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Florian Imgrund
Christian Janiesch
Marcus Fischer
Axel Winkelmann

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Success Factors for Process Modeling Projects

An Empirical Analysis

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Betriebswirtschaftliches Institut
Sanderring 2
D-97070 Würzburg
Tel.: +49 (0) 931 / 31-82901
Fax: +49 (0) 931 / 31-87274
http://www.bwl.uni-wuerzburg.de

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Am Hubland
D-97074 Würzburg
Tel.: +49 (0) 931 / 31-85906
opus@bibliothek.uni-wuerzburg.de
https://opus.bibliothek.uni-wuerzburg.de
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Abstract

Business process modeling is one of the most crucial activities of BPM and enables companies to realize various benefits in terms of communication, coordination, and distribution of organizational knowledge. While numerous techniques support process modeling, companies frequently face challenges when adopting BPM to their organization. Existing techniques are often modified or replaced by self-developed approaches so that companies cannot fully exploit the benefits of standardization.

To explore the current state of the art in process modeling as well as emerging challenges and potential success factors, we conducted a large-scale quantitative study. We received feedback from 314 respondents who completed the survey between July 2 and September 6, 2017. Thus, our study provides in-depth insights into the status quo of process modeling and allows us to provide three major contributions.

First, we focus on providing descriptive statistics to shed light on the current status quo of the design, adoption, and implementation of process modeling projects in practice. This analysis yields some highly interesting findings, such as very low adaptation rates of business process management systems (BPMS), as well as low usage figures of modeling conventions, best practices or guidelines to boost a modeling project's success. Even regarding the usage figures of modeling notations, there is no clear indication of a de facto standard for process modeling – neither BPMN, nor the long-time favorite notation of EPC.

Second, our study suggests that the success of process modeling depends on four major factors, which we extracted using exploratory factor analysis. We found employee education, management involvement, usability of project results, and the companies' degree of process orientation to be decisive for the success of a process modeling project.

Third, we ran multiple linear regression models, indicating that the communicated and perceived importance of process modeling has the strongest impact on the success of such projects. We further present results from multiple linear regression analyses, incorporating distinct and mutual dependencies of seven further explanatory variables that influence the likelihood of success of a modeling project. Ultimately, we revealed variables such as the communication of goals, compliance with conventions, or the companies' degree of process orientation to be of significant influence.

We conclude this report with a summary of results and present potential avenues for future research. We thereby emphasize the need of quantitative and qualitative insights to process modeling in practice is needed to strengthen the quality of process modeling in practice and to be able to react quickly to changing conditions, attitudes, and possible constraints that practitioners face.

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1 Introduction

In a dynamic business environment, enterprises must constantly adapt and improve operations, consolidate organizational structures, reduce costs, and improve efficiency and effectiveness. In general, they can accomplish this by implementing Business Process Management (BPM) as a means to identify, prioritize, analyze, improve, and monitor business processes (Dumas et al. 2013; Rosemann and vom Brocke 2015; van der Aalst et al. 2016). At the core of BPM, process modeling provides the basis for communication, coordination, documentation, and implementation. Process modeling enables its users to capture and organize information about business processes, regardless if the respective notation is drawn on blackboards, paper, or represented in digital form using process modeling software (Harmon 2011).

Although enterprises usually perform process modeling with similar goals such as improving operational quality, initiatives in practice often differ regarding their design and structure (Bandara et al. 2006; Indulska et al. 2009a). In fact, BPM has witnessed a variety of different modeling techniques and standards that serve individual requirements and contexts. To date, there is a variety of notations, ranging from *Petri nets* (Petri 1962) primarily serving to describe distributed systems in mathematical modeling, *flow chart diagrams* to represent algorithms or workflows using very basic shapes (Chapin 1970) to the *event-driven process chain* (EPC) (Scheer et al. 2005) with a focus on business process modeling. In recent years, the business process model and notation (BPMN) (Object Management Group 2011) received strong support from both researchers and practitioners, finally replacing EPC as the de facto standard for process modeling (Owen and Raj 2003; Recker 2010). Although this study remains an exclusive focus on process modeling, and thus, activities to design, enact, or execute process models, we observe major differences how companies use their notation of choice.

On the one hand, companies may follow a decentral approach leveraging process models chiefly for communication and knowledge management. On the other hand, companies use process modeling to implement and automate their core processes. Consequently, it is obvious that different application scenarios require individual approaches, tools, or parameters. Established modeling standards and specifications, however, do not provide support for context-aware or situational process modeling in a concrete business environment. They provide uniform symbols and grammar but no means for contextualization and adaptation. Facing a “one approach does not fit all” situation, we investigated the current state of the art in process modeling by the means of a quantitative evaluation. We received feedback from more than 300 experts employed by companies from different industries and sizes. Due to the breadth of this report, we are able to provide a comprehensive overview of the current use and adaptation of process modeling in practice. More specifically, we are able to identify the current practices in process modeling and to extract success factors for the design and implementation of process modeling projects.

2 Survey Meta Data

This chapter presents an overview of the structure of this study and provides further meta-information on the goals pursued and methods applied in this study. Subsequently, we introduce results from an initial evaluation of company-specific characteristics, as well as information about the respondents' experience with BPM and process modeling, respectively.

2.1 Purpose, Aim, and Survey Method

The study on which this report is based upon had the primary goal of uncovering the status quo of process modeling. Further, we sought to gain in-depth insights on current challenges and trends in the field. More specifically, we collected feedback on the following topics:

- The participants' experiences in process modeling and specific information about organizational characteristics.
- The overall organizational setup of process modeling projects.
- General conditions and extant regulations for process modeling projects.
- Tool support for process modeling projects.
- Educational offers for building process modeling capabilities.

Survey Method. This survey was conducted within a timeframe of 12 weeks in the months of July to September 2017. We received a total of 357 responses from experts working in the following industries: services, manufacturing, and commercial. For any other sectors, we added the response option "others". We disregarded 43 responses due to a large number of missing entries, resulting in a total of 314 fully completed questionnaires.

In the charts and tables below, the total number of surveys may be less than 314 in individual cases as the questionnaire was equipped with contextual filters that determined its structure based on previous answers on experiences, organizational setups, or other characteristics.

2.2 Participating Companies

Companies and employees by sector. We began this survey by asking all respondents about their companies' characteristics. In Figure 1, we present the number of participating companies by sector in the left, while the right part of the figure shows the distribution of employees by sector.

With 132 responses, companies located in the *service* sector account for 42 %, which is the sector most frequently mentioned. The *industrial* sector follows closely behind, with a total of 119 companies (38 %). The *commercial* sector ranks third with a total of 26 participating companies. This is equivalent to 8 %. With 1 %, the share of the *public* sector is neglectable.

Hence, we have moved it to *other* for all further analyses. *Other* sectors account for 11 % (33 responses).

Regarding the number of employees, we notice that the respondents are predominantly employed by small companies with less than 10 or 10 to 50 employees. This trend spreads throughout all sectors (cf. Figure 1b). On average, the industrial sector employs the most staff.

"In which sector does your company operate?"

"How many employees does your company employ?"

(a)

(b)

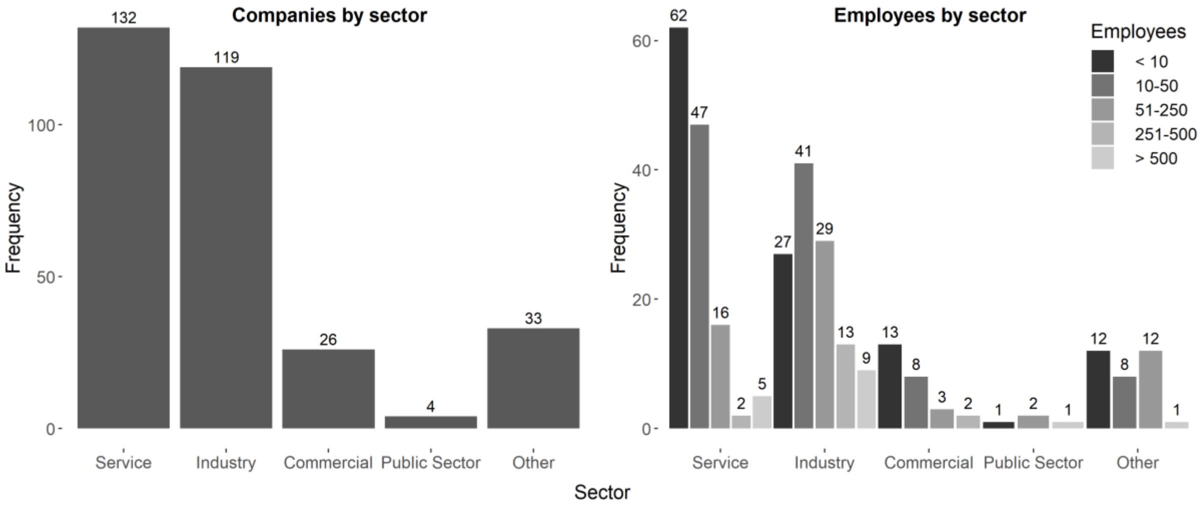

Figure 1: Companies by sector (left) and employees by sector (right).

Revenue by sector. Each respondent was asked to provide basic information about his or her company. Figure 2 informs about the overall revenue of companies. We can observe that the industrial sector is the strongest revenue-generating sector among those surveyed.

"How much revenue does your company generate annually?"

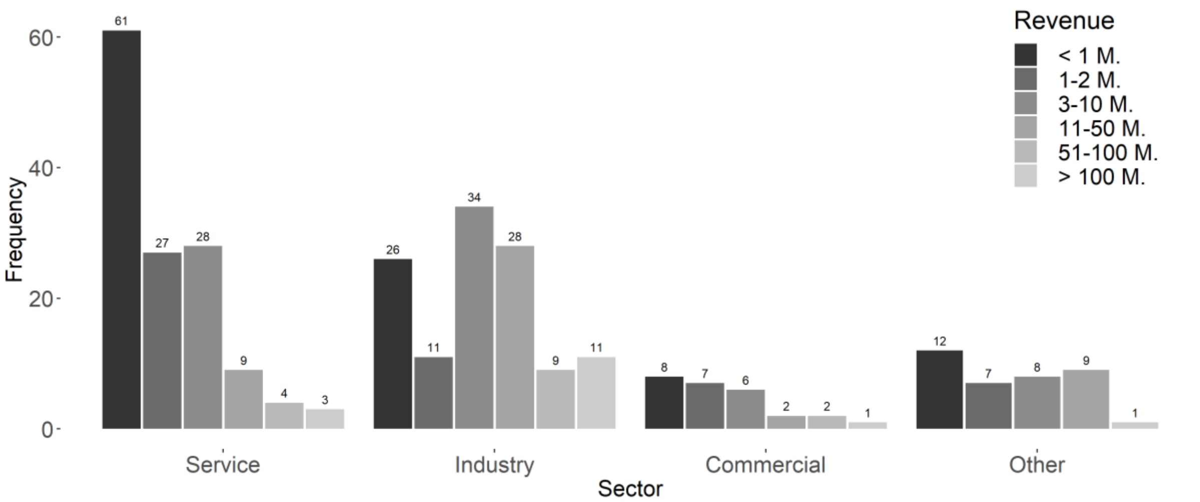

Figure 2: Revenue by Sector.

On average, the annual revenue of participating companies is less than 10 million euros. Across all companies, the service industry is the industry with the highest cumulated revenue, while the manufacturing is the sector with the highest revenue per company.

2.3 Experience of BPM Experts

We asked the respondents to assess their experience in the domain of BPM. The results in Figure 3 indicate that most respondents have considerable experience in the field. With more than 15 years of experience, respondents most frequently selected the highest possible value. This observation holds across all sectors.

"How many years of experience do you have in business process management?"

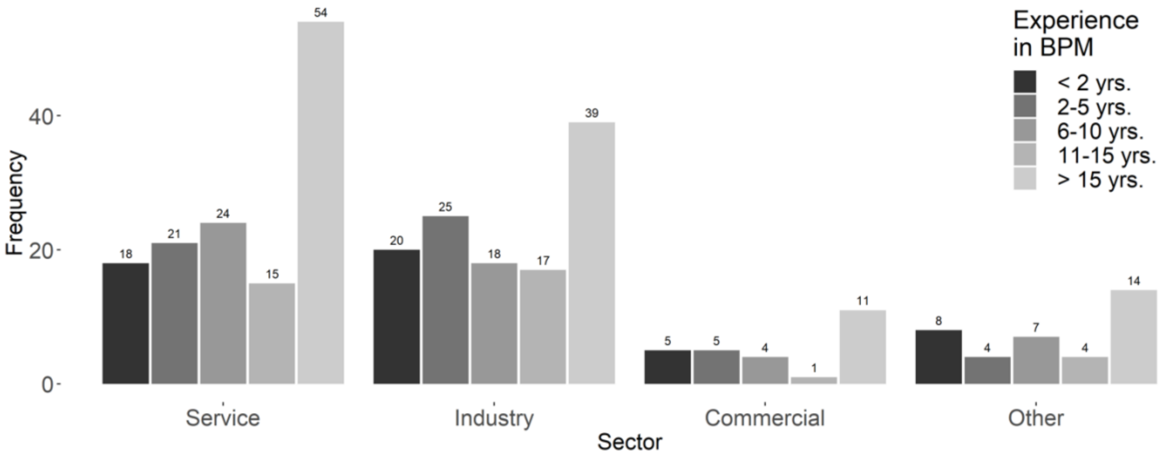

Figure 3: Years of experience in BPM divided by sector.

Next, we asked our informants about their years of experience in process modeling. We can observe in Figure 4 that the respondents' experience in BPM is considerably higher than in process modeling. The commercial sector places the least value on appropriate skills.

"How many years of experience do you have in process modeling?"

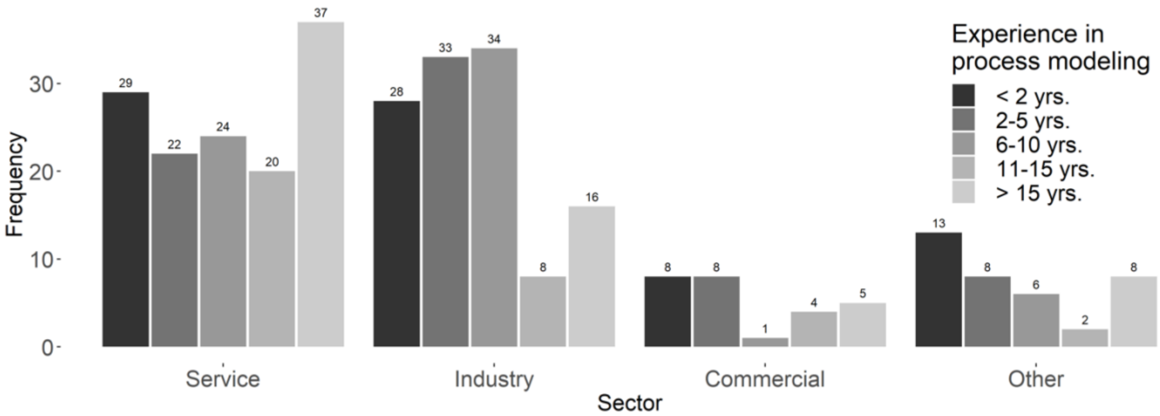

Figure 4: Years of experience in process modeling.

