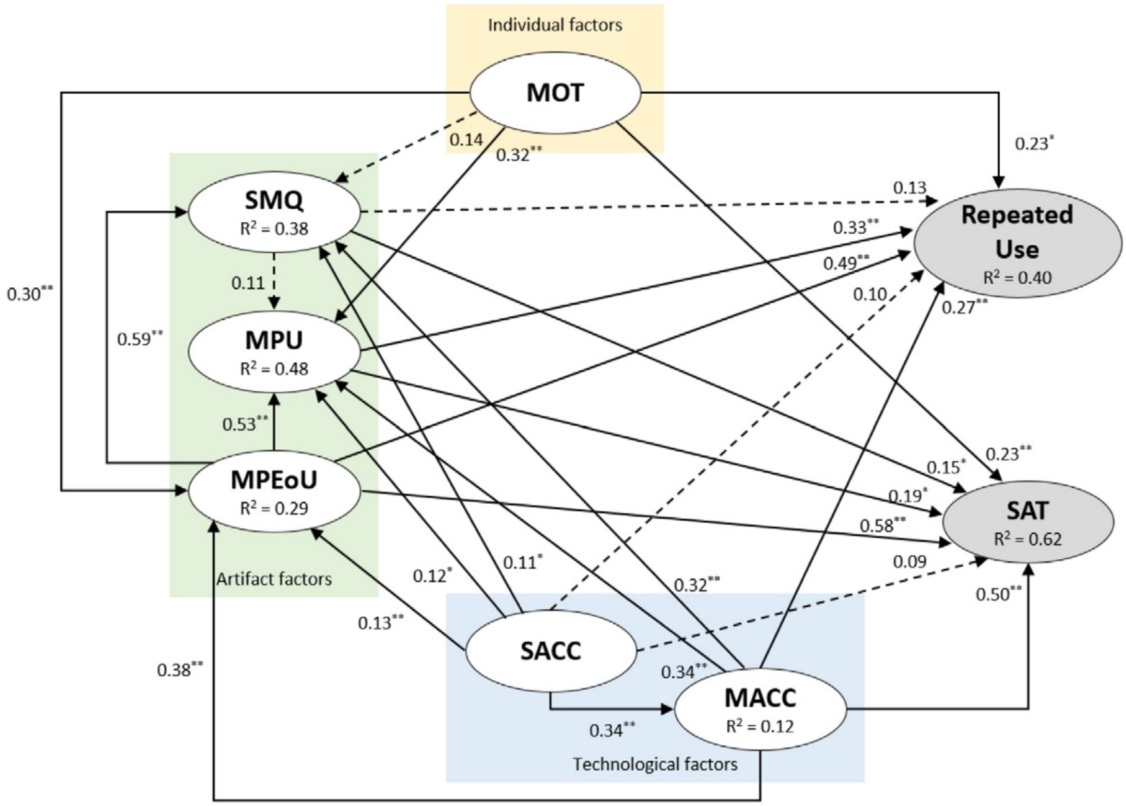

Fig. 4. Structural model results (numbers on the arrows indicate β-values, dashed lines show insignificant paths).

between that and any other construct in the factor correlation matrix. The largest squared correlation existed between the perceived ease of use of a model (MPEoU) and satisfaction (SAT, 0.72), while the smallest obtained AVE value was 0.70 for motivation (MOT). These results suggest that the test of discriminant validity was met.

5.3. Structural model estimation

Next, we examined our theoretical framework in terms of the significance and effect size for each hypothesized path and the explained variance for each dependent variable. The results are shown in Fig. 4. The model explains 40.0% of the variance in repeated process model use. It also explains 61.6% of the variance of satisfaction (SAT), 47.7% of the variance in model perceived usefulness (MPU), 29.3% of the variance in model perceived ease of use (MPEoU), 38.3% of the variance in perceived semantic model quality (SMQ), and 11.6% of the variance of model accessibility (MACC).

The results in Fig. 4 show that the following factors have a direct and positive influence on repeated process model use, in descending order of importance:

- the perceived *ease of use* of a process model (MPEoU, $\beta = 0.49$, $p < 0.01$),
- the perceived *usefulness* of a process model (MPU, $\beta = 0.33$, $p < 0.01$),
- the *accessibility* of a model (MACC, $\beta = 0.27$, $p < 0.01$), and
- the *motivation* of an individual (MOT, $\beta = 0.23$, $p < 0.05$).

