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# Applicability of Business Process Model Analysis Approaches – A Case Study in Financial Services Consulting

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**Abstract.** The analysis of business process models gains more and more attention in IS research. Several analysis approaches have been developed. All of them provide different features, such as syntax checking or pattern recognition. This paper investigates the applicability and relevance of business process model analysis approaches using a case study from financial services consulting. Two research contributions are provided. First, an overview about common model analysis features and its relevance for consulting processes are provided. Second, the applicability of the automatic business process model analysis approaches is investigated. Results show that the majority of features can raise efficiency of analyses in business process reengineering projects.

**Keywords:** business process analysis, model analysis, financial services, case study research, applicability check

## 1 Introduction

The financial services industry experiences a high degree of change which comes along with several challenges. Kohlmann [1] identifies new competition structures, regulatory and fiscal requirements (such as MaRisk, IFRS 9, or Basel III), changing customer demands and structures, product complexity, information technology, and competitive awareness as the central drivers of change initiatives. Consequently, the financial services industry is faced with a high competitive pressure, leading to specialization and consolidation [1-3].

In order to cope with an ever changing environment and the pressure to increase efficiency and effectiveness of business processes, financial institutions attempt to run large business process reengineering (BPR) projects [4] aiming to increase transparency and optimize the process management within the organization. Therefore companies use business process model repositories, i.e. databases for process models, as basis for analyses and optimization. Due to the high number of processes stored in

repositories and required industry knowledge, model analysis is often performed by consultants as they usually provide a cross-company perspective, best practices, industry standards, and benchmarks [5-6]. As more and more financial institutions engage in professional business process management, increasing requirements towards efficiency and effectiveness of process model analysis can be observed. IS research reacts to this demand by developing approaches that analyze business processes (semi-)automatically e.g.[7-10]. These approaches can assist in detecting syntax errors, compliance frauds or common optimization patterns. They have received a lot of attention in academia but or however, they lack empirical evidence in terms of applicability and relevance in practice.

The goal of this paper is to contribute to closing this gap and to provide insights into the perceived applicability of model analysis approaches (MAA) in practice. Considering the identified research gap, we aim to answer the following research question:

*How relevant are automatic MAA capabilities for business process model analysis tasks in financial services industry consulting?*

To answer this question, we conduct a case study in one of Germany's biggest financial services consulting companies and investigate the potential benefits of MAA capabilities for its consultants and BPR experts.

The remainder of this paper is structured as follows. In the next section, we briefly describe common features of business process MAA. Section 3 describes our research design and case setting and Section 4 presents our findings. Finally, in Section 5, we discuss our results and provide an outlook on further research in automated MAA.

## **2 Business Process Model Analysis Capabilities**

Model analysis is often considered with model checking. The term "model checking" originates from computer science and is defined as "an automatic technique for verifying finite-state reactive systems, such as sequential circuit designs and communication protocols" [11]. We perceive business process model analysis in a less technical sense and define it as an automatic technique for verifying graph-based models in order to detect predefined patterns and execute search queries.

Common business process model analysis approaches have several different features which we briefly introduce in this section. Therefore we performed a structured literature search according to the procedure introduced by vom Brocke et al. [12]. In an initial step we searched all A and B journals from the Journal Ranking VHB Jourqual 2.0 (<http://vhbonline.org/service/jourqual/jq2/>), subsection information systems and information management and queried the database Ebscohost with the following search terms: model analysis approaches, process analysis, automatic process analysis, business process analysis, model analysis, automatic model analysis, automatic analysis. The search set was restricted to publications between 2006 and 2012 to ensure that only recent MAA were included. In addition to querying Ebscohost, forward and backward searches, starting from the initial result set, were conducted.

We analysed the results by first reading the title and abstract and, based on the relevance, we read the whole article and derive the features of the introduced approach. All features and relevant approaches are depicted in Table 1.

*Structure Analysis* is one of the fundamental analyses features for business process models. It is used to verify the correctness of the model in terms of completeness, consistency, and feasibility [13-14]. The structural analysis further reveals structural similarity between models, e.g. measured by distance metrics [15]. *Semantic Analysis* detects “the degree of similarity, based on equivalence between words” [16], such as labels, annotations or other semantic elements within the model. Semantic analyses may, for example, detect how similar two process models are based on the analysis of its event and activity labels.