Figure 5 compares the respondents experience in BPM with their experience in process modeling. With this comparison, we demonstrate the relation between the increase in experience in BPM and the increase in experience in process modeling. Across all sectors, the evaluation shows that only few process modelers built up their expertise explicitly, that is, isolated from simultaneously building expertise in BPM. In most cases, the experience with process modeling is similar to the experience with BPM. However, it appears that this trend is weakening slightly with increasing experience. While more than 24.8 % of the respondents still state the same values for both areas in the first five years, it is only 11.5 % from the sixth year onwards and 18.5 % from the 15th year onwards.

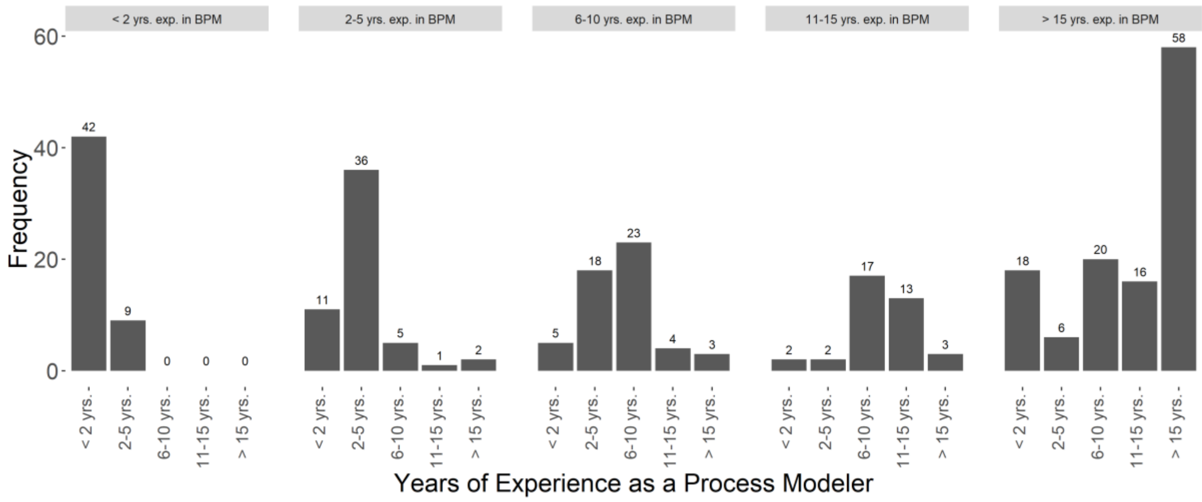

Figure 5: Years of experience in process modeling compared to years of experience in BPM.

Figure 6 provides further information on the expert level to which the respondents' experience most conform. To be able to better interpret the results, the figure also shows the respondents' years of experience with process modeling. With this evaluation, we seek to double check the respondent's own assessment based on the years of experience they have in process modeling.

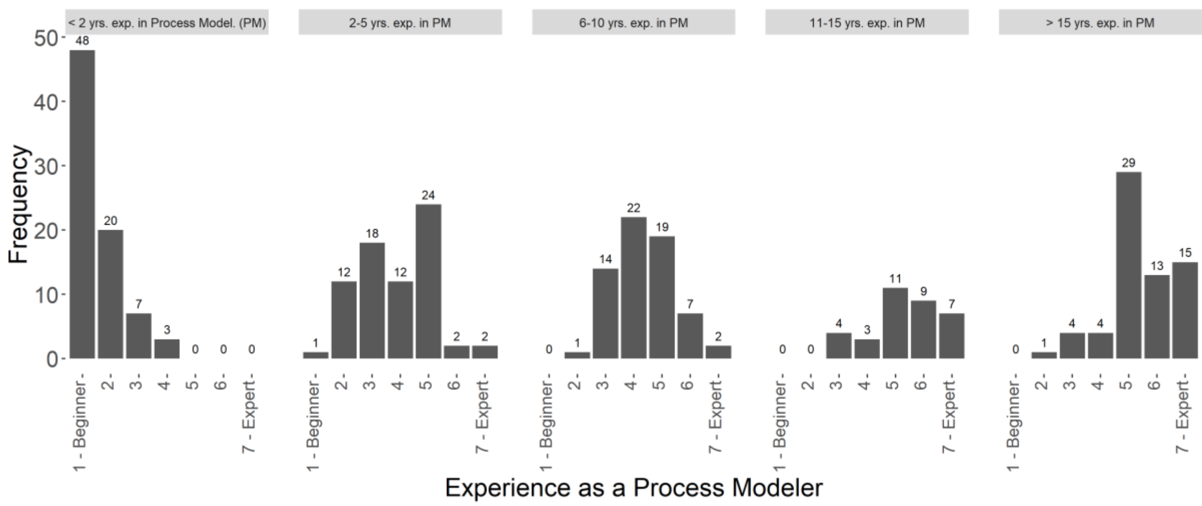

Figure 6: Experience as a process modeler compared to years of experience in process modeling.

Affirming, we can observe that most respondents who have less than two years of experience in process modeling in fact consider themselves as novices. Analyzing respondents with more than 15 years of experience in process modeling, we can observe that even less participants consider themselves as experts. Consequently, we conclude from Figure 6 that experts tend to underestimate their experience level. Since we cannot find significant exaggerations in terms of one's own experience, we do not see any critical consequences for the credibility of this study's results. In conclusion, we can state that most of the respondents have a high level of experience in BPM and process modeling. Albeit less experienced process modelers participated, the majority still has appropriate experience. Nevertheless, we analyzed the responses from less experienced process modelers and did not observe any significant differences in their responses compared to more experienced process modelers.

3 Implementation of BPM and Process Modeling

This section introduces descriptive analysis that deals with the implementation of BPM and process modeling in varying business contexts. Our initial focus is on organizational implementation, after which we examine methodological and technological aspects. Finally, we will examine cultural aspects.

3.1 Organizational Implementation

Regarding the organizational implementation of BPM, we first asked the respondents to elaborate on the existence of a central BPM department in their company. This department or institution often is called "BPM Center of Excellence", "BPM office", or "BPM initiative". Its existence usually indicates that the company has already delved deeper into BPM and process modeling and, at the same time, has recognized the need to centrally manage and coordinate corresponding activities. A central BPM department translates strategic objectives and values into a communication plan and informs process modelers about how these transfer into day-to-day business and operations. Furthermore, a central BPM department usually provides templates and best practices that facilitate continuous improvements, ensure interchangeability of results, and avoid rework. In addition, it monitors process modeling activities within the company, tracks the quality of outcomes, and supports change management activities that accompany modeling projects.

Establishment of a central department that focuses on business process management. Figure 7 indicates that most of the surveyed companies do not have a centralized BPM department. We can observe that only 16.5 % of the companies surveyed have a central department whose employees exclusively work in BPM or related activities. Especially, respondents from the industrial sector and the service sector rejected this notion.

"Does your company have a central department that exclusively focuses on business process management?"

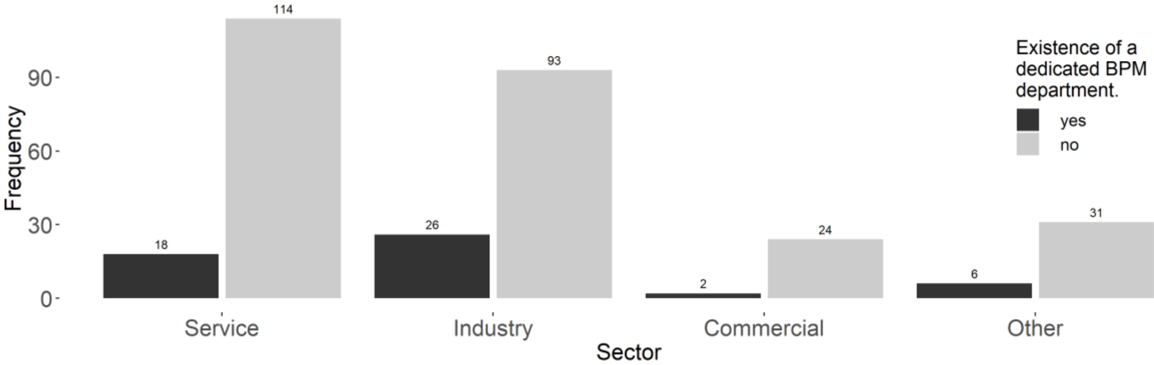

Figure 7: Dedicated BPM department by sector.

Possible reasons for the lack of centralized resources should be questioned in further surveys as it is generally recognized by research and practice that the implementation of a corresponding unit sustainably increases BPM maturity. Exemplarily, Rosemann (2015) describes five typical phases of BPM adoption, in which the *BPM Center of Excellence* completes the implementation of BPM and "*consolidate[s] all BPM-related activities and ensure[s] consistency and cost-effectiveness in its delivery*" (p. 383). On the one hand, one can derive from this statement that primarily companies with higher levels of BPM maturity use a centralized administrative instrument to coordinate BPM activities. On the other hand, however, there may be plenty of other organizational reasons that could prevent companies from establishing a central BPM department, including lacking management support or organizational resources.

Process orientation of the surveyed companies. Process-oriented companies seek to leverage the effectiveness of their corporate processes by adopting a process view. The implementation of a process view requires collective values and beliefs that encourage stakeholders to participate in BPM and process modeling (Fischer et al. 2019). It can also be beneficial to foster process orientation by communicating the benefits of process awareness and to sensitize stakeholders in regular meetings. Figure 8 reveals that most of today's companies are well aware of their internal processes' interrelationships. An overall total of 60.8 % rather agrees than disagrees with being process oriented. The service sector shows the highest values for process-orientation (63.6 %), closely followed by the industrial sector with about 59.7 % of companies rather agreeing to be process oriented than not.

"The company you work for is process-oriented."

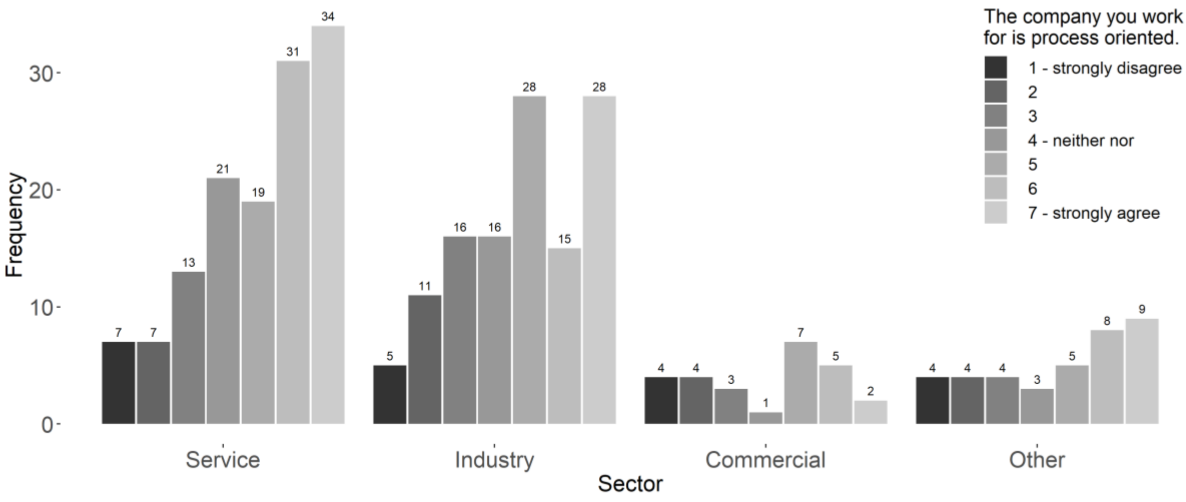

Figure 8: (Perceived) degree of process orientation of the surveyed companies.

Total number of processes within each company. We asked the participants to provide estimates on the total number of processes in their companies. In Figure 9, we present the overall number of processes depending on the company's annual revenue. It indicates that the total number of business processes correlates with revenue. In conclusion, we can state that companies with a higher revenue typically differentiate more processes than companies with less revenue.

"How many processes does your company consist of in total?"

Note: Please use the smallest possible unit. Exemplarily, if your company's entire procurement process consists of approx. 10 sub-processes, which in turn require the execution of approx. 10 individual processes, this would result in a total number of 100 processes for your procurement process."

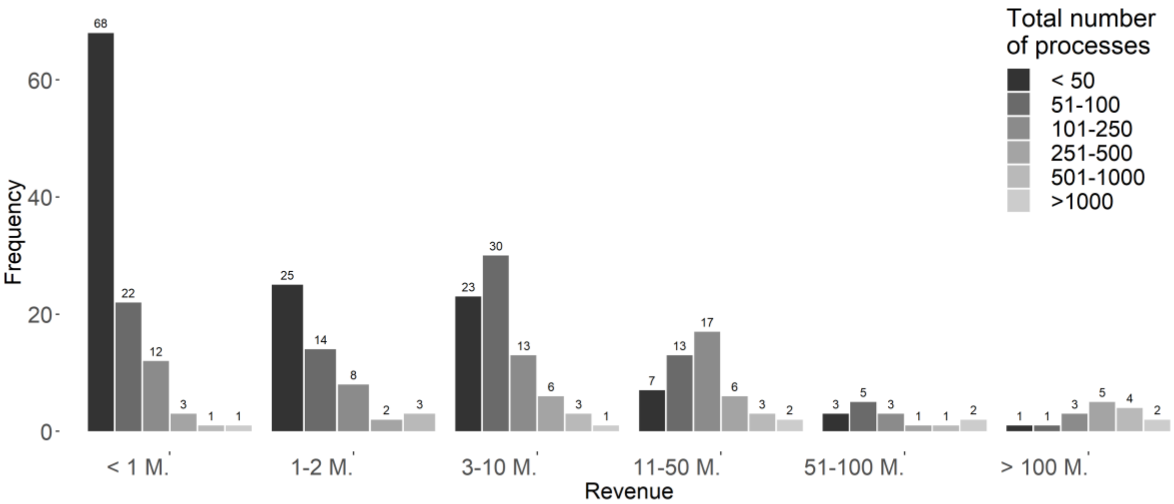

Figure 9: Total number of processes within each company.