On the basis of these results, we believe hypotheses H2 (MPEoU), H3 (MPU), and H6 (MOT) receive support from the data. However, both *semantic model quality* (SMQ, $\beta = 0.13$, $p > 0.05$) and *software accessibility* (SACC, $\beta = 0.10$, $p > 0.05$) were not significantly associated with repeated process model use, leading us to believe that hypothesis H1 is refuted by the data.

Software accessibility (SACC, $\beta = 0.34$, $p < 0.01$) directly and positively influences *model accessibility*, which is associated with repeated use. Thus, hypothesis H8 is partially supported: we expected software and model accessibility to have a positive effect on an individuals' intentions for repeated use, which is true for model accessibility and true as a mediated effect for software accessibility.

Satisfaction (SAT) has no direct effect on intentions for repeated use meaning that hypothesis H4 has to be rejected. However, satisfaction is influenced by most factors that influence intentions for repeated use, namely the *perceived ease of use* ($\beta = 0.58$, $p < 0.01$) and the *perceived usefulness* ($\beta = 0.19$, $p < 0.05$) of a process model as well as

Table 4
Construct descriptive statistics, scale properties, and correlations.

	Mean	S.D.	α	ρ_c	AVE	MACC	MOT	MPEoU	MPU	Repeated use	SACC	SAT	SMQ
MACC	4.64	1.67	0.91	0.94	0.84	1	0	0	0	0	0	0	0
MOT	3.62	1.22	0.86	0.90	0.70	0.27	1	0	0	0	0	0	0
MPEoU	4.94	1.44	0.94	0.96	0.84	0.46	0.40	1	0	0	0	0	0
MPU	4.40	1.44	0.84	0.90	0.76	0.43	0.41	0.66	1	0	0	0	0
Repeated use	4.85	1.37	0.86	0.90	0.70	0.34	0.29	0.56	0.57	1	0	0	0
SACC	3.18	2.93	0.93	0.96	0.88	0.34	0.12	0.22	0.19	0.16	1	0	0
SAT	4.56	1.43	0.93	0.95	0.87	0.54	0.35	0.72	0.63	0.49	0.16	1	0
SMQ	5.38	1.30	0.91	0.93	0.73	0.36	0.21	0.61	0.47	0.46	0.17	0.55	1

Table 5
Item cross-loadings.

	MACC	MOT	MPEoU	MPU	Repeated use	SACC	SAT	SMQ
ModelAccessibility1	**0.88**	0.29	0.36	0.36	0.26	0.19	0.44	0.32
ModelAccessibility2	**0.93**	0.23	0.39	0.34	0.23	0.36	0.46	0.34
ModelAccessibility3	**0.93**	0.23	0.49	0.46	0.41	0.36	0.57	0.33
ModelPEoU1	0.40	0.31	**0.90**	0.57	0.53	0.17	0.64	0.56
ModelPEoU2	0.35	0.28	**0.91**	0.55	0.47	0.22	0.59	0.55
ModelPEoU3	0.42	0.48	**0.90**	0.64	0.51	0.20	0.66	0.54
ModelPEoU4	0.50	0.39	**0.96**	0.64	0.54	0.22	0.74	0.59
ModelPU1	0.43	0.38	0.61	**0.88**	0.49	0.26	0.54	0.42
ModelPU2	0.38	0.35	0.61	**0.93**	0.55	0.13	0.57	0.46
ModelPU3	0.30	0.33	0.49	**0.81**	0.44	0.11	0.52	0.35
ModellingSoftAccess1	0.33	0.13	0.15	0.14	0.12	**0.94**	0.13	0.18
ModellingSoftAccess2	0.31	0.05	0.13	0.11	0.14	**0.94**	0.09	0.12
ModellingSoftAccess3	0.32	0.15	0.32	0.27	0.18	**0.94**	0.21	0.17
Motivation1	0.15	**0.78**	0.30	0.25	0.15	−0.02	0.22	0.24
Motivation2	0.24	**0.86**	0.37	0.36	0.37	0.09	0.31	0.17
Motivation3	0.29	**0.87**	0.34	0.42	0.24	0.21	0.35	0.16
Motivation4	0.20	**0.84**	0.32	0.31	0.19	0.09	0.29	0.17
RepeatedUse1	0.17	0.01	0.25	0.31	**0.70**	−0.04	0.28	0.22
RepeatedUse2	0.28	0.35	0.52	0.52	**0.86**	0.18	0.42	0.36
RepeatedUse5	0.28	0.19	0.49	0.49	**0.85**	0.14	0.41	0.42
RepeatedUse6	0.35	0.33	0.55	0.53	**0.93**	0.17	0.48	0.48
Satisfaction1	0.56	0.31	0.70	0.62	0.52	0.12	**0.92**	0.56
Satisfaction2	0.49	0.28	0.62	0.57	0.41	0.18	**0.96**	0.50
Satisfaction3	0.45	0.40	0.69	0.56	0.43	0.15	**0.92**	0.47
SemModelQual1	0.27	0.16	0.60	0.38	0.39	0.15	0.46	**0.86**
SemModelQual2	0.27	0.13	0.46	0.42	0.42	0.18	0.42	**0.84**
SemModelQual3	0.30	0.12	0.39	0.37	0.38	0.13	0.47	**0.85**
SemModelQual4	0.33	0.20	0.50	0.39	0.35	0.19	0.48	**0.84**
SemModelQual5	0.35	0.28	0.62	0.45	0.41	0.08	0.51	**0.86**