The *Text / Label Analysis* covers a narrower model analysis, compared to the Semantic Analysis. Such analyses focus on analyzing and comparing element labels, model annotations and other text elements within the process model. In addition, MAA include word topologies, such as sentence structures or synonyms. The outcomes of such analyses are mainly distance metrics between two models, e.g. from a sample text, a company model, or process elements [13], [17-18].

*Data / External Information Inclusion* is of growing practical relevance. This model analysis feature includes elements which are not necessarily part of the analyzed model itself. External information sources or data can consist of linked models (such as organizational structure diagrams), data fragments from data-aware compliance rules, and annotations containing any forms of external information necessary for the process model [15], [19]. Thereby, the focus is set on inclusion and flow of external information, data or annotations. The included data is then used to create performance indicators, such as process costs or processing times [20].

The *Execution / Behavior Analysis* focuses on the process model and the transition states. The analysis often uses control-flow information to determine possible process states. Reachability or deadlock checks can be executed based on the information delivered by the execution and behavior analysis [16], [21].

*Across Modeling Language Comparison*, meaning the comparison of process models, developed with different modeling languages, becomes a more and more regarded feature. A typical application domain includes comparisons with reference models, as in the publications by Dongen et al. or Ghose and Kolliadis [15-16]. In addition, as a direct comparison is rather complicated, the MAA transforms the process models into a comparable modeling language before analyzing them [15].

*Complex / Loop Construct Analysis* enables the detection of complex process model structures, such as control flow loops and process execution rules. Dongen, Dijkman and Mendling use causal footprints for complex model analysis [16]. Awad and Sakr use a graph based representation to match graphs within repositories and therefore use the Business Process Modeling Notation Query language (BPMN-Q) within their approaches to handle and analyze models regardless their complexity [22].

*Pattern / Model Construct / Sub graph Analysis* is a feature that enables the analysis of a particular combination of model elements, such as Activity A must be executed before Activity B begins. Famous workflow patterns are, for example, described in

[23]. Thereby, patterns and constructs represent a specific rule that can express a structure, semantic, object, behavior or any other kind of requirement for a process model. MAA try to match the defined structure with the process model [24]. On the one hand, a sub graph can be a specific type of construct or pattern that can be searched for. On the other hand, pattern and construct analysis may use sub graph isomorphism [25] to reduce the analysis time and limit the analysis to defined sub graphs [26-27].

**Table 1.** Business Process Model Analysis Capabilities

	Structure Analysis	Semantic Analysis	Text / Label Analysis	Data / External Information Inclusion	Execution / Behavior Analysis	Comparison Across Modeling Languages	Complex / Loop Construct Analysis	Pattern / Model Construct / Sub-Graph Analysis	Tool Based Analysis / Visualization	Modeling Language Independence
Graph Matching Algorithms for Business Process Model Similarity Search (Dijkman et al. 2009) [12]	X	X	X		X		X			X
Measuring Similarity between Business Process Models (Dongen et al. 2008) [15]	X	X	X		X	X	X			X
On Enabling Data-Aware Compliance Checking of Business Process Models (Knuplesch et al. 2010) [18]				X			X		X	
Auditing Business Process Compliance (Ghose and Koliadis 2007) [14]	X			X	X			X	X	
Querying Graph-Based Repositories of Business Process Models (Awad and Sakr 2010) [21]	X	X		X	X		X	X	X	
Structural Patterns for Soundness of Business Process Models (Dongen et al. 2006) [25]							X	X	X	X
Pattern Identification and Classification in the Translation from BPMN to BPEL (García-Banuelos 2008) [20]	X				X		X	X	X	
Querying business processes with BP-QL (Beeri et al. 2008) [19]	X			X			X	X	X	
An Efficient Algorithm for Workflow Graph Structural Verification (Touré et al. 2008) [23]	X						X	X	X	
Clone Detection in Repositories of Business Process Models (Dumas et al. 2010) [16]	X		X					X	X	
Fast Business Process Similarity Search with Feature-Based Similarity Estimation (Yan et al. 2010) [17]	X		X	X				X		X
Fast Detection of Exact Clones in Business Process Model Repositories (la Rosa et al. 2012) [10]	X		X		X	X		X		X

The *Tool Based Analysis* feature expresses the support for model analysis by a software application. Therefore, it is not sufficient that the approach's analysis algorithm has been provided. Rather the feature is fulfilled whenever the approach has been implemented within a tool solution, providing visualization etc. Most approaches implemented the algorithms in a tool. If they do not provide tool support, the analyzed paper only provides the description of the analysis algorithm.