In companies any company, we can observe a focus on a small number of key processes, while large parts of their organizational structure remain untouched. Due to its inherent interdependencies, however, academic literature suggests that all processes are important when seeking to build well-performing operations (Imgrund et al. 2017a). As processes differ concerning their improvement potential and the number of low-value processes typically exceeds the number of high-value operations, companies face a long-tailed distribution of expected benefits across all processes.

Imgrund et al. (2017a) frame this phenomenon as the "*long tail of business processes*" and further describe BPM as a neoclassic utility maximization problem, in which companies naturally try to maximize their utility as a function of expected benefits of process improvement and resulting costs. Refer to Figure 10 for a visualization of the long tail of business processes. For further explanations, see Imgrund et al. (2017a). In addition, Imgrund et al. (2018) provide propositions on how companies can increase the overall number of manageable processes by implementing a "*hybrid approach*" to BPM.

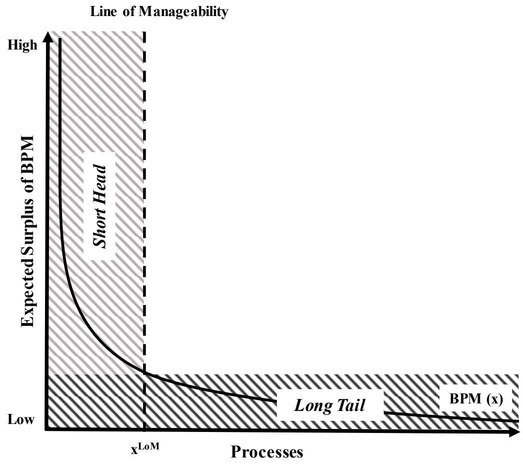

Figure 10: The long tail of business processes (cf. Imgrund et al. 2018, p. 4).

Purpose of the last modeling project. In most cases, companies use process modeling in various contexts and backgrounds and for different purposes (vom Brocke et al. 2016). They generally perform decision-making on whether and how to implement a modeling project based on environmental conditions or individual technological and organizational characteristics. Consequently, companies frequently have unique goals, structures, and configurations related to process modeling projects. However, following Fischer et al. (2019), companies tend to focus their overall purpose of a modeling project on one of the following contexts:

- **Communication and/ or Learning**: Companies deploy process modeling projects to improve communication between employees and departments and to learn from each other. This approach usually builds its actions on decentralization and collaboration.
- **Standardization and/ or Documentation**: This strategy serves to acquire a comprehensive understanding of the company's business processes and, thus, to document business processes to finally facilitate operational process execution.
- **Automation**: Companies that require high degrees of process automation usually rely on the automation strategy to implement process modeling projects most efficiently. Top management usually determines the roadmap of respective projects and is responsible to ensure the project's overall success.

Subsequently, we asked the respondents about the main objective of their last major process modeling project. As response options, we allowed to choose between the three above-mentioned strategies. Figure 11 indicates that most companies used process modeling to standardize and document business processes. This applies to 60.6 % of all companies surveyed from the service sector. Roughly the same applies to the industrial sector, were 59.7 % of the companies implement process modeling projects to standardize or document their business processes. Communication/ learning or automation strategies are applied in barely more than 30 % of the companies – downscaled to the respective sectors.

"What were your objectives in your last major modeling project?"

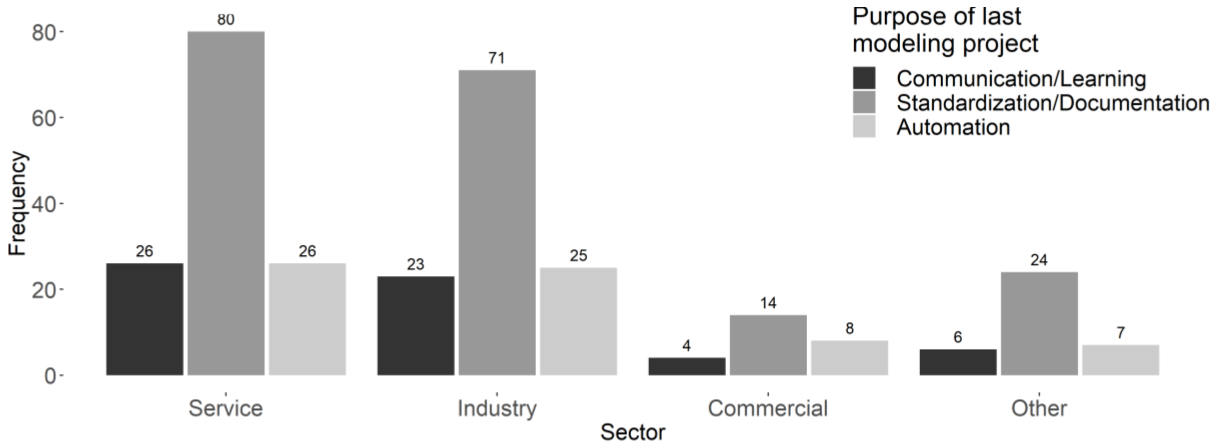

Figure 11: Purpose of the last modeling project.

Availability of a process architecture as structuring element for process modeling projects. In BPM, a process architecture represents a framework that determines the priorities of process modeling projects by providing an organized overview of deliberately selected and prioritized processes. A process architecture is often referred to as the linkage between business and IT, as it explicates the relationship of a company's processes and determines the scope of process modeling and redesign activities (Dumas et al. 2018). To support the enactment of process modeling, the framework often provides guidelines and best practices. Although a process architecture serves as structuring element and, thus, process modelers relate to it in their day-to-day routines (Dumas et al. 2018), only 36.3 % of the surveyed companies do not make any efforts to build and manage a process architecture (cf. Figure 12).

"A process architecture defined the scope of the modeling project."

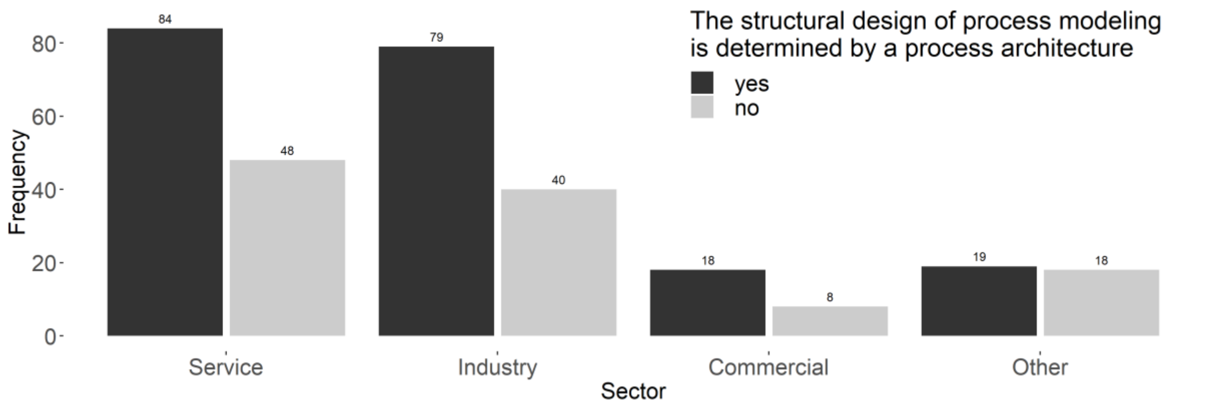

Figure 12: Availability of a process architecture that structures modeling activities.

Central definition of roles and responsibilities. According to Rosemann and vom Brocke (2015), the definition of roles and responsibilities is key to enable "*appropriate and transparent accountability […] for different levels of BPM*" (p. 115). The clear definition of roles and responsibilities can reduce work redundancies and lead to a higher quality of process modeling results. In this survey, we asked whether the respondents´ companies define roles and responsibilities prior to the implementation of a process modeling project. Figure 13 indicates that especially the service industry cares about defining roles and responsibilities prior to implementing a process modeling project. In this sector, roughly 38 % of respondents strongly agree that their companies do so. However, this effect does not hold for data collected from the industrial sector and is neglectable in the commercial sector and for all others.

"Roles and responsibilities for the process modeling project were centrally defined."

Figure 13: Pre-definition of roles and responsibilities.

Central definition of modeling conventions. In the past, numerous contributions promoted the importance of modeling guidelines and conventions (*see* Becker et al. (2000) *or* Mendling et al. (2010) *for further information*). These procedural directives improve the transparency of modeling outcomes and prevent the co-existence of different modeling purposes, techniques, and tools (Becker et al. 2013). In the following, we introduce the two questions asked to collect data on modeling conventions.

The modeling project was accompanied by modeling guidelines and conventions. Our results suggest that practitioners do not yet share the same appreciation for the modeling conventions' usefulness as researchers do. That is, the left part of Figure 14 shows that roughly 52.3 % of companies in the service sector do use modeling conventions. In the industrial sector, this percentage is only as high as 48.7 %. The ratio is negative for the commercial sector. In this sector, only 26.9 % of companies use modeling conventions.

Enforcement of modeling conventions. The right diagram in Figure 14 reveals whether top management or any other regulative unit monitors the compliance of process modeling with modeling guidelines and conventions. In this evaluation, only respondents whose companies use modeling conventions were able to see and answer the question. The evaluation shows that most companies do monitor if a project's stakeholders comply with predefined conventions. This is particularly true in the service sector, where more than 75 % confirm corresponding activities. The same is true for the industrial sector, although to a smaller extent. 31 % of respondents tend to deny corresponding activities for this sector. Across the remaining sectors, the ratio of companies that do monitor or do not monitor guidelines and conventions, respectively, is balanced.

"The modeling project was accompanied by modeling guidelines and conventions."

"Your company monitored compliance with the guidelines and conventions."

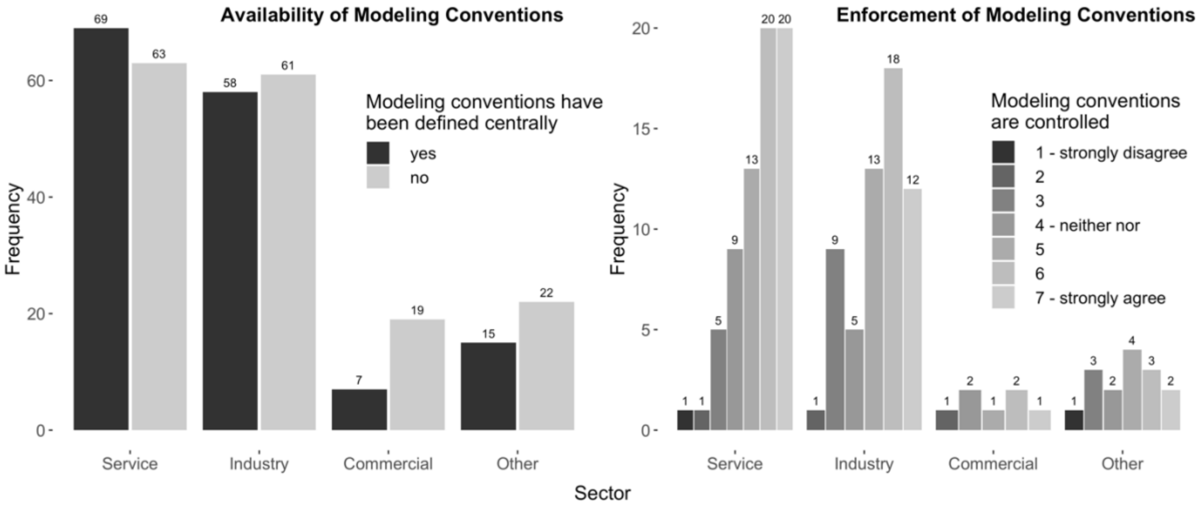

Figure 14: Active control of modeling conventions.

Compliance with modeling conventions. The definition of conventions is a good start to improve the quality of process modeling, but compliance with them often is not guaranteed. Even though respecting respective rules is an important indicator for highly usable and, thus, helpful process models.

"Guidelines and conventions were complied with during modeling."

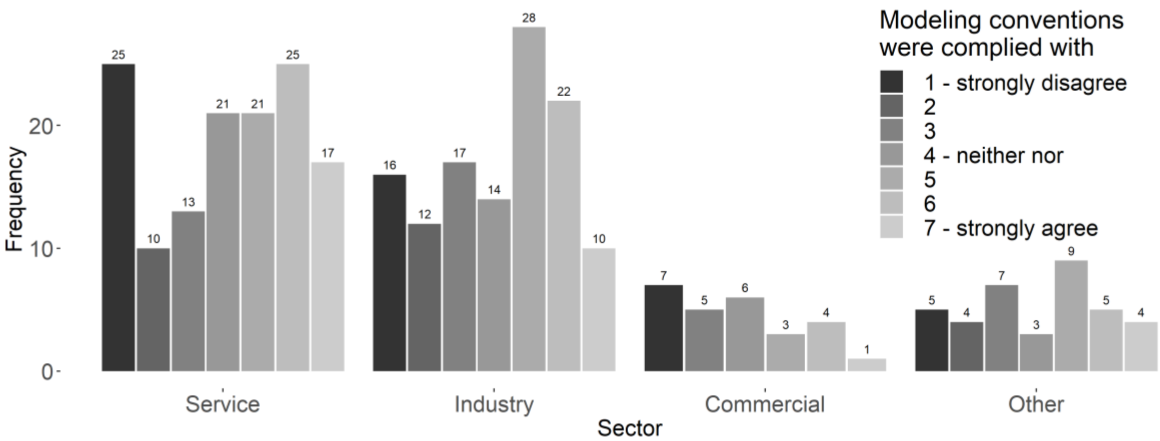

Figure 15: Compliance with modeling conventions.

Thus, we asked whether modeling conventions usually are complied with. Figure 15 indicates, however, that compliance with modeling conventions is not of major importance for companies and their employees. We observe only 46.1 % in the service industry rather agreeing to do so than disagreeing. While this percentage grows to 50.4 % in the industrial sector, we achieve totals of 30.7 % in the commercial sector and 48.6 % for other companies.

Effect of control mechanisms on compliance with conventions. In the following, we question whether actively controlling modeling conventions has an impact on their actual compliance. To this end, Figure 16 puts the two questions *“are conventions monitored”* and *“are modeling conventions complied with”* into perspective. We can observe that there is in fact a negative impact of not checking the adherence to modeling conventions regarding their compliance. If respondents strongly disagreed to the existence of a regulative instance for modeling conventions, 77.3 % also strongly disagreed that they are complied with. On the contrary, employees whose companies do enforce the compliance with modeling conventions have a strong motivation to build process models that conform to them.