Bold letters indicate which items belong to which factor.

an individual's *motivation* ($\beta = 0.23$, $p < 0.01$) and *model accessibility* ($\beta = 0.50$, $p < 0.01$). Satisfaction is also influenced by the *perceived semantic quality* of a process model ($\beta = 0.15$, $p < 0.05$). *Software accessibility* has no effect on satisfaction ($\beta = 0.09$, $p > 0.05$) but influences model accessibility. We thus have to reject hypotheses H9 and H10 since neither SPU nor SPEoU had a positive effect on an individuals' intentions for repeated use.

The structural model results in Fig. 4 also confirm several other associations between the constructs we examine, for example, that MPEoU is positively and significantly associated with MPU ($\beta = 0.53$, $p < 0.01$) or that model accessibility is influenced by software accessibility ($\beta = 0.34$, $p < 0.01$) and is associated with MPEOU ($\beta = 0.38$, $p < 0.01$) and satisfaction with model use ($\beta = 0.50$, $p < 0.01$).

5.4. Supplementary qualitative analysis

Our survey also included free text answer fields in addition to the previously analyzed Likert-style scales, which allowed us to gather additional qualitative feedback. During data examination, we noted that this optional way of providing answers was used by 85% (73 out of 86) of survey respondents. Due to this prominence, we decided to conduct a supplementary qualitative analysis. In what follows, we will analyze the different processes that the participants described and report on reasons for repeatedly using those models, suggestions for improvement, and means of accessing them.

5.4.1. Characteristics of repeatedly used process models

Analyzing the descriptions of process models by the participants we discovered a number of differences. Descriptions varied with respect to:

- *Model size*: Some models only consisted of very few elements while others appeared to be rather complex, covering different aspects of a process (e.g., decision points).
- *Granularity*: While some models were overviews containing activities such as "risk assessment" that might include sub-processes, others were very fine-grained (e.g., "filling out an order form"). Some participants even included hints on where to look for sub-processes, thus indicating that they in fact are part of a larger *process landscape*.
- *Linearity*: While some participants described *linear sequences* of process steps, others also included *decision points*, thus allowing for different process outcomes.

All in all, the models reported cover different processes and process models, indicating that the results gained from our analysis are generalizable with respect to a larger variety of models.

5.4.2. Reasons for repeatedly using process models

During the qualitative analysis, we also aimed at identifying potential reasons for *actual repeated use behavior*. We found that *gaining knowledge* about a process that participants are involved in is a major reason—especially when a person is taking over a new job. This relates to their own role in a process as well as the involvement of *other departments*. Participants also stated that they repeatedly use process models in order to be informed about potential process changes. Models are also repeatedly used due to enquiries by external stakeholders, such as people from other departments and external partners (e.g., customers or outsourcing partners), which again can be considered a knowledge-seeking activity.