The last identified feature is *Modeling Language Independence*. Approaches that support this feature enable the analysis of process models developed with different languages [28]. Compared to the feature *Across Modeling Language Comparison*, modeling language independence does not focus on comparing process models. These approaches may rather analyze arbitrary process models individually. As Becker et al.

[28] argue that banks are not willing to change their common business process modeling technique for implementing MAA, this feature gets more and more attention.

### **3 Research Design**

Given the high pressure to redesign business processes in financial institutes and the features of business process analysis approaches, we aim to explore the practical relevance of such analysis approaches. In particular, business process consultants are frequently requested to analyze and improve business processes [29-30]. Therefore, they can be seen as one key user group of business process MAA. In this paper, we investigate whether business process MAA are capable of supporting or even replacing manual model analysis tasks in financial services consulting.

Based on the findings of [4] who report on massive model repositories containing about 1,800 business process models, we assume enormous effort for consultants to analyze such a high number of business processes manually. In addition, the failure rate, meaning that not all process improvement capabilities or compliance frauds will be detected, is much higher compared to scenarios in which consultants make use of automation support.

The study at hand aims to investigate the relevance of MAA. Therefore we follow Rosemann and Vessey [31] and apply an applicability check prior to a typical research process. Applicability checks allow “[...] practitioners to provide feedback to the academic community on the research objects it produces or uses in theory-focused research” [31]. We thereby focus on separated semi-structured interviews with professionals of the financial services consulting domain.

The selected participants have been identified by applying the “snowball sampling approach” [32] which suggests accessing the best interviewees by asking interviewees for other potential interviewee suggestions. This approach is commonly used “to contact groups of people for whom there is no sampling frame” [32]. For this study, the interview topics have been specified at first, and then a snowball sampling took place. The investigated company is one of Germany’s biggest consulting companies for the financial services industry with customers in every segment of the industry. Altogether, five interviewees were selected, based on their expertise in BPR projects. One more participated in a pre-test which was conducted in order to ensure that all questions are understandable and unambiguous. The respondent details and its expertise are summarized in Table 2. Altogether, the face to face interview sessions led to the collection of about 37.700 words of transcribed data.

The interview was divided into nine question categories along the time slot of one hour. Question categories comprise of the following topics:

1. Short topic introduction, presentation of research subject and objectives, explanation of interview setting (audio recording, timeline), collection of demographics.
2. Presentation and evaluation of currently used model analysis approaches.
3. Exploration of model analysis tasks and model analysis requirements within the consulting process.

4. Collection of typical process flows and modeling problems (such as reoccurring weaknesses and difficulties and challenges).
5. Assessment of relevance and desired features of automatic business process MAA. Each interviewee rated the importance of each feature on a one-to-five scale.
6. Effort estimation (current, manual approaches vs. automated approaches).
7. Introduction of an automatic model analysis approach for previously discussed features. Presentation of sample use cases (interviewee is mostly passive here).
8. Mapping of model analysis features to the consulting tasks and process steps which resulted from categories 1 - 6.
9. Evaluation of the manual approach in comparison to the automatic approach. Collection of additional use cases in consulting and additional features desired.

**Table 2.** Respondent details

	Age	Position within the Consultancy	Unit	Department	Working Experience as Consultant	Employee of the Consultancy	Experience with Process-Consulting	Other
Participant I	31	Manager	IT	IT Strategy	6 Years	6 Years	6 Years	-
Participant II	29	Senior Consultant	Organization and Transformation	Process- and Qualitymgmt.	4 Years	3 Years	2 Years	-
Participant III	35	Senior Manager	Organization and Transformation	Process- and Qualitymgmt.	4 Years	4 Years	4 Years	Has been employed in Processmgmt in banking before
Participant IV	45	Senior Manager	Organization and Transformation	Banking Systems	12 Years	4 Years	8 Years	-
Participant V	46	Senior Manager	IT	IT Strategy	17 Years	5 Years	12 Years	EAM-Generalist
Average	37	Manager+	-	-	9	4	6	-

## 4 Study Findings

### 4.1 Business Process Reengineering Steps and Tasks

During the pre-test, we identified all the typical BPR stages at the consulting company. These stages are depicted in Figure 1 and defer from the well-known BPR stages, introduced by Hammer and Champy [33]. During the interviews we justified these stages and use them to classify the features of MAA in typical BPR projects.



