

Analysis of Business Process Model Reuse Literature: Are Research Concepts Empirically Validated?

Michael Fellmann¹, Agnes Koschmider², Andreas Schoknecht²

1 Institute for Information Management
and Corporate Governance
Osnabrück University
Katharinenstr. 3, D-49074 Osnabrück
michael.fellmann@uos.de

2 Institute AIFB
Karlsruhe Institute of Technology (KIT)
Building 05.20
D-76128 Karlsruhe
first_name.surname@kit.edu

Abstract: Business process modeling is a highly manual task. The effort of business process modeling might be reduced if process modelers are provided with the option of reusing existing process model assets instead of creating new models from scratch. Numerous research efforts thus have been focused on the reuse of existing model assets leading to a great variety of methods, models, algorithms and tools. However, up to now, the state of empirical evidence in respect to proven positive effects using these approaches is largely unclear. We therefore fill this gap by systematically analysing the available publications. Our paper contributes to the understanding of business process model reuse and consequently also to the knowledge base regarding process model reuse.

1 Introduction

Business process modeling is often considered to be a time-consuming and error prone task. Typically, business process modelers capture the process knowledge of domain workers in a business process model, i.e. process modelers interview domain experts involved in a business process about their tasks and the execution order of those tasks. Thereby, the business process model is usually constructed from scratch through various interview techniques [GEW09] without considering existing processes in a repository. The same applies for the redesign of business process models. For the design of to-be processes existing knowledge in process models is seldom utilized in practice [KP06]. By providing a rich repository of business process models a modeler is no longer restricted to his or her own thoughts and ideas but can obtain new insights from other models. A modeler might be able to incorporate parts or whole process models into her own model in order to find a suitable solution for her problem. For example, when a new process model variant is needed she might find a suitable process model in a repository, which she can reuse. Consequently, a repository of process models and efficient techniques, which allow exploiting the process models, is a suitable solution. It is also claimed that business process model reuse reduces modeling time and errors, increases model quality and flexibility [AC11], [Ho10]. Given the situation that business process model reuse is not commonly used, its positive effects and empirical evidence have to be studied. A large amount of literature related to business process model reuse has been

published which points, from a research point of view, to an already solved problem, but it remains to be investigated if the claimed positive effects of business process model reuse are validated.

Compared to available literature reviews on business process model reuse (e.g., [FG2012]) the added value of this paper is to question *if* process model reuse is really beneficial (by questioning the empirical validation of these proclaimed positive effects). Particularly, the goals that are pursued by reuse publications and the extent of their empirical analysis regarding these goals have been analyzed. We also analyzed if these publications empirically validate the positive effects of business process model reuse such as a reduction of modeling time and modeling errors or an increase of model quality. These investigations should clarify if a gap between the goals of a reuse publication and its empirical validation exists. To come up with answers, the following questions are considered:

- RQ1: *How many papers on business process model reuse provide empirical insights?*
- RQ2: *What goals are pursued in the area of business process model reuse?*
- RQ3: *Which positive effects are empirically validated in area of business process model reuse?*

To answer RQ1, relevant research papers have been investigated with respect to the criterion if they provide an empirical analysis of their approach. Regarding RQ2 the motivating goals described in the literature are analyzed and categorized, i.e. what are the reasons for suggesting a new business process model reuse approach. RQ3 should elucidate if positive effects concerning the stated goals are empirically validated.

To provide answers for RQ1-RQ3 the paper is structured as follows: The literature review process is summarized in Section 2. The results from the literature analysis are described in Section 3. The paper ends with a summary and an outlook on future research directions.

2 Literature selection

The review presented in this section gives an overview on research works related to business process model reuse and serves as the foundation of our analysis regarding RQ1-3. To classify related literature we define a taxonomy for business process model reuse (see Figure 1). Fundamentally, research on business process model reuse can be classified in empirical research (i.e. describing and explaining existing phenomena in studies or theories) and in research where new assets are designed and suggested (i.e. the results are normative or prescriptive). The latter category can be further refined in the technical artifact (architecture, framework or repository) and method. Within the method category we distinguish four sub-categories: (1) abstraction (encompassing works

relating to patterns, reference models or meta-models), (2) selection (describing approaches related to retrieval and similarity of models), (3) specialization (works that elaborate on the configuration, customization or adaptation of models) and (4) integration (describing the composition of models out of fragments and modules). To each of these categories, we assigned keywords reflecting the categories' content (cf. the rectangles with dotted border to the right of the categories), which we used during the literature search process.