5.4.3. Suggestions for improving the repeated use of process models

The questionnaire also offered the participants the possibility to suggest improvements of the model quality as well as the software. In general, participants mentioned that models are generally perceived as being "useless" due to the following reasons:

- There is *no appreciation* for people who use process models and thus devote time to e.g. keep them up to date.
- People who develop and groom process models *do not receive any feedback* whether or not their models are actually being (repeatedly) used.
- Most of the models are perceived to be *outdated* and thus perceived to be not relevant.

- Only a *subset* of existing processes is documented.
- Models are documented using *different modeling tools* and *different modeling notations* making them hard to use repeatedly.

In order to overcome this perception, the participants made suggestions that we will report below.

5.4.3.1. Artifact factors. Most of the participants stated that process models should be "*short and simple but with enough details to understand them*." This is in line with our finding that the perceived ease of use is a major factor for individual intentions for repeated use. While most participants acknowledged that process models should be easy to understand, the proposed means of achieving this are different. Some participants suggested enhancing process models with *additional information* such as screenshots, documents, or descriptions while others argued that this would make them "*harder to understand*."

5.4.3.2. Individual factors. While there were no suggestions directly attributed at individual factors, we still found suggestions with respect to the organizational surrounding aiming at the individual on which we will report below.

5.4.3.3. Organizational factors. Some participants suggested that the significance of process models could be increased by *management support*. Others suggested that people should be given resources (i.e. *more time*) to use process models. Some mentioned that people might be willing to repeatedly use process models but they simply are not capable of understanding them due to *missing knowledge about process modeling*. Consequently, one participant suggested that there should be courses on process modeling while another one mentioned the need for *expert support*. It should also be made sure that *all processes are documented*.

5.4.3.4. Technological factors. Most of the suggestions focused on improving *process model accessibility* in the corporate knowledge base. In particular, participants mentioned the poor capabilities of finding process models and suggested to improve the *text-based search mechanism* of the knowledge base. Participants also suggested to link models with each other thus allowing a control-flow-based exploration of the repository. Finally, one participant also suggested to create one single entry point for the process landscape.

6. Discussion

Our main contribution is that we conducted the *first study that examines repeated process model use empirically*. Our findings have several implications for better understanding antecedents of repeated process model use and future research in this area. In particular, we identified five determinants that contribute to an individual's intention to repeatedly use process models (c.f. Fig. 4):

1. the perceived *usefulness* of a process model,
2. the perceived *ease of interpretation*,
3. the *purpose* of the model,
4. an individual's *motivation* to repeatedly use a process model, and
5. the *accessibility* of a process model through a modeling software.

These determinants refer to factors related to the artifact, the individual, and the technology.

With respect to factors related to the *artifact* (the process model itself), it became clear that process models should be understandable (i.e. easy to use) *and* useful (i.e. contain useful information that is not outdated and relevant for process execution) in order to foster repeated use. The perceived semantic quality of a process model has—in contrast to the previously described data screening (c.f. Section 5.1.2)—shown not to be a direct promoter of an individual intentions for repeated use. An organization should thus focus on creating process models that are easy to understand. Organizations should thus abstain from creating complex models that include all details of a process and should rather focus on creating models that are easy to understand. This could e.g. be achieved by splitting complex models into smaller ones or create overview models that can then be used as an entry point for exploration. An organization should also support individuals to use models, e.g. through courses on process modeling or expert support on demand. Process models could also be enhanced with additional information such as screenshots in order to improve expressive power as well as understandability.

Next to identifying motivation as the main *individual* factor, our qualitative analysis indicates that the lack of motivation to repeatedly use process models mainly stems from them not being perceived as useful. Another factor that potentially reduces motivation is the lack of appreciation for maintaining models. In order to foster motivation, organizational support could be established in a way that resources are dedicated to repeatedly use process models. Management support, e.g. providing appropriate resources, could also encourage repeated process model use. *Satisfaction* apparently does not directly influence an individual's intention for repeated use. It should, however, be noted that most of the factors mentioned before influence satisfaction, which indicates its relevance in this context. Furthermore, satisfaction in contrast to repeated use is fostered by the perceived semantic quality of process models. It is thus important to create formally correct models, in order to improve satisfaction.

Properties of a modeling software, such as usefulness and ease of use, appear to be less relevant for an individual's intentions for repeated use. The main technological factor rather is *model accessibility*. This finding is underpinned by our initial data screening, as we found process models to be repeatedly used not only in an electronic but also in a printed form. It is thus not important if access happens through a modeling software, in print or in a knowledge base. Instead, process models should be readily *accessible*, for instance by offering search or exploration mechanisms in a knowledge base.