**Fig. 1.** Business Process Reengineering Stages

**Clarify Reengineering Objectives.** In the beginning of a BPR project at the consulting company, the objectives have to be determined. The interviewees describe the business process analysis project as business and management driven. The objectives are identified by “document review of strategy papers, [conducting] top-management workshops, in order to find out in which direction you should proceed [...]” (interviewee four). According to interviewee number five, the central goals are to “struc-

ture the processes” and to analyze problems regarding “economic necessity” of business processes.

**Create a Transparent As-is World.** Reengineering projects require a deep and thorough understanding of the current state. Therefore, it is necessary to understand the as-is processes as well as respective strengths and pain points. This is usually reached by means of conducting workshops and reviews of existing documentation. According to interviewee five, process models are “only modeled deeply in areas where a positive effect can be expected”, meaning that solely for documentation purposes, they do not develop process models. Further, interviewee one said that for cost reduction projects, he “begins with the analysis of the current state to determine the cost drivers [...]”. When necessary, the elicited information is transferred into a process modeling tool of the consulting company and enriched by connecting it with other processes, organizational units, IT systems, and process performance indicators. These indicators might be “[...] key data, for example for project costs or capacities of the organizational units” (interviewee one) which are annotated to the organizational units and process steps by “[...] using tools such as ADONIS” (interviewee three). The process models are used to provide an overview on business areas and create a high level of transparency, interviewee one expressed.

**Identify Requirements.** In the subsequent step, drivers for change have to be identified which specify the requirements for the reengineering objectives and help to “[...] develop the target picture [...]” (interviewee one). The current state is analyzed to detect typical weaknesses in the business processes, interviewee three and four stated. When perceived as beneficial, best practice patterns will be applied. Manual business process analysis is supposed to avoid complex analysis (“[...] you do not need to create solutions with a complex analysis method, which are so complex that you actually can’t even use it”, interviewee one). Interviewees four and five described this analysis stage as a gap analysis between the as-is and to-be situation described by the business strategy. “This means that, out of the complete view, we try to operationalize the business strategy by breaking down the necessary operational and technological changes” (Interviewee five). If the objectives require far-reaching process changes, the as-is analysis is rather small since the business processes will be redesigned anyway. The analysis level always alters according to the project scope (“It means the level of detail is certainly dependent on what should be the results at the end”, interviewee four).

**Develop To-be Situation.** After specifying the requirements, a precise to-be situation is developed. By changing the parameters for the key factors influencing the reengineering objectives, continuously improved business process models are created, interviewee one stated. Interviewee three mentioned that “[...] the new processes [are also developed] as target-state-processes”.

**Evaluate and Roll-out.** After the development of the to-be situation, the to-be processes are created and implemented in the company. During the so called roll-out phase, the quality cycles ensure that the reengineering objectives are met and that the business continuation is guaranteed (“And then we pay attention at different phases during the roll-out and ensure the procedural quality through appropriate quality cycles”, interviewee three).

#### **4.2 Weaknesses of the Manual Business Process Model Analysis**

During the interviews, several business process analysis weaknesses evolve out of unclear process definitions. Redundancies in existing processes are common and market, product or services boundaries are not clearly set, which hampers the process analysis, interviewee five stated. Furthermore, the granularity often differs, which was mentioned as a particular problem in distributed modeling and analysis processes (“[...] there are too many people with different levels for detailed-modeling”, interviewee three).

The maturity of skills in process management, process documentation and process optimization is described as varying. Some companies provide and expect digital business process models; others provide process documentations and in some projects, information about business processes has to be gathered through interviews. “Some customers want specific tools and other customers have nothing and there is just a written instruction order and you have to go through available data, but in case of doubt, you’ll just conduct interviews”, interviewee five said. Business process models, even if digitalized, may not be maintained and are therefore outdated. They may also provide wrong data as inexperienced users make modeling mistakes. Moreover, the models may not provide information on the necessary level of detail or they are not representing the way processes are really handled within the company. This leads to the analysis of processes that are not described by models (“[...] we basically try to structure the processes which are not documented at all”, interviewee five). Moreover, even if modeling methods are used correctly, there are still gaps between the modeled information and the actual process.

Additionally, interviewee four mentioned that the application of professional process management tools is rare and mostly limited to companies which have a high process management competence. Most companies in the market use MS Visio or PowerPoint for process description and process analysis. Interviewee two additionally state that “processes are not documented properly. Processes will not be executed like they are modeled“. This leads to a lack of transparency in the as-is situation.