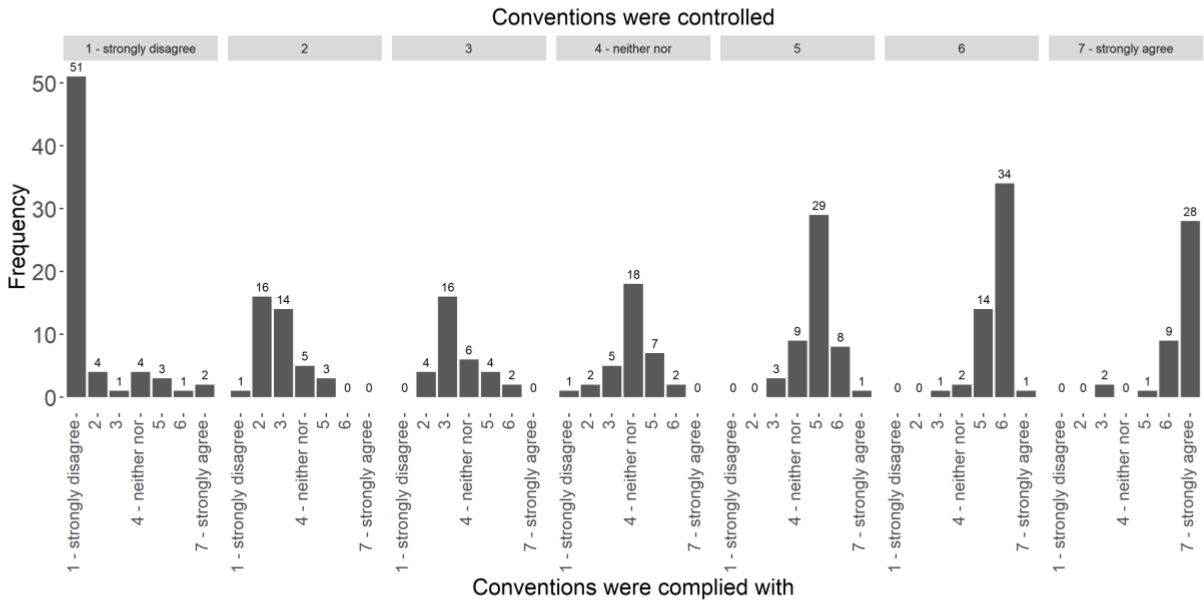

Figure 16: Effect of control mechanisms on compliance with conventions.

Availability of templates and best practices to support process modeling. This section concludes with information on the usage of templates and best practices for process modeling. Academic literature strongly suggests leveraging the efficiency of process modeling projects relying on appropriate instruments. Companies can use best practice approaches and procedures to provide well-proven and established ways to tackle a particular problem. Butler (1996) describes a best practice as a procedure that “*needs to be adapted in skillful ways in response to prevailing conditions*”. Thus, if applied as intended, templates and best practices can significantly improve the overall activity of redesigning processes.

Figure 17 shows the availability of templates and best practices. We can observe that the provision of these resources is not overly well embraced in practice. Only 52.3 % of the respondents from the service sector agree with this statement and only 48.7 % from the industrial sector do. Based on these insights, we strongly recommend companies to provide their process modelers with templates and best practices to increase the quality of modeling outcomes while simultaneously cutting project processing times and, thus project costs.

“Templates/ best practices were provided to support process modeling.”

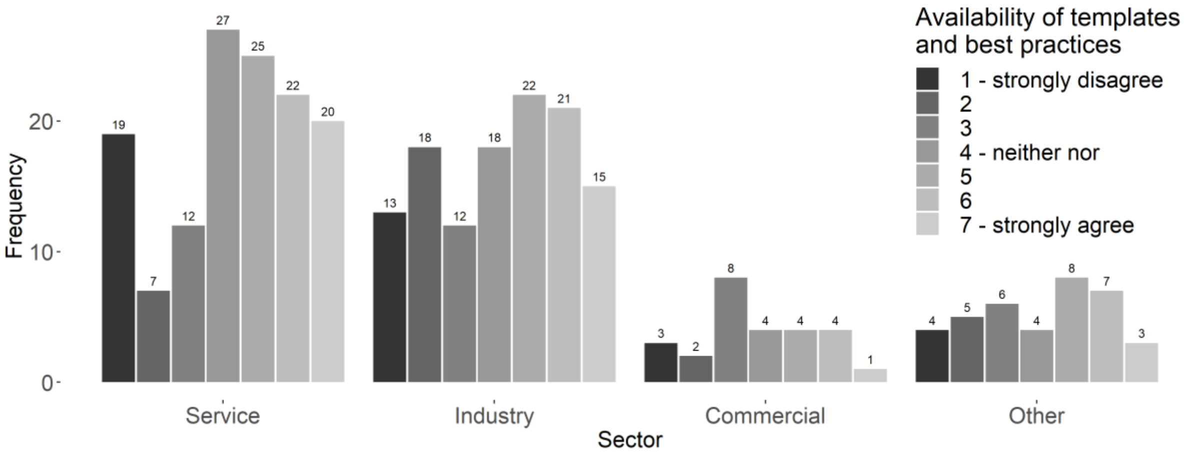

Figure 17: Availability of templates and best practices to support modeling activities.

3.2 Methodological and Technological Implementation

This section describes methodological and technological issues that we see as relevant for the implementation of process modeling projects. Consequently, this section includes questions about process standards, the availability of software tools to support process modeling, and how companies ensure the sound execution of automated processes.

3.2.1 Methodological Aspects

Standard notation for process modeling. In general, models of any kind provide engineers with early design blueprints and can accompany the overall process of creating a service or artifact. Especially in business process modeling, it is essential to guarantee a shared understanding and unambiguous communication between the producer and reader of the model regardless of whether the process model is consumed by a human or even a software tool. Thus, all stakeholders must not only agree on a particular notation (Ottensooser et al. 2012), but also establish a shared understanding on the meaning of symbols, syntax, and semantics. However, referring to the amount and adoption rate of different process modeling notations depicted in Figure 18, we can assume that practitioners still struggle to select their modeling language of choice. Likewise, this question is not yet conclusively addressed in academic literature

(Ottensooser et al. 2012). Considering that the choice of a modeling notation is decisive for the success of corporate modeling projects, it is eminent for companies to determine a resilient and uniformly accepted standard for specifying business processes. However, as neither practitioners nor academics were able to commit sustainably to one standard, the Object Management Group (OMG) has addressed this issue in 2004. The OMG acts as a not-for-profit computer industry standards consortium and has years of experience in developing manufacturer-independent standards. With the BPMN, the OMG provides and maintains a notation that allows adapting companies to specify business processes that are readable and interpretable both by humans (graphical representation) and machines (markup-based execution semantics). Although BPMN is regarded as the de facto standard of process modeling (Recker 2010), there is evidence (Leopold et al. 2016; Recker 2010) that companies often struggle to adapt the notation due to the inflexibility of their existing system infrastructure. This aligns with the well-known problem that "one size does not fit all". Consequently, there is no guarantee that all stakeholders are confident with the choice of the notation. Indeed, we can observe a great spread in the distinct notation's adaptation numbers in Figure 18, indicating that plenty of companies do not yet have chosen their ultimate modeling notation satisfactorily.

"Which notation did you use in your last major modeling project?

Choose one or more of the following: BPMN, Event-driven Process Chain (EPC), Unified Modeling Language (UML), Petri Nets, Flow Charts. Multiple answers are possible."

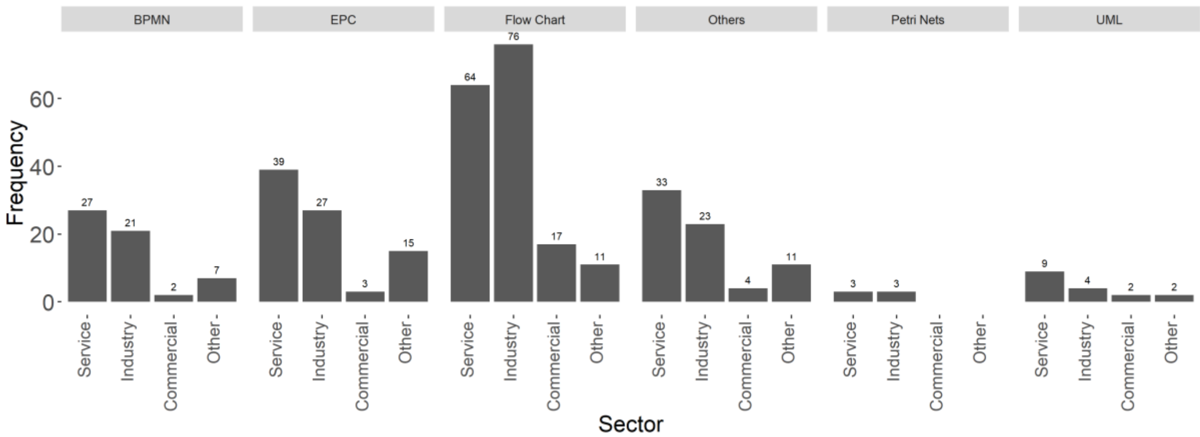

Figure 18: Modeling notations used by companies.

Figure 18 identifies flow charts as the most commonly used modeling standard across all sectors. Without having any further information about the reasons for the usage figures of specific standards, we assume that this is particularly due to limitations from existing software and the stakeholder's individual process modeling habits. Since we allowed the respondents to give multiple answers to this question, the high number of companies using flow charts might stem from its universal applicability and its high ease of use. These advantages are particularly attractive for companies that primarily use the notation for communication purposes or the informal explanation of issues of any kind. The BPMN is only the fourth most used notation and ranges behind the Event-driven Process Chain. Again, we attribute this to be justified in existing limitations of corporate IT systems and infrastructures. That is, we assume that companies whose business operations are based on an enterprise resource planning system (ERP) are tied to using event-driven process chains (EPC) by their software, as this has long been the only modeling notation supported by ERP systems.

Usage of modeling standards compared to the overall objective of the project. Referring to Section 3.1, Figure 19 illustrates usage figures of modeling standards compared to the overall purpose of the respective modeling project. Again, we assume the high adoption rates of flow charts to be justified due to the notation's versatile applicability. However, interpreting this question is difficult, as we are not able to derive the exact application context in which the notations were used. Therefore, we can only make assumptions at this point. To this end, it might be the case that flow charts are regularly being used for producing ad-hoc results during meetings, whereas EPC or BPMN is rather being used as a means of modeling complex business processes. Nevertheless, we expected significantly higher usage figures for the notations BPMN and EPC, especially in the context of standardizing and documenting business processes.

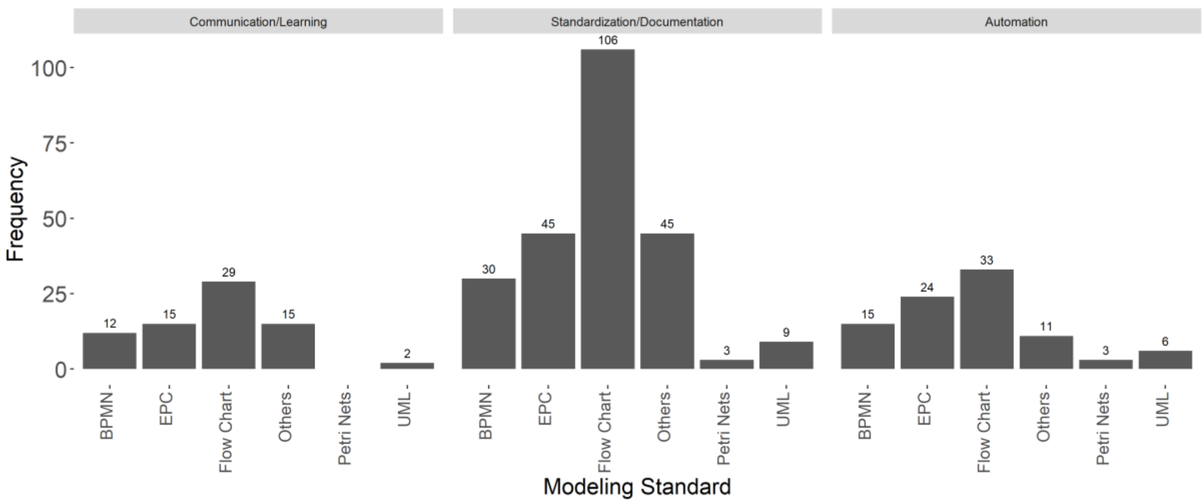

Figure 19: Modeling standards divided by the objective of the project.

Excursus: the gap between intended and actual use of a notation/ standard. With the term standardization, we refer to the process of "*developing and implementing specifications based on the consensus of the views of firms, users, interest groups and governments*" (Xie et al. 2016, p. 69). To promote compatibility, interoperability, and quality, a standard must determine sound and practical specifications for all formats and procedures it might be applied to. At the same time, a standard must provide full jurisdiction and reproducibility for its results without restricting or violating the needs of its stakeholders (Tassey 2000). Thus, to provide a standard that is as universally applicable as possible, the organization that is responsible for the standard's definition must neither restrict nor allow for too much room to maneuver within its specifications, as this will result in many different versions of the standards at user-level. Additionally, practitioners favor a standard with consistent rules and a relatively small vocabulary. The standard's syntax and semantics must provide safety and reliability to reduce coordination and costs, while increasing flexibility and promoting business.

Figure 20 illustrates for the domain of process modeling, however, that there no notation seems to finally fulfil all of its stakeholders' needs. This figure relates to the question, whether the respondent's companies were satisfied with the modeling notation or whether they had to adapt it for their individual purposes. Looking at each modeling language, we can observe a particularly need for adaptations for companies implementing their projects based on EPC. For this notation, roughly 70 % of respondents rather agreed to having adapted the notation than those who rather disagreed. In the case of flow charts, this number rates at 54.2 %, while 56.1 % of companies using BPM adapted the standards to better fit the company's individual requirements.

"The modeling language your company uses is adapted to the individual needs of its stakeholders."