6.1. Implications

The findings of this study have a number of implications for research and practice.

First, we have shown that the *perceived ease of use* as well the *perceived usefulness* of a process model are the strongest promoters of an individual's intention for repeated use. The *perceived semantic quality* of a process model had no influence on intentions for repeated use despite influencing satisfaction. These findings are partly in line with prior research on model re-use [33] and corporate code re-use [35,36], which identified factors related to the artifact as important factors to promote re-use. In contrast to previous research, our findings show that simplicity is more important than the technical correctness of a model. Model designers should thus focus on creating models that are understandable rather than formally correct. This, however, does not mean that model designers should deliberately create formally incorrect models. It rather means that the focus should be on creating models that are easy to understand rather than overly complex. This finding could also guide future research on the technical design for re-use [23]. Since perceived semantic quality does influence user satisfaction, it can be assumed that high-quality models potentially promote satisfaction but are not necessarily fostering repeated use. This shows the importance of ease of use and usefulness in the context of research on model quality [67] as models that are easy to understand are more likely to be repeatedly used.

Notably, participants reported that process models were assumed to be useless. Such a negative opinion can be heard when discussing with practitioners as much as positive statements about the usefulness of process models. While we investigated the consequences of perceived usefulness, there is a need to further study its antecedents in future work. Possible starting points would be the connection of the models with certain tasks from the perspective of cognitive fit [68] or task relevance, which reflects the purpose of modeling as often emphasized in formal model definitions [69,70].

Furthermore, we found that the perceived usefulness and ease of use of a *modeling software*—in contrast to the perceived usefulness and ease of use of a *process model*—does not influence intentions for repeated use. Instead, we identified *accessibility* of a process model to be the strongest promoter of intentions for repeated use from a technical perspective. Our results show that model accessibility is positively influenced by software accessibility. They also suggests that technological support through, for instance, query mechanisms [25] and other information retrieval concepts [28], could assist repeated process model use in process model collections [10] more than easy to use modeling software.

We also established that *motivation* influences an individual's intentions to repeatedly use a process model. While this finding is hardly surprising, it confirms that modeling-related tasks depend on an individuals' willingness to engage in such tasks. This adds to the existing body of literature on model re-use [33] by showing the importance of other than artifact-related factors to promote repeated use.

Second, we developed and validated an array of measurements capturing various evaluations of users of models and modeling software. While we used this instrument to examine intentions for repeated model use, it may also be suitable for other research areas. It can be used to assess the acceptance of modeling artifacts or modeling software [53] as well as intentions to continue or discontinue using process models. Subsequently, it could also be used to assess the impact of technological and individual factors on the re-use of code fragments [35–38], software packages, or other knowledge artifacts [31]. The instrument can further be revised and improved. For example, we relied heavily on self-reported perceptual measures. Usefulness and accessibility, amongst others, could also be measured through factual data, such as task performance or software access statistics. Provided such data can be accessed, our instrument could be used to correlate usage data with beliefs by users.

Our study also has *implications for practice* as it shows the importance of useful process models that are easy to understand. When creating or revising process models, companies and consultants should focus on creating easy to use in order to foster repeated use. We also identified potential approaches to foster repeated use behavior in organizations that already have a large collection of process models. These approaches include giving users more *time* to repeatedly use models and providing them with means to *easily access and explore* them, such as text-based search and links between models. Finally, the developed measurement instrument can also be useful for organizations to assess their current practices for repeated use as well as the impact of means taken to increase intentions for repeated use.

6.2. Limitations

There are a number of limitations to our study related to the design of our study and our framework. As it is common with first quantitative evaluations of a theoretical framework, we employed a cross-section survey within one organization. This limits generalizability to users from similar organizations. Alternatively, we could have conducted a cross-sectional survey on the organizational level. However, this would have precluded us from evaluating individual intentions and behaviors—which we deemed more suitable to initially evaluate our framework. It would have also made it difficult to isolate model-based factors since it would be hard to know which models were used using which software. We thus focused on a single organization enduring this limitation as we perceive it as a reasonable tradeoff. Future research could now replicate our study with other organizations to improve external validity.