#### **4.3 Importance of MAA Features for the Manual Business Process Analysis**

The interviewees were asked for an overall rating of the feature importance independent of the process reengineering stages as well as an in depth evaluation of the feature importance for each BPR stage. Therefore, each interviewee rated the importance of each feature for the different phases on a scale

from one (meaning unimportant) to five (meaning very important). Figure 2 depicts the cumulated results. On the left side of the figure, the consultants rated the overall importance of the features, independently from the business process analysis stage. The “Structure Analysis”, the “Semantic Analysis” and the “Tool Based Analysis” are important for the process model analysis tasks. The “Text / Label Analysis” and the “Modeling Language Independent Analysis” are just of little importance for the interviewees.

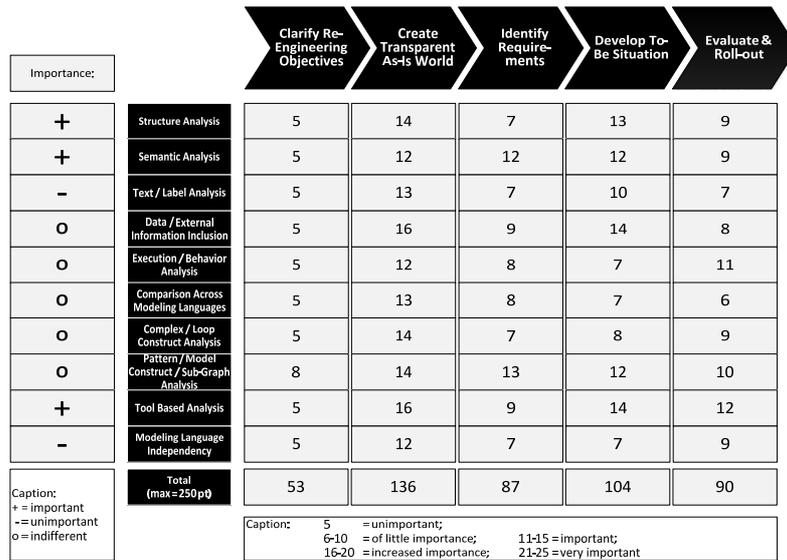


Fig. 2. Importance of Features for Manual Business Process Analysis

Regarding the assignment of analysis importance to process steps, three out of five interviewees expressed that the features of MAA are particularly relevant for the process steps “Create transparent as-is world” and “Develop To-Be Situation”. The stages “Identify requirements”, “Evaluation & Roll-out” are identified as less useful stages for the application of process model analysis features. The first BPR stage, “Clarify reengineering objectives”, is of minor to no importance for business process MAA.

#### 4.4 Importance of Automatic Business Process Model Analysis

The rating of automatic model analysis features depends on the “level of automation of the analysis”, interviewee five said. A high level of automatic analysis is especially important if the analysis of “masses of models” is necessary.

**Features Rated as Rather Important.** It turned out that the analysis of Data / External Information Inclusion is of high importance for the business process reengineering tasks. In particular, “the analysis of attributes” (interviewee one), such as processing times, costs, locations, occurrence probabilities, and dependencies with other models

was described as important. The relationships between the process and further attributes and processes on other hierarchical levels are seen as important to understand the whole process model. Including external data and information into business process analysis ensures that all external information is included in the analysis (“I need the possibility to link to external data”, interviewee three).

Regarding the analysis approaches that provide Modeling Language Independency, interviewees stated that in contrast to the feature rating for manual process analysis, it is important to integrate models developed with different tools into the analysis tool and vice versa (“we used ARIS at Bank X [and] we found ADONIS at Bank Y”, interviewee five). We explain this rating difference with the brief discussion on that feature, e. g. by discussing a large merger between several independent banks using different modeling tools. The feature is especially relevant as the tool support that is currently available, is perceived to be insufficient for this task (“It is important for consulting [that] [...] in the end I can transfer all the processes into a tool which the customer already uses”, interviewee three).

Execution / Behavior is also been rated as important – especially for technical processes. Other processes are not in scope because they are perceived as “too inaccurate and fuzzy”. In addition, the combination of economic key factors, such as process costs, with the process simulation is considered to be highly relevant. The feature should be able to create a “what-would-be-if analysis regarding business ratios [...]” along the business process models.