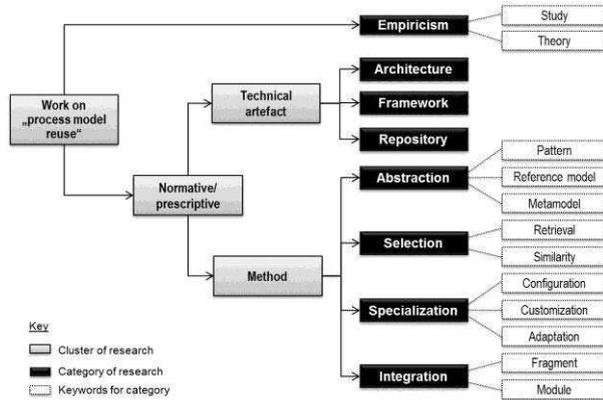


Figure 1: Categories of business process model reuse literature.

This taxonomy has been derived from a wide range of concept categorizations (e.g., for software reuse, life-cycle models and model reuse). The *Method* branch corresponds to the categorization of software reuse (see [Kr91]).

To validate this categorization we also browsed available literature e.g., review on business process model reuse [FG2012]. The paper of [FG2012] considers the following five categories: SOA, Pattern, Ontology/Reasoning, Variants/PL and others. From our point of view, the categories used in [FG2012] limit the number of related papers (in [FG2012] only 52 papers were considered). Keywords of each category have been defined individually according to assets that are reused. Therefore, the categories proposed in [FG2012] are not further considered.

Methodology: To collect and retrieve appropriate literature, we applied WEBSTER and WATSON's approach [WW02]. The scope of the literature review cannot be described as exhaustive. Business process model reuse is also complementary to a wide body of research streams, e.g., version management, compliance management, process variants. Besides, literature generally addressing but not directly focusing on business process model reuse (e.g., process model similarity for compliance or variance management or service-oriented composition) is not further considered.

Three authors received the task to search for literature on process model reuse. The query terms were restricted to the categories of our business process model reuse taxonomy and no time restriction was applied. The literature review process consisted of the following three steps adopted from WEBSTER and WATSON [WW02].

- First, research databases such as IO-PORT.NET and ISI WEB OF KNOWLEDGE (which considers ACM, IEEE, SPRINGER LINK) were browsed and the following query terms were used ("business process", "process model", "process modeling", "business process model") AND ("reuse", "model reuse") AND category/category keyword. We also used synonyms for the category keywords where applicable (e.g., *query* and *search* as synonyms for *retrieval*). For instance, a valid query was "*process modeling*" AND "*model reuse*" AND "*pattern*".
- Second, GOOGLE SCHOLAR was used to widen the search scope. Thereby identical query terms were used. Results published but not meeting scientific criteria (e.g. working reports on personal homepages) were excluded from further examination.
- Third, a backward search was conducted. Every paper, found during the first two steps, was analyzed with respect to relevance. Only papers explicitly mentioning reuse were further considered. Eventually, 92 out of 143 research papers fulfilled the criteria (no duplicate entry, research focus on process model reuse) and were further considered.