Second, our survey is susceptible to mono-method bias. We relied entirely on self-reported data. This was a constraint of the collaboration with our partner organization because we were not able to obtain access to factual data on repeated use (e.g., from system logs).

Third, repeated use as a behavior can also be studied over time using longitudinal data. Panel studies or longitudinal case studies can yield more insights on how and why repeated process model use may vary due to learning, knowledge gains, organizational events, or changes in the business processes themselves. The survey method we employed is ill-suited to examine such variations.

Fourth, while we created a framework spanning artifact-related, individual and technological factors, we cannot claim comprehensiveness or exhaustiveness. The obtained results demonstrate acceptable explanatory power ($r^2 = 40\%$) and also allowed us to discriminate factors that apparently are unrelated to repeated use. Still, it may well be that other factors are of similar importance. For instance, our qualitative study uncovered organizational factors such as dedicating resources that could potentially influence repeated use intentions (c.f. Section 5.4) that were not covered by our framework or quantitative analysis. Factors relating to the process being modeled or the task being executed may likewise exert influence on the motivations or strength of determinants to repeatedly use a particular model.

Fifth, after our pilot study, we had to drop the organizational factors from the quantitative analysis because the measurements did not show sufficient validity and reliability. Additionally, our partner organization constrained the length of our survey instrument, which meant that we had to cull some items—in this case, those we found to be problematic. In turn, we were only able to collect qualitative data on organizational factors. Therefore, we cannot make statements about organizational elements that may influence the repeated use of models or other objects, even though it is possible that certain organizational beliefs and values would influence intentions toward repeated use. One example of such a possible scenario is a culture dominated by beliefs of teamwork, responsibility, customer orientation, and excellence—which has been shown to be conducive to business process management initiatives [71], including the (repeated) use of models. Still, the qualitative insights gained provide some empirical material for further theorizing and quantitative measurement.

Sixth, our data analysis was bounded by the available sample size. To assess the risk of limitations to external validity, we performed two independent power analyses. Results suggest that we could draw statistically valid conclusions for large effect sizes. A larger sample would have made it possible to detect small effect sizes with sufficient statistical power.

7. Conclusion

This study has developed the first conceptualization and empirical study of repeated process model use behaviors in organizational practice. Based on the literature, we built a conceptual model of factors that potentially influence an individual's intention to repeatedly use process models. We evaluated this model through a cross-sectional survey of process model users. Results from the study indicate the importance of quality and ease of understanding of models alongside individual factors, such as motivation and expertise, and thereby provide directions for increasing the benefits of process modeling.

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Appendix A. [1]

Artifact factors

Perceived semantic quality (based on [45]), anchored between strongly disagree and strongly agree.
The process model represents the process correctly. All the elements in the process model are relevant for the representation of the process. The process model gives a complete representation of the process. The process model is a realistic representation of the process. The process model contains contradicting elements.
Perceived usefulness of a process model (based on [53]), anchored between strongly disagree and strongly agree.
Using this process model improved my performance in the task I set out to do. Using this process model in the task I set out to do increased my productivity. Using this process model enhanced my effectiveness in the task I set out to do.
Perceived ease of interpretation of a process model (based on [53]), anchored between strongly disagree and strongly agree.
Learning how to use this process model was easy. It was easy for me to understand what this process model was trying to visualize. Using this process model was never frustrating. Overall, this process model was easy to use.
Satisfaction with model use (based on [58]).
Considering the use of this process model to date, … I am [extremely displeased...extremely pleased] with my use of this process model. I am [extremely frustrated...extremely contented] with my use of this process model. I am [extremely dissatisfied...extremely satisfied] with my use of this process model.

Individual factors

Self-determination (based on [50,56]), anchored between strongly disagree and strongly agree.
I use process models because it's fun. I enjoy using process models. I find using process models a pleasurable activity. I get pleasure and satisfaction from using process models. * I use process models because they interest me.[a]
Modeling experience (based on [17])
I used process models for the first time [about 1 year ago, about 2 years ago, about 3 years ago, about 4 years ago, about 5 years ago, more than 5 years ago].
Modeling intensity (based on [15]), anchored between never and hourly or more.
I use process models…
Modeling experience (based on [17]), anchored with true, false, I don't know.
For exclusive choices, exactly one of the alternative branches is activated. Exclusive choices can be used to model a repetition. Synchronizations means that two activities are executed at the same time. An OR gateway can be used to model concurrent paths. If two activities are concurrent, then they are executed at the same time. If an activity is modeled to be part of a loop, then it has to be executed at least once. An AND gateway at the end of a loop can lead to non termination of a process. A deadlock is the result of a inappropriate combination of joins and forks. Processes without loops cannot end up in a deadlock. For joining multiple paths out of an OR split, you can use either XOR or AND gateways.