The tool support is described as “important without a doubt”, interviewee five said. In particular, for large process model repositories, it is mandatory, mentioned interviewee three. The tools provide the possibilities for structuring as well as search and analysis functionalities across the models, which was also perceived as important.

**Features Rated as Rather Neutral.** The pattern, model-construct and sub-graph analysis is considered as semi important. Interviewee five perceives this functionality particularly important for “mass analysis”. The pattern analysis is, therefore, dependent on the usage scenario. Especially for routine tasks, where banks are confronted with different formal requirements which have to be checked in the process models, a pattern analysis “[...] is highly relevant”, interviewee five said. This analysis is seen as dependent on correct process and element labels (“The captions are highly relevant in order to detect [patterns] in large models”, interviewee three).

The interviewees have rated the Comparisons Across Modeling Languages as semi-important. Comparing different models, which can be created by using different languages, may be useful for understanding the model semantics. It (“[...] is more like a check of understandability”, interviewee five). The interviews have shown that this type of analysis has arbitrary application potentials, as very different modeling languages are used in companies (“I think it is important to analyze different syntax [...]”, interviewee four).

While three interviewees perceive Semantic Analyses as rather important, one interviewee considers this feature as less relevant (“Analysis approaches that consider the [semantic correctness] are rather irrelevant”, interviewee one). Interviewee three argues that “the bigger [the process models], the more important but also the more

difficult it becomes”. Semantic analyses become particularly important in distributed analysis settings. Furthermore, semantic checks are important if they can be used to identify the gaps between process models and real world process execution (“The focus of [semantic checks] is more on checking whether the modeled process represents the real-world process”, interviewee four).

The Structure Analysis has been evaluated as useful for decision tree analysis. Interviewees state the need to check each possible path of a process. The structure analysis can be used to identify the “catch-all branches” (interviewee five). The interviewees describe the task of creating consistency as important (“Checking inconsistency is rather important [...]”, interviewee four). The importance of structural correctness increases along with the increase of model complexity and model size (“Hence, the bigger the process quantity, the more complex the process landscape, the more important is this topic”, interviewee three).

**Features Rated as Rather Unimportant.** The Text / Label Analysis is recognized as supportive analysis. One major reason for the lack of support is that someone cannot “[...] trust these analyses”, interviewee five said. The correct naming of elements is considered important, but that has to be done during the modeling phase. This is in particular necessary in distributed modeling projects. Interviewee three stated that “due to the involvement of many different people with different modeling skills, the same process or process step will be described differently”. Furthermore, the Complex / Loop Construct Analysis is seen as an unimportant feature for the analysis. Interviewees state that they don’t have to search for such complex patterns.

#### 4.5 Importance and Usage Scenarios along the Consulting Process Stages

After the tool- and presentation-based demonstration of the features of automatic MAA, the interviewees have been asked to state in which phase of the reengineering process they would apply automatic business process MAA and why. Therefore, the importance of MAA for each process reengineering stage should be rated by marking the relevant phases with a cross. The results are depicted in Figure 3, whereas the numbers indicate the cumulated crosses. All five interviewees rated the phase ‘creation of a transparent as-is world’ as an important application area for MAA.

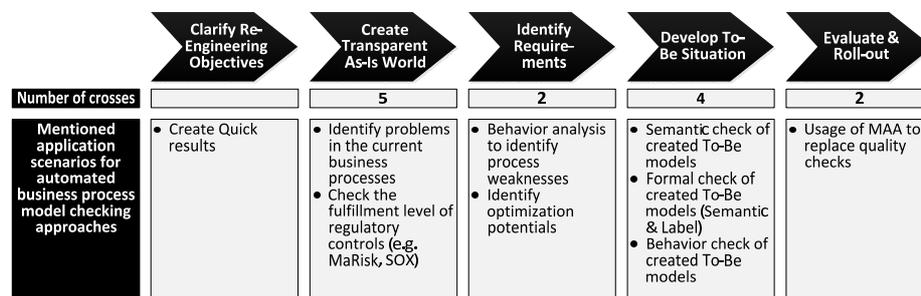


Fig. 3. Application scenarios of automated MAA for consulting process

Four interviewees see the development of the to-be situation as an important application area. The other phases show less importance. In general, the interviewees understand automated business process MAA as a chance to simplify manual analysis: “I think that we need more support in any case, the more automation the better”, interviewee five said. “In particular, in complex big projects, there exist meaningful application scenarios”, interviewee one said. Automated process model analysis can be used at different stages in the process reengineering project process. Although, not explicitly “checked” by the interviewees depicted in Figure 3, they mentioned that the approaches can support the project setup during the *Clarify reengineering goals* stage as well. The ability to use automatic model analysis for quick results as basis for clarifying the reengineering goals has been mentioned as relevant for this stage.