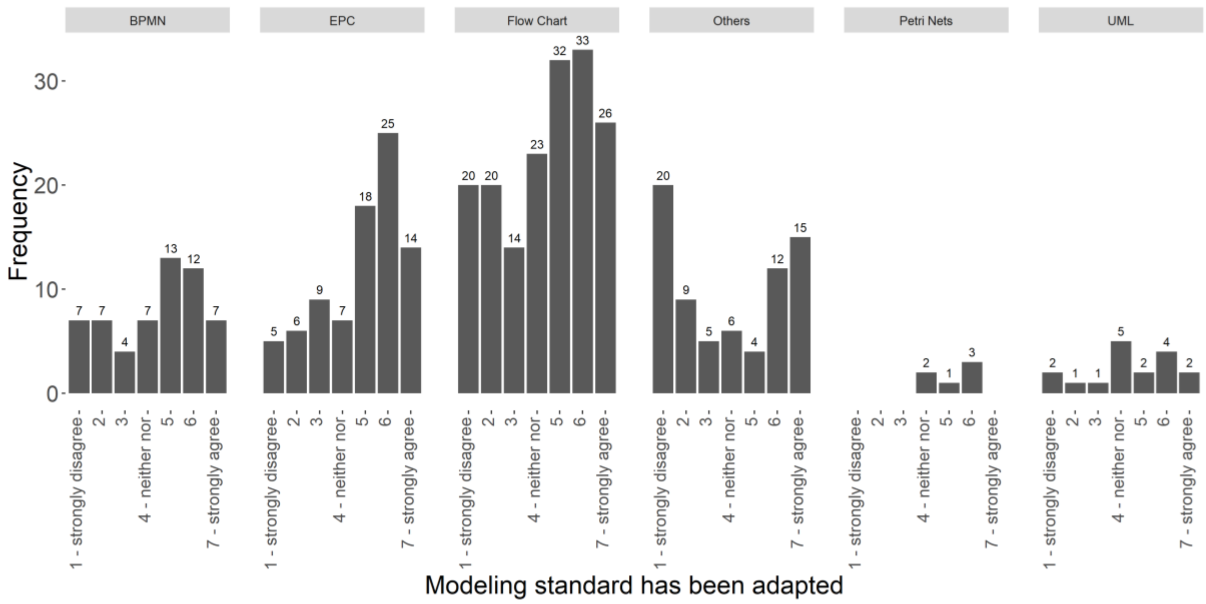

Figure 20: The preferred modeling has been adapted to the project's individual requirements.

We will not enter further into the discussion as to whether it is reasonable or even possible to provide a standard that is universally applicable and acceptable for all of its stakeholders regardless of their intention towards process modeling. Nevertheless, we would like to emphasize that especially in BPM, there is numerous research on the question how BPMN is used in practice, and whether this usage differs from its intended use. Imgrund and Janiesch (2016) address this issue by questioning a potential mismatch between the theoretically suggested use and the practical implementation of a standard. In this context, the authors provide a classification framework that raises research questions regarding a notation's syntactical and semantical fitness.

The authors' framework analysis a notation's usage from three different perspectives. On the first level, there is the notation including its rules and specifications as defined by its publisher. This level's content is determined by the corresponding notation's standardization document(s). The normative level summarizes all adaptations of the notation made or recognized and approved by official bodies. The company-specific level covers all adaptations that the company includes to adapt the notation to company-specific contexts. Finally, there is the application level in which the actual use of the notation is being examined. Practical insights confirm that the actual user of the notation eventually applies the standard based on his or her individual needs and habits and, thus, often produces results that violate the notation's syntax. Accordingly, Imgrund and Janiesch (2016)'s observations confirm that there is a significant difference between the application of a standard and its intended application as defined by the respective standardization document. Considering the adaptation rates indicated by Figure 20, we strongly encourage further research in this area, particularly by deploying qualitative research. Research questions should focus along "*why is there a mismatch between the intended and the actual use of the BPMN notation*" or "*why do standards fail in meeting the specific requirements of their most important stakeholders*?"

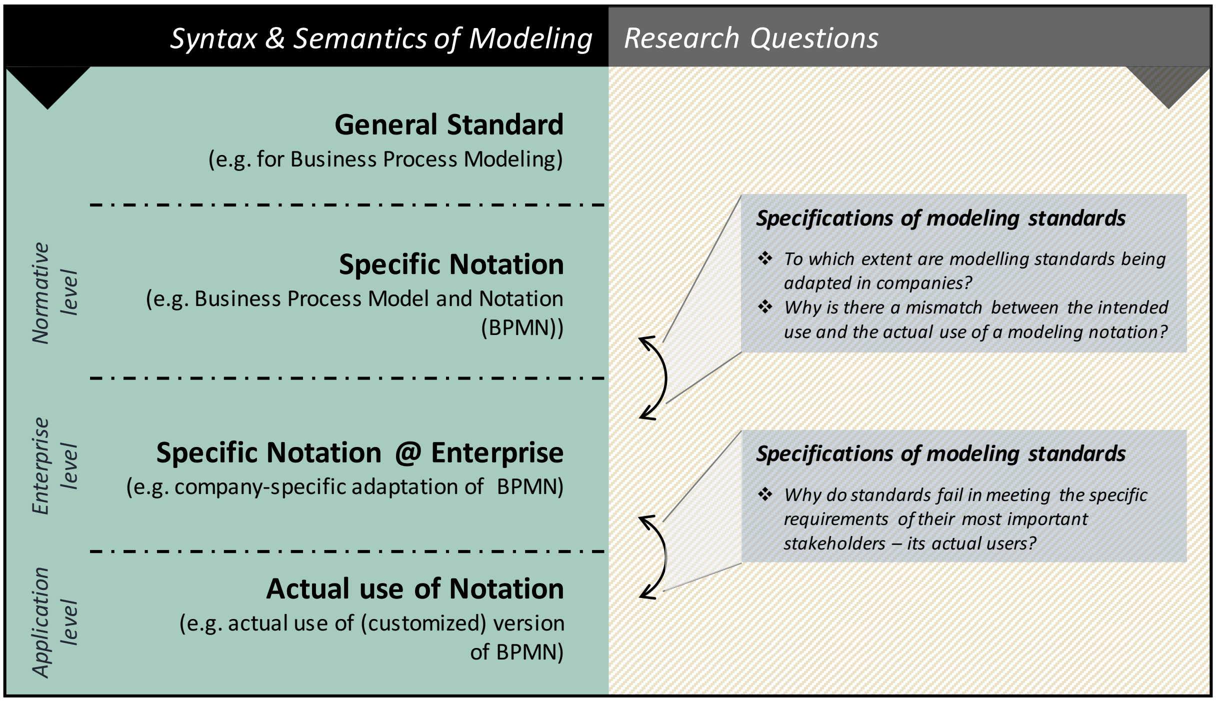

Figure 21: Modeling standards companies are using broken down by the objective of the project.

3.2.2 Technological Aspects

This section's questions primarily focus on the current technological implementation of process modeling projects in practice. We primarily question the integration of respective tools and software into the company's ecosystem including its IT- and system infrastructure. Further, we want to evaluate to which extent the companies' infrastructure yields integrated project outcomes that are centrally accessible.

Availability of a business process management system (BPMS). A BPMS is a software tool that companies often use to design, implement, improve, and automate business processes towards a specific organizational objective. With a BPMS, companies can create and monitor workflows with the overall objective to reduce organizational inefficiencies, eliminate human errors, and prevent miscommunication among employees. Although current BPMS come with powerful features that can significantly reduce the time and resources one has to involve for the management of business processes – especially when it comes to process automation – many companies still implement process work without any tool support. Affirming, we see in Figure 22a that hardly a third of the companies surveyed use a software that supports process modeling. In the commercial sector, the number of companies is even less than 15 %.

We further evaluated whether there is any linkage between the adoption rate of a BPMS and the overall purpose of a modeling project. Figure 22b indicates that companies that use process modeling primarily for process automation have a greater understanding and/ or need for the benefits of adequate software tools. In contrast, companies pursuing communication/ learning objectives or standardization/ documentation objectives rarely implement BPMS to support the automation of their business processes. Of course, one can implement process modeling without using a BPMS at all. Affirming, we heard in a numerous talk with practitioners that they still rely on very basic tool support such as Microsoft's Visio to depict business processes. However, it is obvious that we live in an increasingly globalized world with a steadily growing complexity of internal and external structures, in which technological aids do have the potential to boost performance significantly compared to manual work or basic software. Accordingly, BPMS help companies in identifying and avoiding bottlenecks and quality issues due to their monitoring capabilities. Further, appropriate tool support can improve efficiency of process modeling endeavors as it operates on an integrated database that the company has full control of, which is fully visible, and on which the company can act in real time, both for reporting and analyzing purposes. Given multiple further possibilities in which companies can benefit from the implementation of a BPMS, future research should address current impediments and hindrances of software adoption in the domain of process modeling.

22a. "Did your company provide the modeling project's stakeholder with access to modeling software?"

22b. Same question evaluated depending on the overall purpose of the project.

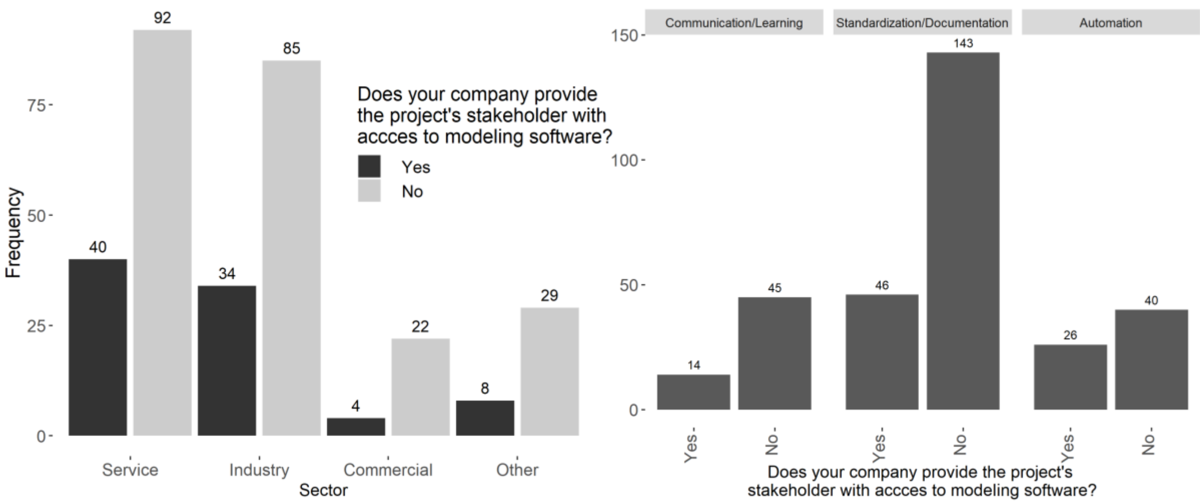

Figure 22: Access to modeling software.

From ongoing practitioner talks, we can already assume several possible reasons for the low BPMS adoption rates indicated in Figure 22b. First, we observed a lack of understanding for the many benefits of a BPMS. Second, BPMS have witnessed rapid growth of functionalities and in market share. In addition, there are acquisitions or mergers of companies in this area, making it increasingly difficult for companies to compare functions and licensing models of different BPMS. Affirming, we emphasize that it is not conducive for business to choose a randomly selected BPMS rashly, which might enable the adopting company to implement process modeling with a plethora of expert functionalities promising to boost the company's success. Instead, selecting and implementing an appropriate BPMS must follow current best practices and recommendations for professional software selection (Scheer et al. 2002). Otherwise, imprudently investing in a BPMS might slow down process modeling projects due to the software's inappropriate usage caused by a lack of training, uses cases, or even due to missing change management and emerging resistances of employees.

The modeling software automatically checks compliance with conventions and guidelines. Not providing any guidelines and conventions will most likely result in ten different models being if ten different process modelers are involved. Consequently, it is not sufficient to streamline training offers and to provide an integrated education plan for your process modelers (cf. Section 3.3), but there is also a need to provide modeling conventions and guidelines whose compliance should be actively controlled as indicated by Figure 16.

In Figure 16, we evaluated whether companies that already implemented a BPMS engage automatically check the compliance of process models with predefined conventions or guidelines. In this context, we assume modeling conventions to include regulations that restrict the number of allowed objects, prescribe naming conventions or specify general rules on the layout of the process model such as possible restrictions regarding layout size or the model's appearance. Using automated convention checks, the software can prevent undesired diversity in shapes, sizes, colors, and flow directions of modeled processes by disallowing the user to save or archive inconsistent process models. Most BPMS support the definition of individual conventions by enabling administrative to implement corresponding rules in their administrative interface of the software.

Despite the usefulness of automated compliance checks, Figure 23a shows that there is only a relatively small number of companies making use of respective software functionalities. Divided by a company's distinct objective towards process modeling projects, Figure 23a indicates that some companies focusing on standardization and documentation do in fact rely on automatic verifications of modeling conventions. However, there is also a relatively high number of companies that do not apply automated convention checks focusing on these objectives. Since we cannot derive a clear picture or trend in Figure 21a, we further subdivided the usage of automated convention check by notation (cf. Figure 21b). In this figure, we can observe that automated process model verifications are common for most companies using BPMN. Contrary, this cannot be confirmed for any other modeling language. This leads us to believe that BPMN is primarily being implemented by companies that yield high quality process models and, thus, might show higher maturity and skill levels regarding the implementation of process modeling projects.

23a. "The modeling software automatically controlled compliance with predefined conventions."

23b. "The modeling software automatically controlled compliance with predefined conventions." (compared to notation used)

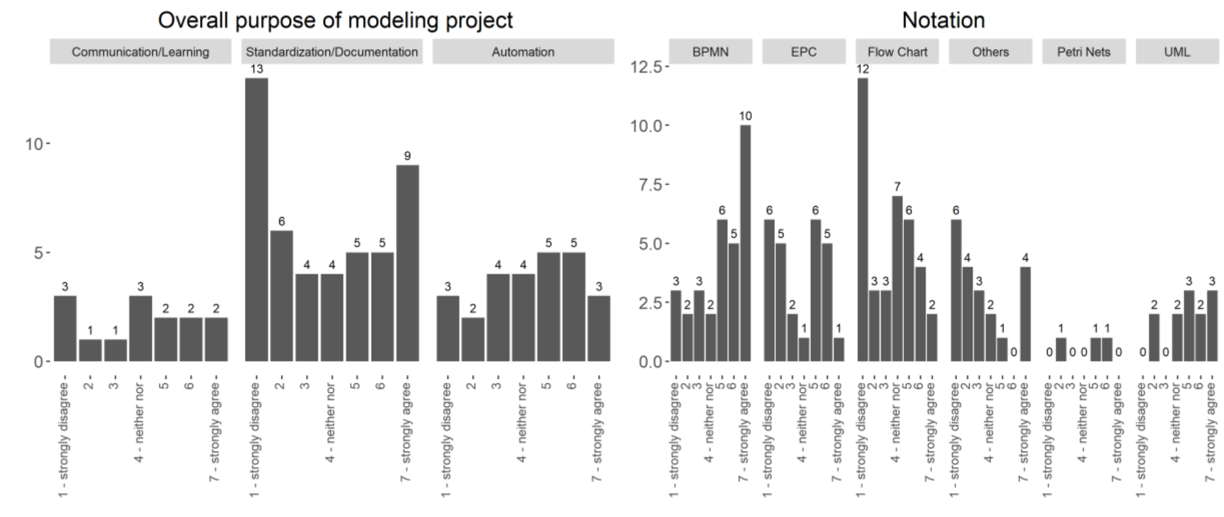

Figure 23: Automatic checks of conventions by modeling conventions compared to the project's overall purpose (left) and notation (right).