Name	Category description	Related literature
<i>Abstraction</i>	Research publications classified into this category are related to reference modeling, meta models or patterns. Thus, this work abstracts from concrete models and presents findings for more general cases specifically addressing reuse aspects, e.g. [58, 74].	[1, 2, 6, 8, 10, 16, 23, 28, 34, 43, 48, 57, 59, 60, 70, 71, 72, 73, 74, 75, 78, 79, 80, 81, 82, 84, 89]
<i>Architecture</i>	Research publications classified into this category are understood according to [24] as an organization of processes and related elements to enable reuse of processes. In essence, an architecture description contains all elements that are necessary to enable and facilitate reuse of processes.	[3, 11, 14, 24, 35, 63, 66, 74, 76, 78, 87, 92]
<i>Empiricism</i>	Research publications classified into this category cover empirical studies about e.g. factors influencing the reuse of process models [33] or the adoption of related concepts in practice.	[32, 33]
<i>Framework</i>	Research publications classified into this category have two different meanings. On the one hand it refers to mechanisms that are needed and useful to support and enable reuse of process models. On the other hand a framework can be a description of a process model or a part thereof which allows reusing this process (part) in other process models.	[11, 22, 25, 49, 50, 51, 55, 61, 70, 86]
<i>Integration</i>	Research publications classified into this category refer to the reuse of parts of process models, e.g. the reuse of certain process fragments, e.g. [46, 47].	[5, 18, 46, 47, 67, 68, 90]
<i>Repository</i>	Research publications classified into this category refer to specifications of components that compose a process repository for the storage of process descriptions, e.g. [62].	[17, 19, 20, 26, 27, 29, 41, 47, 69, 85, 88]
<i>Selection</i>	Research publications classified into this category refer to retrieval and similarity related methods for the reuse of process models, e.g. [3].	[3, 36, 37, 52, 54, 62, 83, 85, 91]
<i>Specialization</i>	Research publications classified into this category refer to the adaption or customization of process models to reuse an existing model with changes due to some reasons, e.g. [39, 40].	[4, 7, 9, 12, 15, 30, 31, 38, 39, 40, 44, 45, 53, 56, 64, 65, 77]

Table 1: Categorization of business process model reuse literature.

Afterwards, the search results were collected and duplicate entries removed. The same three authors that performed the search read the selected papers and assigned them to a category individually. If a paper was assigned to several categories, the assignment was discussed until consensus was achieved. The low number of relevant literature can be explained due to the use of the query term "reuse," which highly limits the result list. Research works are classified in most cases into one category only, except for some works (e.g., [3] or [70]), which addressed several reuse issues. Papers published by same authors in different years (e.g., as a conference or journal paper) were counted once. Four research works – [13, 21, 42, 58] – are not mentioned in Table 1 as they describe general methods and procedures of how to apply model reuse. A complete overview of the categories and their corresponding literature can be found in Table 1, while a list of literature references can be obtained online due to space limitations (see http://semreuse.aifb.kit.edu/downloads/Literature_Review_Modellierung2014.pdf).

3 Analysis of the literature

In order to give an answer to the research questions RQ1-3 and hence to assess the state of empirical research, we have manually analyzed all the literature mentioned in Section 2, which is in total 92 papers. The analysis of the papers comprised reading each paper and extracting the required information to answer our research questions. In case of any room for interpretation we discussed the issues within the team of three researchers until consensus has been reached. In the following, we report on our results.

Quantifying empirical research in process model reuse: Regarding RQ1 „*How many papers on business process model reuse provide empirical insights?*“ our result is that 16 papers from 92 investigated papers comprise empirical studies. This calculates to an amount of 21 % of the papers containing empirical investigations. It can thus be concluded that the overall amount of empirical research in the core categories for business process model reuse is quite small.

Goals pursued by researchers in the business process model reuse field: In order to answer RQ2 “*What goals are pursued in the area of process model reuse?*” we have investigated the contribution of all 92 research papers carefully. The contribution of a paper, i.e. what is achieved by the research described in the paper, has subsequently been reformulated as a goal of the paper, using a verb at the beginning. For example, “design tool support for reuse” would be the goal of a paper elaborating on the design of a system capable of recommending model elements. If the goal has not been on our list, we added the goal and added the numerical value “1” for the amount of papers. If the goal was already on our list, we added “+1”. Figure 2 summarizes the goals we identified in all 92 analyzed papers and also the amount of papers supporting the respective goal. As it can easily be seen, most of the research work is centered on improvements of reuse. The authors of the corresponding papers thereby envision methods and models describing the improvement of reuse approaches such as procedural models, frameworks for reuse and other artifacts. The goal pursued second most by the authors is the improvement of tool support for reuse. That is pursued by even slightly more papers than the goal of developing dedicated methods for reuse.