For *creating a transparent as-is world*, the automatic MAA seems to be useful to identify problems in the existing processes and to identify differences from, e. g., reference models. In particular, the semantic and syntax analysis are to be used for the task (“I can easily compare as-is processes with reference processes and detect differences”, interviewee five). In addition, tool support is important in this phase in order to “create transparent processes” and to “identify process weaknesses”, interviewee three said. The management of the regulatory requirements is another field of application. Therefore, the number of process models and necessary formal business process checks are seen as important application scenario. Within the as-is analysis, a completeness check is seen as one application scenario (“[...] in such environment [model analysis] is really relevant because you have a lot of regulatory requirements [...]”, interviewee five).

Within the *Identify Requirements* stage, comparisons across models and across modeling languages are identified as important for project success. In order to identify requirements, the interviews have shown that the process model comparison with “reference models and process landscapes” (interviewee four) is identified as one application area. Furthermore, behavior analysis to identify further requirements and optimization potential is perceived as a relevant application area (“You could make simulations based on expected case numbers in order to identify bottlenecks”, interviewee four).

During the stage *Develop To-Be Situation* stage, the automatic MAA is perceived as useful to analyze the to-be processes in order to ensure syntactical and behavioral correctness. Interviewee one identified the analysis of “completeness and clarity” and a “unique use of language” as an important application. Furthermore, the comparison of as-is and to-be models and checking “whether errors occurred during process modeling” (interviewee three) are seen as further use cases.

## 5 Discussion and Outlook

The study examines the potential of automated business process MAA within consulting projects in financial services industries. Interviews provide insights into the relevance of model analysis features and also pointed out potential use cases along typical project steps of business process reengineering. In general, business process MAA are

relevant for very large projects where large model repositories have to be analyzed. Lessons from consulting projects show that companies do not usually keep an accurately maintained repository ready for analysis, but that model translation efforts and alignment with “real world” processes is necessary prior to conducting model analysis.

The results indicate that business process MAA have the potential to support business process consulting in the financial services industry. Many features, such as the inclusion of external data and information, modeling language independent analysis, and execution / behavior analysis, are perceived as important for model analysis tasks. Secondly the results indicate that the applicability of MAA differ among the different consulting process steps. In particular, the creation of a transparent as-is world and the development of a to-be situation can benefit from automatic MAA. For the clarification of engineering objectives, no benefit could be identified.

Therewith, we provide the following two research contributions. First, we evaluate the practical relevance of MAA in a real-world scenario and provide an initial insight into its relevance. The results are in particular important for the ongoing development of research in model checking, as only little evidence for the practical relevance of MAA was given so far. Second, we provide an overview on the most important and less important features and their usefulness in different consulting stages. These insights can enable a focused ongoing development of MAA features. From a practical perspective, we provide some possible application scenarios for MAA which might encourage other consultancies to rethink their internal consulting processes in order to evaluate the usefulness of MAA for increasing BPR project efficiency.

Nevertheless, the presented study has some limitations. The case study comprises only a limited set of data. Thus, the results provide a first initial insight into in this area. Furthermore, the interviewees are employed at the same consulting company which might lead to some bias in their ratings. Interviewees might sometimes focus on one or two certain consulting phases and have only limited knowledge about the other phases which again biases the results.

As both intensity and frequency of BPR projects increase – especially in the financial services sector – one can predict increasing demand for analysis support in BPR projects. Research on automated business process MAA can contribute to these demands if developed in accordance with practical use cases. Therefore, we suggest two concrete enhancements of MAA. First, the *use of patterns and reference models should be extended*. Existing patterns and reference models (or model fragments) can be used to express standard queries for analysis. This could be, for example, deployed to analyze compliance issues in process models. Second, *unstructured data should be included in MAA*: According to the experience of the consultants in this study, few companies use one single modeling standard, language, or software solution (cf. results on feature inclusion of internal/external data). To overcome the syntax issues, tool-based converters and translators are promising to enhance the relevance of MAA. All in all, this study suggests that business process MAA are relevant for financial services industry consulting and encourage ongoing research in this area.

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