Technological factors

Accessibility of a process model (based on [52]), anchored between strongly disagree and strongly agree.
This process model is readily accessible to me. This process model is very accessible in general. This process model is easy to access.
Accessibility of a modeling tool (based on [52]), anchored between strongly disagree and strongly agree.
Within the modeling software I described before, this process model is readily accessible to me. Within the modeling software I described before, this process model is very accessible. Within the modeling software I described before, this process model is easy to access.
Perceived usefulness of a modeling software (based on [53]), anchored between strongly disagree and strongly agree.
Using the modeling software enables me to use this process model more quickly. Using the modeling software improves my performance when using this process model. Using the modeling software increases my productivity when using this process model. Using the modeling software enhances my effectiveness when using this process model. Using the modeling software makes it easier to use this process model.
Perceived ease of use of a modeling software (based on [53]), anchored between strongly disagree and strongly agree.
I find the modeling software useful for using this process model. Learning to operate the modeling software to use this process model was easy for me. I find it easy to use this process model with the modeling software. Interacting with the modeling software is clear and understandable. It was easy for me to become skillful at using the modeling software. I find the modeling software easy to use.

[a] Items marked with an asterisk were removed from the analysis due to bad factor loadings / reliability issues.

[1] Please note that the following instruments were translated as the survey was conducted in German.

Repeated use intentions

Intention to repeatedly use a model (based on [48]), anchored between strongly disagree and strongly agree.
I intend to use this process model again in the future to support this work task.
I intend to use this process model again in the future to support this work task rather than using any alternative source of information.
* I intend to use this process model again in the future to support a different work task.
* I expect that other people within my organization will use this process model again in the future.
If I could, I would like to use this process model again in the future.
I would prefer to use this process model again in the future for this work task rather than not use it.

Appendix B. Item correlations

	Task: execution/ management	Task: exceptional/ repeated	Task: knowledge-intensive	Task: complex/ easy	Model size	Model complexity	Process complexity	SMQ	MPU	MPEoU	SAT	MOT	MACC	SACC	SPU	SPEOU	Repeated use
Task: execution/ management	1																
Task: exceptional/ repeated	−.126	1															
Task: knowledge-intensive	.262*	.117	1														
Task: complex/ easy	−.138	.351**	−.431**	1													
Model size	.081	.027	.278**	−.202	1												
Model complexity	.154	−.128	.296**	−.216*	.472**	1											
Process complexity	.123	−.079	.292**	−.204	.587**	.769**	1										
SMQ	−.013	.127	.101	.032	.154	−.073	−.068	1									
MPU	.034	.149	−.069	.220*	.041	−.245*	−.177	.466**	1								
MPEoU	.038	.126	.045	.045	.156	−.342**	−.281**	.597**	.652**	1							
SAT	.029	.235*	.185	−.038	.055	−.211	−.128	.545**	.624**	.717**	1						
MOT	.002	−.028	−.079	.014	.059	−.221*	−.133	.210	.400**	.399**	.351**	1					
MACC	.017	.260*	.104	.109	.155	−.097	−.145	.357**	.419**	.450**	.533**	.264*	1				
SACC	.303*	.216	−.034	.363**	.069	−.045	−.008	.203	.230	.245	.182	.136	.408**	1			
SPU	.224	.314*	−.065	.126	−.007	−.235	−.082	.244	.282*	.272*	.355**	.302*	.319*	.483**	1		
SPEOU	.273*	.192	−.140	.212	−.059	−.370**	−.223	.263*	.326*	.411**	.327*	.325*	.316*	.593**	.802**	1	
Repeated use	.079	.278**	.095	.145	.218*	.027	.137	.438**	.550**	.537**	.472**	.252*	.315**	.162	.231	.245	1

* $p < 0.05$.
** $p < 0.01$.

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