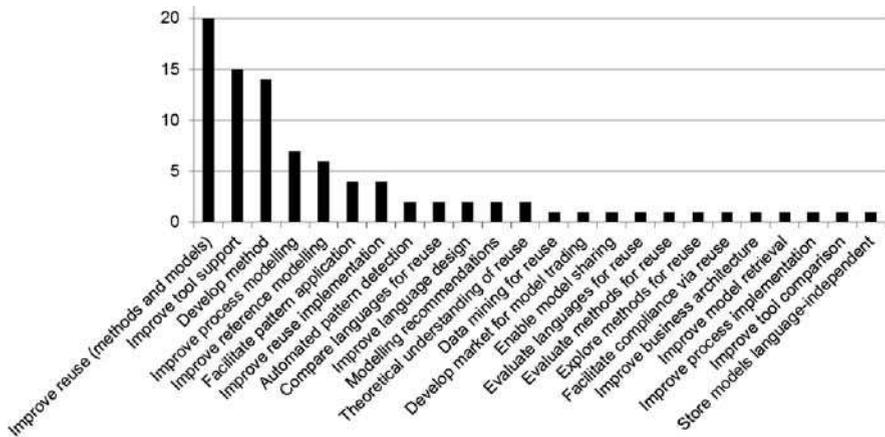


Figure 2: Goals pursued in the core business process model reuse literature.

In contrast to the first goal *Improve reuse* which also comprises papers containing methodological aspects, papers supporting the goal *Develop method* devise procedures that have been designed from the ground up for reuse purposes – i.e. they do not aim at incremental improvements but rather at specialized new methods.

The next goals when reading Figure 2 from left to right are *Improve process modeling* and *Improve reference modeling*. Authors supporting these goals strongly anchor their work in the existing body of knowledge concerning semi-formal process modeling and reference modeling. The following goals are diverse in nature and resemble to a long tail. Regarding RQ2 it hence can be concluded that most papers pursue goals that are on a rather abstract level describing artifacts such as methods and models, aim at an improved tool support or focus reuse-centered improvements of modeling approaches. Besides this, there is a great spectrum of diverse goals each pursued by one paper.

Goals that are validated in an empirical setting: Regarding RQ3 “Which positive effects are empirically validated in area of business process model reuse” we first analyzed the papers to detect all contained empirical analyses (bottom-up approach). Second, we examined the papers if they contain broad claims on positive effects of process model reuse and checked in a third step if these claims are substantiated systematically by an empirical or non-empirical analysis (top-down approach).

As the result of our bottom-up analysis, we detected 16 papers out of 92 that contain an empirical analysis (see also RQ1). In summary, the 16 papers evaluate (1) the efficacy of automatic pattern detection, understandability, consistency, correctness, model management, acceptance issues and the technical quality in terms of time and memory consumption – all the claims in respect to these goals are validated by conducting experiments, (2) the relevance of patterns by an analysis of a collection of more than 200 process models, which is contained in two separate papers, (3) the technical quality of an approach for storing process models conducting an experiment using 595 EPC models from the SAP R/3 reference model and 248 EPC models from IBM’s BIT library, (4) the required adjustments when reusing models and the impact of reuse on model quality

using an experiment, (5) granularity issues of reuse by conducting a comparative study, (6) the feasibility of the proposed approach by implementing a prototype or conducting case studies. Surprisingly, although tool development is the ultimate goal of many efforts, none of the empirical analyses of these prototypes is based on user experiments. Regarding RQ3 it can be concluded that there is a low number of papers addressing the empirical analysis of goals. Moreover and quite alarmingly, experiments with end-users seem to be largely neglected.

To conduct our top-down analysis, we specifically analyzed the abstract and motivation sections of all papers to detect broad claims on positive effects that are used to motivate the research conducted in the paper. If such claims were present, we analyzed whether they are supported by an (non-)empirical analysis. Thereby we identified that reduction of modeling time, reduction of errors in process models, general statements on the positive correlation between business process model reuse and model quality, as well as a gain of modeler productivity were the most often mentioned broad claims on positive effects of process model reuse in these papers. Reduction of errors thereby refers to e.g. the elimination of concrete modeling errors like misspellings or incorrect use of the modeling language syntax while the general model quality aspect is concerned about e.g. layout of models or suitable decomposition of big models into smaller ones. 46 out of the 92 considered papers mentioned one or more of the aforementioned positive effects while in the other half no positive effects were mentioned. The results of this investigation can be found in Figure 3.