Further, the high usage figures of other notations (cf. Figure 18) that companies are generally using indicates that process modeling projects are subject to various application contexts in which different notational standards are needed. Especially the fact that 53.5 % of companies regularly use flow charts suggests that either this notation is used to kick-off projects with fast results, or that respective companies are not interested in creating complex process models.

Central availability of modeling software. In practice, process modeling projects often involve multiple stakeholders with varying objectives and viewpoints (Fischer et al. 2019). To streamline distributed modeling activities, companies often rely on software that is centrally accessible and, thus, facilitates communication and collaboration among stakeholders. This question was posed only to informants who previously indicated their company to have already implemented a process modeling software. With 86 out of 319 companies, this corresponds to about 27 % of the surveyed participants. Referring to the software's central and free availability to its stakeholders, Figure 24 indicates that this is true for less than 50 % of companies surveyed.

"The modeling software that you had access to in your last modeling project was fully available to all employees."

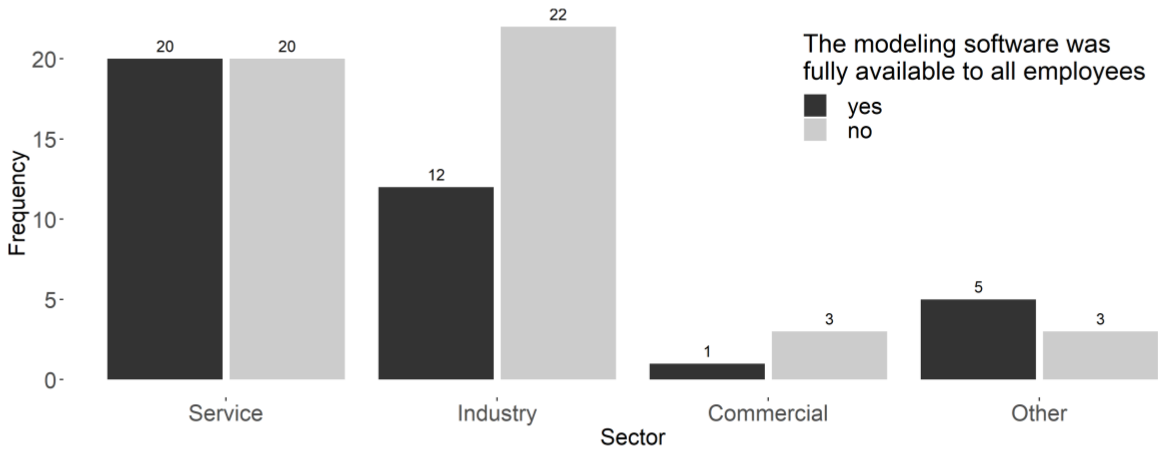

Figure 24: Central and full availability of modeling software to all employees

Given that scaling software licenses is usually very cost-intensive, however, we would have expected even lower figures for this question. From the responses, we can observe that particularly the service sector attaches great importance to the unrestricted access of its tool environment, while this effect is slightly flattening for the industrial sector. Due to the low number of participants, it is not possible to make any specific statements for the commercial sector and others.

The modeling software supported the communication between stakeholders. To guarantee maximum dissemination of the project's results, the corporate system infrastructure must ensure mechanisms to efficiently share and discuss project outcomes. Based on numerous talks with practitioners from different industries, we know that most companies deploy a web-based process repository to foster communication and collaboration. Usually, this process repository represents a company's process architecture or process landscape and grants reading access to all of its employees. Interested employees access the process viewing portal using their corporate authentication details through the company's intranet. Most BPMS vendors provide this function standard wise.

Figure 25 shows very unbalanced numbers for this question without a recognizable tendency. Both in the service sector and the industrial sector, there are both numerous informants rejecting communication features, but also approximately the same number of informants who gave their consent. More specific, about 37.5 % of the answers received from informants in the service sector and 41.1 % received from the industrial sector do not agree with the statement that their corporate modeling software supports communication and collaboration to share and discuss project results among stakeholders. At the same time, however, 52.5 % of respondents from the service sector and 58.8 % from the industrial sector agreed that their company's modeling software provided the means to communicate and collaborate on a project's outcomes with involved colleagues.

"The modeling software supported the communication among stakeholders."

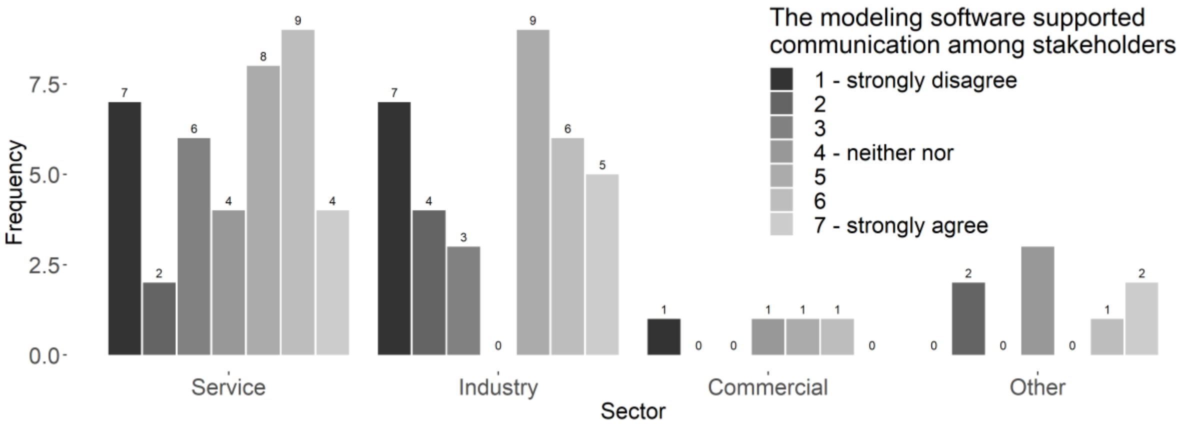

Figure 25: The modeling software engaged supported communication among stakeholders.

The use of methods and tools to promote communication and collaboration in BPM has not only already been thoroughly discussed in practice but has also established its own research stream in academic research, to which is often referred to as social BPM or agile BPM. Social BPM refers to the combination of BPM and social software that defines process management as a corporate asset that is widely used throughout the company and provides the means to involve all stakeholders related to the project (Dengler et al. 2011).

The goal of social BPM is to increase the company's performance by enabling employees to participate in designing and executing processes (Brambilla et al. 2011). For this purpose, the company loosens internal and external project structures and boundaries and advocates collaborations between employees. The paradigm underpinning social BPM is characterized by social features that allow to access, comment, edit, and share process-related work. Consequently, social BPM is rather a methodology than a management approach. However, especially due to its focus on knowledge diffusion, social BPM limits its application paradigm and range of functions to less restrictive approaches than current top-down implementations of BPM allow for (Imgrund et al. 2017a). Nevertheless, embedding social features into BPM promises to improve the identification, design, and optimization of processes by enabling a bilateral transfer of information, facilitating communication among stakeholders, and establishing commons-based peer production (cf. Section 3.1, *hybrid BPM*).

Integration of the modeling tool into the IT system architecture. This question is all about "breaking down silos". We examined, whether companies already engaged with resolving functional dependencies that are very often the result of a barely or even non-integrated IT system architecture accompanied by inefficient operations and ineffective implementations of strategy. This aligns to the view of Becker et al. (2013), who claim that most of today's application systems "*cannot cope with the requirements of process orientation since they are constructed in the form of functional programming hierarchies and, therefore, orient themselves towards the fulfillment of single functions*" (p. 263). However, embedding tools into a larger context or system architecture requires substantial adaptations whose immediate benefits are often not apparent to a company's c-level management. This may result in further in-house developments or specialized software requirements whose implementation often result in even larger inflexibility. Thus, we can imagine that resolving functional dependencies requires fundamental change management initiatives and a profound adaptation plan, which practitioners do not see the immediate benefits in and need for.

Referring to Figure 26, the evaluation included indicates that about half of the companies surveyed are not eager in integrating their IT infrastructure, including the BPMS they use. Our survey reveals that the rate of companies integrating their BPMS into the corporate IT infrastructure exactly rates at 50 % for all sectors except the service sector. In this sector, there is a slightly stronger tendency of companies integrating their BPMS to the existing infrastructure (52.5 % argued for *yes*).

"The modeling software was implemented into the existing IT infrastructure of your company."

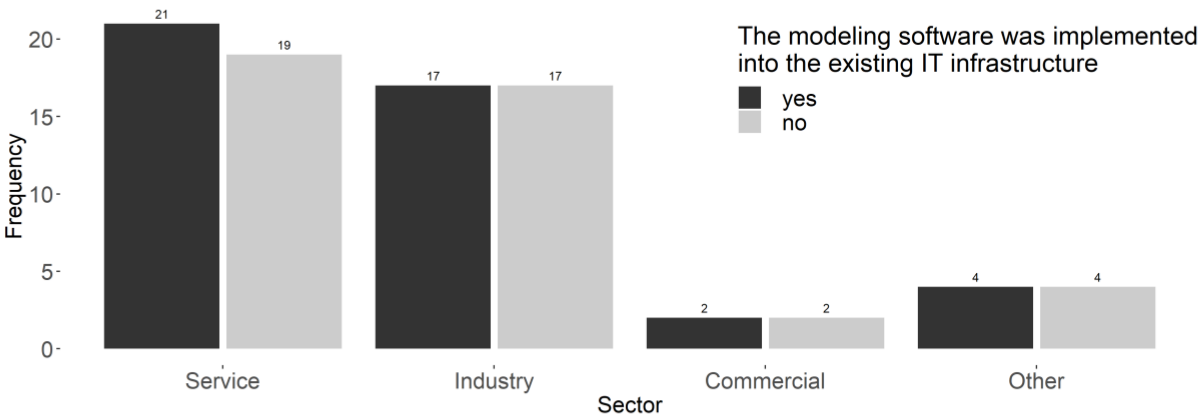

Figure 26: Integration of process modeling tool into existing IT infrastructure

In addition, we can see in Figure 27 that the overall purpose of the modeling project also seems to influence the decision whether to integrate the tool into the existing infrastructure. Particularly for the communication/ learning objective in the service sector, it becomes evident that the integration of the BPMS into the IT infrastructure is of no significance to the respective companies. At the same time, we see only limited interest from companies pursuing a communication/ learning strategy to implement and use an appropriate BPMS. However, as Imgrund et al. (2017b) emphasize, tool support is essential for companies engaging with local process optimizations carried out by the company's workforce. In practice, this is not yet reflected. For the purpose of standardizing and documenting processes, we see far higher usage figures. Here, companies in the service sector prefer to operate on integrated IT infrastructures explicated by a majority of 63.2 %. In the industrial sector, only 42.9 % of the informants inform that their company integrated the BPMS into the existing IT infrastructure.

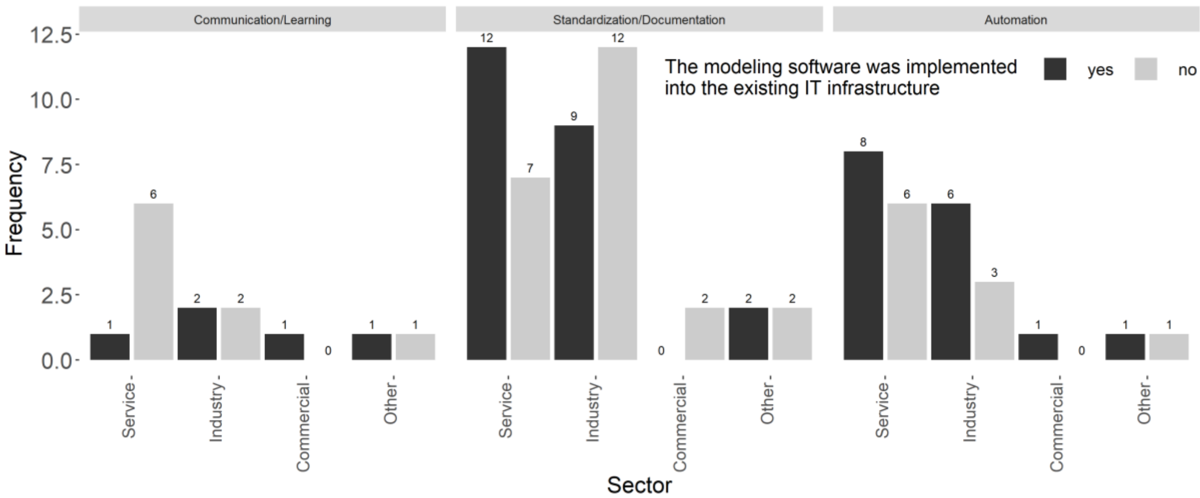

Figure 27: Integration of process modeling tool into existing IT infrastructure compared to sector and overall purpose of modeling project

All respondents in the commercial sector (2) decline the statement. For companies focusing on automation, there is a slight tendency to integrate their BPMS into the system architecture. While it is by no doubt essential to have a properly integrated system architecture when focusing on automation yielding integrated processes and outcomes, we observe most of the surveyed companies in this sector operating not acting accordingly.

Central availability and distribution of project outcomes. Finally, we asked respondents about the central availability of project outcomes and whether interested stakeholders can access the modeling project's outcomes without restriction. As mentioned before, many companies do this by providing a HTML-based webpage that directly connects to the BPMS and, thus, provides an up-to-date blueprint of the corporate process landscape. Figure 28 indicates that companies either tend to share project results than restricting access. This is particularly true for the overall objective of standardization and communication, for which 68.8 % of companies surveyed confirmed the modeling project's outcomes to be centrally available. This percentage diminishes to 62.7 % for the overall objective of communication and learning, hitting a low for automation projects, in which only 54.5 % of respondents confirm the central availability of project outcomes.

"Were the process models made available to all employees centrally when the modeling project was finished?"