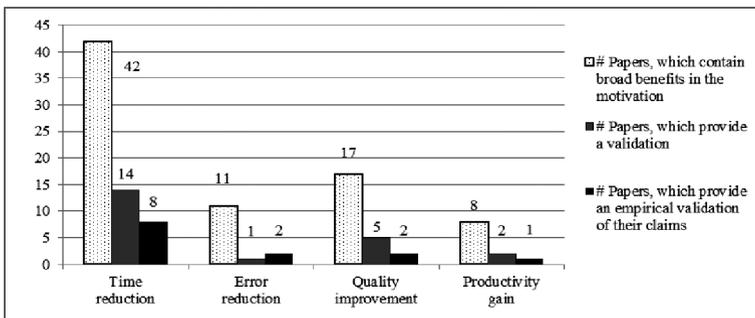


Figure 3: Number of papers considering positive effects of their approach.

Most frequently the reduction of modeling time needed to construct a process model is mentioned as a positive effect of business process model reuse (42 times). However, only 8 papers out of 42 provide an empirical validation of that claim (19%). Another 14 papers (33%) provide other kinds of investigations regarding the efficacy of the approach, which do not directly relate to the general claim of reducing modeling time or do not provide an empirical analysis (e.g. they describe a research prototype and related scenarios possibly leading to the reduction of modeling time [TCN11] but do not measure any kind of concrete modeling time). The same observation holds for the other effects: In every effect category (time reduction, error reduction, quality improvement and productivity gain) only few papers provide an empirical validation while a few others provide other kinds of validations. But still most papers do not provide any validation regarding their claimed positive effects. Overall 78 statements regarding the

four positive effects can be found in the literature but only 13 statements (17%) were empirically validated. Another 22 statements (28%) were validated without explicit empirical focus, which means that 55% of the stated positive effects were not validated in any way. To sum up this aspect of our literature analysis, a large amount of research work has been published – however, without any empirical investigation regarding the positive promises of business process model reuse.

4 Conclusion and outlook

Since there is a great variety of research available regarding reuse in business process modelling, we have investigated the state of empirical evidence in respect to the positive effects accompanied by these approaches. To do so, we systematically investigated the proposed approaches, which led to the consideration of 92 research papers. Regarding our research questions RQ1-3 we have to state that while there are numerous approaches devising methods and models for reuse or design tool support, there is a lack of empirical research to substantiate the positive effects attributed to the approaches and tools. Regarding the more general, broad claims on positive effects (e.g. regarding time, effort and quality), it has to be stated that a validation in this respect is almost completely missing. We hence come up with the following conclusions and recommendations. Firstly, we suggest the community of BPM researchers to do more empirical research in terms of evaluating the positive effects of their approaches. Secondly, we encourage researchers to investigate the effects of their approaches in a more holistic way.

6 References

- [AC11] Aldin, L.; de Cesare, S.: A literature review on business process modelling: new frontiers of reusability. *Enterprise Information Systems*, 5(3), pp. 359-383, 2011.
- [FG2012] Fantinato, M.; Gimenes, I. M. de Souza; Rocha, R. dos Santos; Thom, L. H.; Toledo, M. B. Felgar de: A Survey on Reuse in the Business Process Management Domain. *Int. J. Business Process Integration and Management*, 6(1), pp. 52-76, 2012.
- [GEW09] Grosskopf, A.; Edelman, J.; Weske, M.: Tangible Business Process Modeling – Methodology and Experiment Design. In S. Rinderle-Ma, S. Sadiq, F. Leymann (Eds.), *Proceedings of BPM 2009 International Workshops*, pp. 489-500, Ulm, 2009.
- [Ho10] Holschke, O.: Impact of Granularity on Adjustment Behavior in Adaptive Reuse of Business Process Models. In R. Hull, J. Mendling, S. Tai (Eds.), *Proceedings of the 8th BPM conference (BPM 2010)*, pp. 112-127, Hoboken, 2010.
- [KP06] Klein, M.; Petti, C.: A handbook-based methodology for redesigning business processes. *Knowledge and Process Management*, 13(2), pp. 108-119, 2006.
- [Kr91] Krueger, C. W.: Software reuse. *ACM Comp. Surveys*, 24(2), pp. 131-183, 1992.
- [TCN11] Tran, H. N., Coulette, B., Narbonne, D.: Automatic Reuse of Process Patterns in Process Modeling. In *Proceedings of the 2011 ACM Symposium on Applied Computing*, pp. 1431-1438, 2011.
- [WW02] Webster, J.; Watson, R. T.: Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, 26(2), pp. xiii-xxiii, 2002.