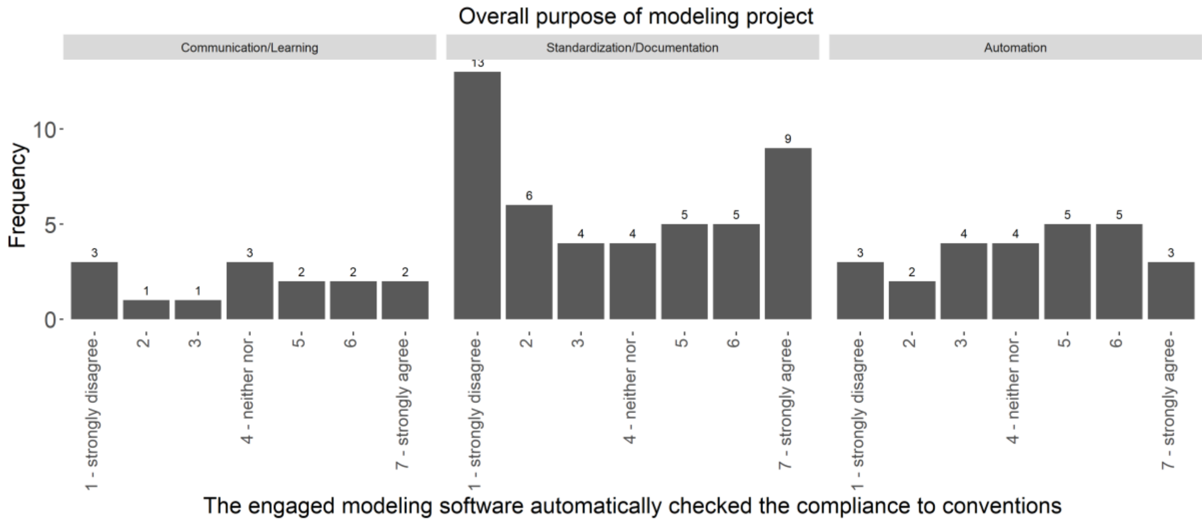

Figure 28: Central availability of project outcomes.

3.3 Cultural Implementation

Besides organizational, technological, and methodological aspects, companies must deal with serious cultural challenges and change management when modeling or redesigning processes. In this section, our questions aim to shed light on the relationship between process modeling and cultural change. We focused our questions on integration, training offers, and usability issues, as insufficient stakeholder participation and integration often leads to major drawbacks and pitfalls that jeopardize the quality of the entire modeling project including its outcomes. Due to the fact that stakeholders rarely realize the full benefits of process modeling projects (Indulska et al. 2009b), companies need to sensitize them accordingly. Additionally, process modeling projects involve different stakeholders with different backgrounds, objectives, and viewpoints, which makes it essential to streamline their activities and attitudes (Rosemann 2006).

Involvement of relevant stakeholders into the modeling project. In this first question, we asked respondents whether their companies involved the relevant stakeholders timely. Respondents across all industries rather confirmed this and most often strongly agreed that stakeholders have been involved appropriately. The integration of stakeholders, however, does not only deliver benefits, but also entails organizational challenges. While numerous studies have proven that the involvement of key employees is essential for project success (Hermano and Martín-Cruz 2016; Kovačič and Indihar Štemberger 2015; Ravesteyn and Versendaal 2007; Schmiedel et al. 2015), companies must initiate appropriate actions to ensure a seamless communication between and with stakeholders. On the one hand, this means that companies need mechanisms to structure their process knowledge as stakeholders produce large process repositories due to increasingly local and/ or peer-produced process models (Fischer et al. 2019; Nolte et al. 2016). On the other hand, when involving stakeholders from various backgrounds and viewpoints, it is essential for companies to provide training offers to compensate for possible knowledge gaps and, thus, to streamline knowledge to a common denominator (Fischer et al. 2019).

"Relevant stakeholders were involved in the modeling project."

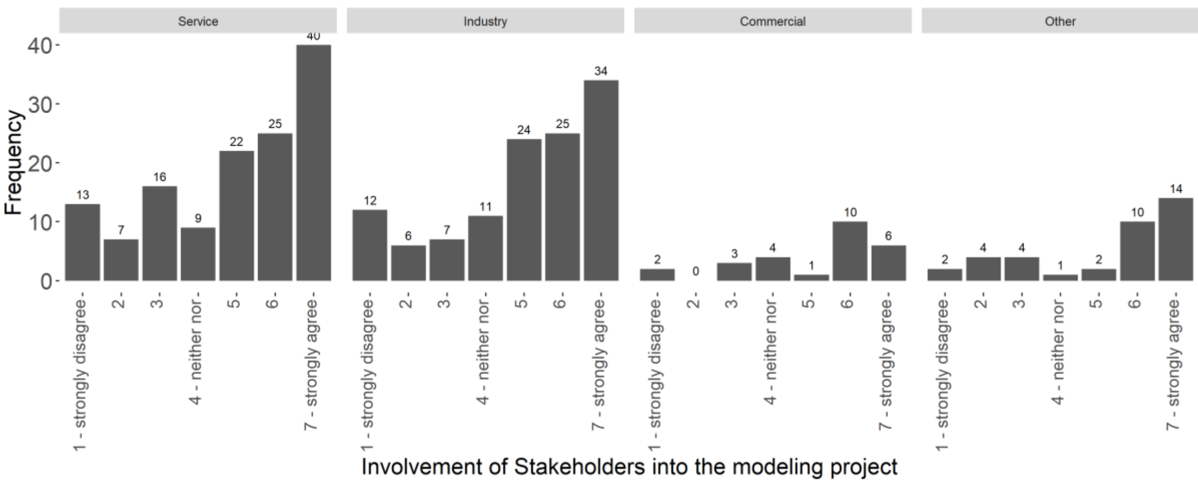

Figure 29: Stakeholder involvement.

Availability of training offers to build process modeling skills. To assure a certain level of quality, companies must provide adequate training courses (Fischer et al. 2019; Imgrund et al. 2017b). Contradictory to that, companies do not give much value to the providence of training courses in practice, as indicated by low the adoption rates in Figure 30.

Fischer et al. (2019) and Imgrund et al. (2017b), however, have found out that it is in fact a major success factor for process modeling projects to provide adequate training courses. Regardless of the sector and the overall purpose of the modeling project, most of the companies surveyed do not offer any training courses for process modeling. Evaluating based on a projects purpose, the refusal ratio is 74.6 % for projects seeking to improve communication, 73.5 % for standardization and documentation projects, and 63.6 % for automation projects. Subsequent analysis (cf. Section 4) shows, however, that educated and experienced staff significantly increases the probability of successful process modeling projects. We therefore strongly recommend companies to provide training courses that facilitate basic understanding towards process modeling. Ideally, companies offer differentiated training courses that address employees according to their individual skills and experience-levels (Fischer et al. 2019; Imgrund et al. 2017b).

"Did your company offer preparatory training for the modeling project?"

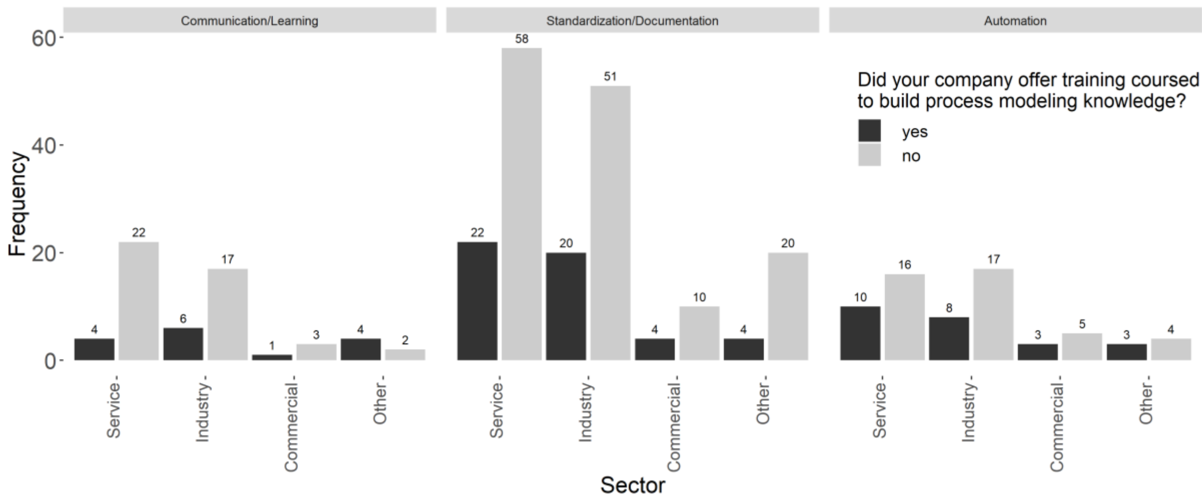

Figure 30: Availability of training offers that serve as preparation for process modeling projects.

Simplicity and comprehensibility of a process modeling project's results. The ease of use of a project's outcomes is essential regarding user acceptance (Born et al. 2007). This is primarily essential in the light of various goals and backgrounds that companies can accomplish with process modeling. To this end, we asked respondents whether their companies demanded outcomes to be user-friendly, that is, with high degrees of usability, simplicity, and intuitiveness. Figure 31 affirms that the respondents' companies in fact attached great importance to the comprehensibility and simplicity of a process modeling project's outcomes. Surprisingly, the results of the survey were much more significant than we expected – especially for companies seeking to standardize and document their business processes. Here, 62.6 % of respondents agreed or strongly agreed that process models were provided in a comprehensible form. In contrast, only 7.7 % disagreed or strongly disagreed with the statement.

Similarly, projects with the main purpose of communication and learning, as well as projects yielding process automation indicate favoring a clear and understandable representation of project results. For the communication and learning purpose, 69.5 % support the statement, compared to 18.6 % who do not agree. The remaining 11.9 % neither agree nor disagree to the statement. In projects that automate business processes, the disapproval rate for the statement is 16.8 %, with 9 % neither agreeing nor disagreeing, and 74.2 % agreeing.

Besides providing an education program and ensuring adequate ease of use of a project's results, companies should be aware that stakeholder commitment is key to a process modeling project's success. If companies do not agree and, thus, do not facilitate process orientation, no matter how sophisticated the company's organizational, technological, and methodological setup is, the project will most likely not deliver the expected benefits and outcomes (Fischer et al. 2019).

"Simplicity and comprehensibility of the modeling project's results was of major importance."

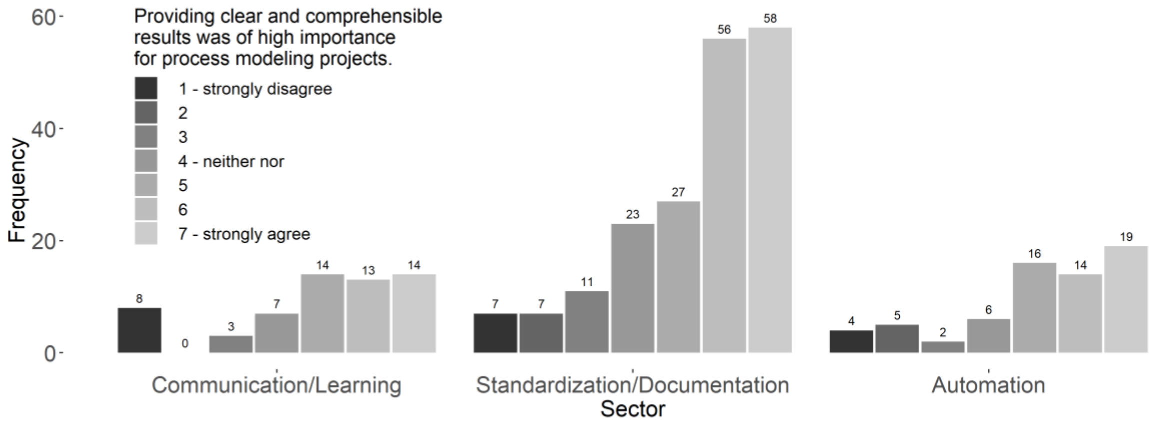

Figure 31: Importance for process modeling projects to provide clear and comprehensible results.

Successfully deploying process modeling projects fundaments in process-aware employees. However, as awareness for processes won't emerge automatically, especially not in functional organizations, companies must communicate benefits, success stories, provide educational offers, and resolve conflicts or opposing opinions and expectations at any time. For further details on implementing successful process modeling projects, see Fischer et al. (2019). The authors provide ready-to-use guidelines and success factors. The research further provides three different configuration setups seeking to provide companies with the most suitable recommendations for action depending on their individual application context.

Number of interfaces and dependencies of the company's processes. According to Reisert et al. (2018), it is essential for process modelers to fully understand the corporate process complexity and dependencies. This is particularly important if a company's process landscape exhibits complex organizational structures. Figure 32 confirms that companies most commonly consist of a complex process infrastructure with numerous interfaces and dependencies.

To cope with organizational complexity, companies must empower their employees to contribute and collaborate in a self-organizing substructure of local dependencies and allow for distributed control instead of insisting on central and hierarchical authority. Moreover, we know from academic literature that functional and process structural often co-exist, further increasing organizational complexity (Nesheim 2011; Palmberg 2010). To remain effective in an increasingly competitive environment with high-paced market dynamics, however, companies must not reduce complexity but begin to find efficient ways in managing it (Hamel 2009). To manage organizational complexity, we recommend companies shifting their focus from hierarchical-only management approaches, towards management paradigms that outsource responsibilities, establish commons-based peer production, and facilitates communication, coordination, and collaboration among a project's stakeholders (Imgrund et al. 2018).

"Your company's processes have many interfaces and dependencies."

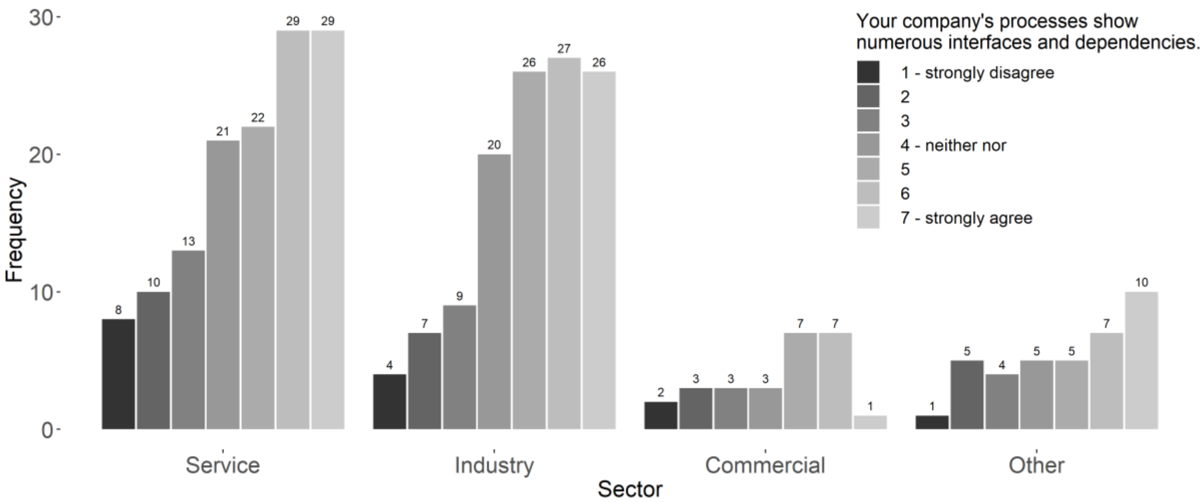

Figure 32: Your company's processes have many interfaces and dependencies.

4 Success Factors of Process Modeling

So far, the report presented demographic and descriptive details that allowed for general insights on structure and characteristics of the domain as well as to assess the appropriateness and representativeness of the sample. Further, we gave in-depth details on the current implementation of process modeling project in practice and related it to current literature. Ultimately, this section contextualizes the preceding evaluations and shows factors that we identified as significant for the success of a process modeling project. To this end, we first introduce to our test setup, before we begin with hypothesis testing using both simple and multiple linear regression models.

4.1 Dependent Variable, Predictor Variables, and Test Setup

As mentioned in Section 2.1, our report summarizes information provided by 314 informants working for companies from different industries and sizes. We asked a total of 42 questions to provide in-depth insights into how process modeling projects are currently carried out and which characteristics promote or impede their success. To discover statistically significant relationships among the variables, we engage simple linear regression as well as multiple linear regression, which are commonly used to predict the behavior of a *dependent variable* based on one or multiple *predictor variables*. The latter are also often referred to as *independent variables*.

Dependent variable. To assess the success of a project, we fundament our statistical analysis on the variable *success*. This variable's score determines how successful a process modeling project was according to responses of informants (cf. Figure 33). To answer the corresponding questions, we provided our informants with a seven-point Likert scale from 1, indicating to not agree with the project's success at all, to 7, indicating full agreement to the project's success.

"The modeling project as a whole was successful."

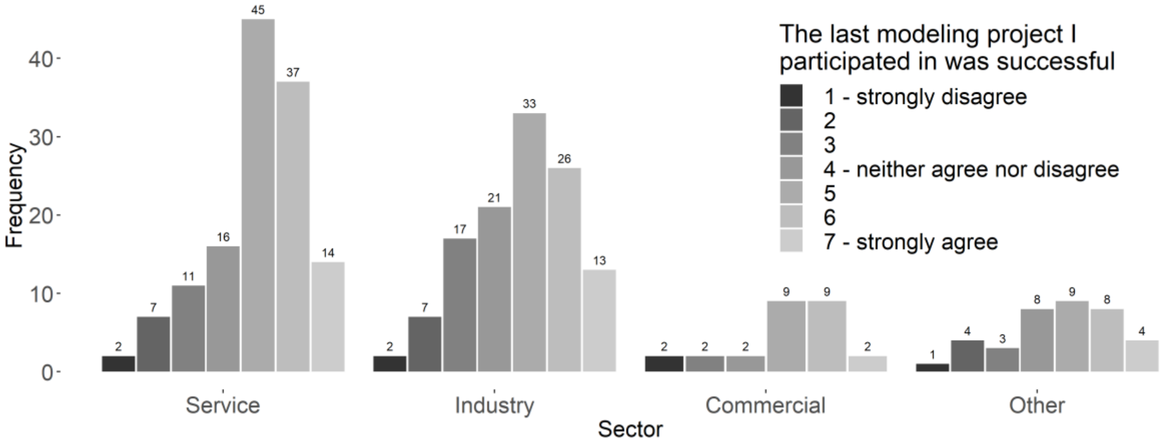

Figure 33: Success of process modeling projects.

With a mean of 4.8, process modeling projects were usually successful. In more detail, a total of 10.8 % of respondents rated the success of their last modeling project with the best possible rating. Only 2.2 % chose the worst rating. The majority of respondents (66.6 %) tended to rate their project as successful rather than unsuccessful.

Besides the bar plot in Figure 33 which separates the success rates of process modeling projects based the sectors of the companies, we provide the accumulated figures in Figure 34, depicted as a Likert plot.

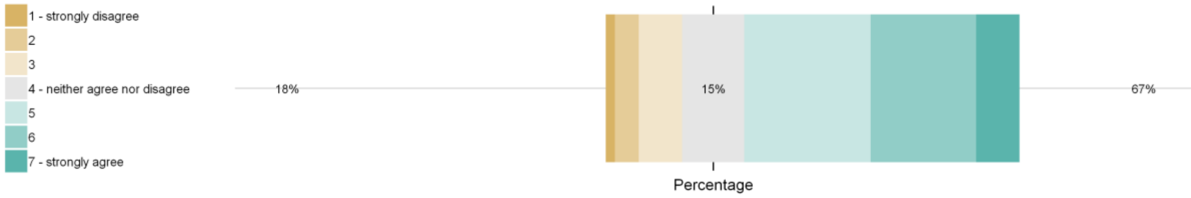

Figure 34: Success of process modeling projects plotted using a likert diagram.

We abbreviate the variable described in these diagrams as *success* and use it from now on as our dependent variable for all statistical computations to follow. Having defined a dependent variable, we are able to conduct statistical tests on how this variable's score alters based on the influence of one or multiple further variables, which serve as our predictive variables.

Predictive variables. To find variables that significantly influence the success of a modeling project, we initially deployed a stepwise regression. The stepwise regression is a procedure in which the algorithm automatically determines predictive variables that have the highest explanatory power to explain the phenomenon studied (Hocking 1976). During each step, the algorithm includes or excludes a variable from its initial set of explanatory variables. While the stepwise regression features various techniques to find adequate predictive variables, this study's computations rely on the adjusted R^2. Stepwise regression led us to focus on the variables listed in Table 1 as our predictive variables. In the table, we abbreviate the variables in the first column and give a short explanation in the second, we provide their type in the third column, and a mean of the respondent's answers in the fourth column. The mean is based on the response option's numeric values. Exemplarily, for *ExperiencePM*, the mean value is 2.8. That means, that the average experience of the respondents is closest to the response option *6 to 10 years*. The stepwise regression did not include the following variables as predictive variables, despite their subjective importance: *training of employees* and *usage of conventions*. However, manual checks of our data confirmed that the variables have no significant influence on the success of a process modeling project. Eventually, we are well aware that academics dispute on the reliability of stepwise regression to achieve statistically sound results (Knapp and Sawilowsky 2001). However, having conducted manual checks of the significance of each variable included to our sample, we could fully confirm the choice of explanatory variables as suggested by stepwise regression.

Table 1: Predictive variables including description, response options, and mean.

Variable name	Description	Response options	Mean
ExperiencePM Years	Years of experience in process modeling. (cf. Section 4.2, Figure 35)	- less than 2 years - 2 to 5 years - 6 to 10 years - 11 to 15 years - more than 15 years	2.8
ExperiencePM Scale	Experience as a process modeler from beginner to expert. (cf. Section 4.2, Figure 36)	- 1 – Beginner - 2 … 6 - 7 – Expert	3.9
Experience BPM	Years of experience in business process management. (cf. Section 4.3, Figure 38)	- less than 2 years - 2 to 5 years - 6 to 10 years - 11 to 15 years - more than 15 years	3.4
Communication Goals	Communication of the modeling project's objective by management. (cf. Section 4.2, Figure 40)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	5.1
TopManagement Support	Top management actively supported the modeling project. (cf. Section 4.2, Figure 42)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	5.7
ImportancePM Project	The modeling project was of great importance for the respondent's company. (cf. Section 4.2, Figure 44)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	5.1
Compliance Conventions	Guidelines and conventions were complied with during modeling. (cf. Section 4.2, Figure 46)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	4.1
Usability	The clarity and comprehensibility of the results of the modeling project was a factor. (cf. Section 4.2, Figure 48)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	5.3
ProcessOrientation	The company you work for is process-oriented. (cf. Section 4.2, Figure 50)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	4.8
Complexity	Number of interfaces and dependencies of the company's processes (cf. Section 4.2, Figure 52)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree	4.9

Please refer to the appendix for a more comprehensive representation of Table 1.

Test setup. After having determined the dependent variable including the reduction of predictive variables to a total of 10 variables, we proceed with further statistical tests to identify the significance of each variable. To ensure our statistical analysis to run on cleansed data, we first checked the completeness and correctness of the data. Additionally, we only used completed surveys that had no missing values in any of the responses. In the following evaluations, we seek to extract success factors of process modeling. While stepwise regression allowed us to identify variables with explanatory power to our dependent variable, we proceed with simple linear regression on these variables. We are well aware that the exclusive reliance on statistical testing of hypothesis has been criticized in academic literature multiple times

(Kaplan and Duchon 1988). To this end, we fundament this study's quantitative analysis on prior qualitative insights that we recently published in Fischer et al. (2019). Consequently, this report quantifies insights acquired in multiple practitioner talks and case studies and, thus, benefits from multiple contexts, experiences, and backgrounds. By cross checking results of our quantitative analysis with our previous qualitative insights, we are able to eliminate misleading hypothesis or conclusions, achieving reliable findings validated through a multi-method approach based on qualitative and quantitative insights (Kaplan and Duchon 1988).

4.2 Hypothesis Testing Using Simple Linear Regression

In this Section, we use linear regression to predict the statistical relevance of the predictive variables defined in Section 4.1. Linear regression relies on minimizing the sum of squared errors. For this study, we rely on the adjusted R^2 value as an indicator to assess the explanatory power of our regression model. Simplified, the adjusted R^2 determines the percentage of variation to which the model's independent variable(s) affect the dependent variable. For each of the following hypothesis, we provide a boxplot that includes the betrayed variable's quantiles, its median, maximum and minimum values, as well as outliers if present. Additionally, we offer insights to the residuals and coefficients that result from linear regression by including the diagnostic plots of logistic regressions for each predictive variable. Table 2 provides some explanations on how to interpret the diagnostic plots. Based on the residuals, we can check if linear regression assumptions are properly met. Finally, we obtain each variable's significance by evaluating its predictor value (p-value), which indicates whether the relationship between the predictive variable and the dependent variable is statistically significant.

Table 2: Explanations for diagnostic plots.

Diagnostic plot type	Explanation
Residuals vs. fitted	The residuals vs. fitted plot detects whether the residuals contain non-linear patterns. Residuals should be spread equally around a horizontal line to not indicate any non-linear relationships within the examined data.
Normal Q-Q	The normal Q-Q indicates whether residuals are distributed normally across the data. If they follow a straight line rather than being deviated significantly, there is no indication that the distribution of the data is any other than normal, such as exponential.
Scale-location	Scale-location allows to evaluate if the assumption of equal variance is met. A horizontal line with equally spread points indicates that equal variance along the range of predictors is given.
Residuals vs. leverage	The residuals vs. leverage plot allows to identify influential cases in the data. If we observe values with a relatively high Cook's distance, we suppose the value to be extreme against the regression line and, thus, alter the results of the regression if excluded. However, extreme values are not obligatory to alter the regression. Instead, this is only the case if the values are outside of the Cook's distance, whose distance score is plotted against the y-axis.

Hypothesis 1: Experience in process modeling has a significant influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression to prove a statistically significant impact of the variable *experiencePMYears*, i.e. year of process modeling experience, on the variable *success*. Referring to the boxplot in Figure 35a, we see a significant relationship between the two variables. Further, consulting the model's *coefficients*, we can observe the strongest significance score (***) with a *p-value* of *6.69e-12*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.37134*, adding a more experienced process modeler (evaluated based on a certain amount of years, cf. Table 2) means that the success of the process modeling project increases by the estimate. That is, assuming a mean of *3.83* for a process modeling project to be successful with only beginners being involved (leftmost value on the x-axis in Figure 35a), a process modeler *with two to five years of experience* would increase the success of the process modeling project by the value of the estimate to *4.20137*. The residuals in Figure 35b indicate that the regression model worked well for our data.

(a) (b)

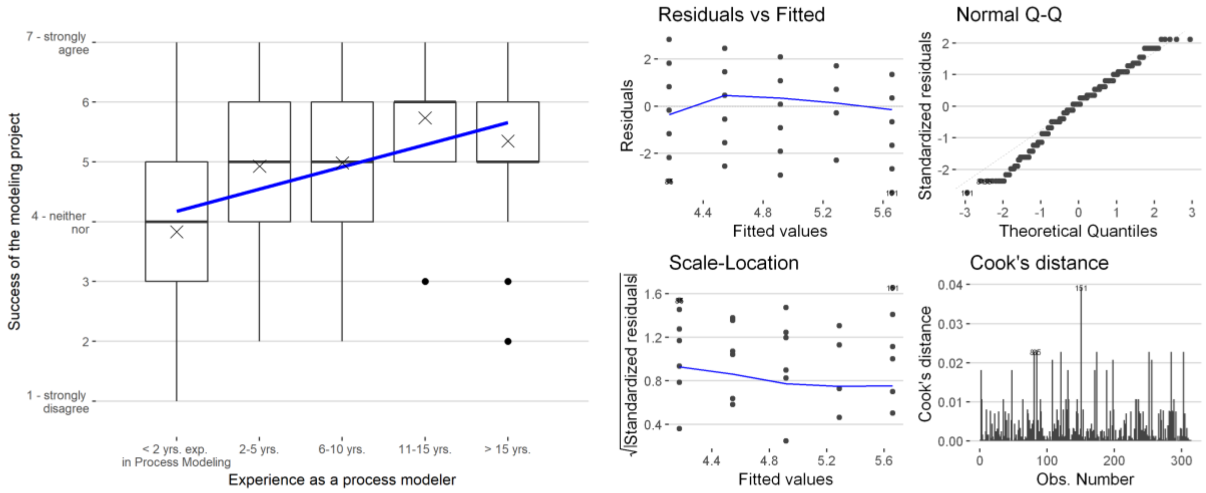

Figure 35: Years of experience of process modelers as significant factor for the success of a modeling project.

As we asked respondents two questions about their experience in process modeling, we also present the variable *ExperiencePMScale* in the following, which captured the self-judgement of the experience level of the respondent. The linear regression was computed on the *experience as a process modeler (scale)* as predictor and the variable *success* as dependent variable. Looking at the boxplot in Figure 36a, we see a significant relationship between the two variables. Further, consulting the model's *coefficients*, we can observe the strongest significance score (***) with a *p-value* of *<2e-16*.

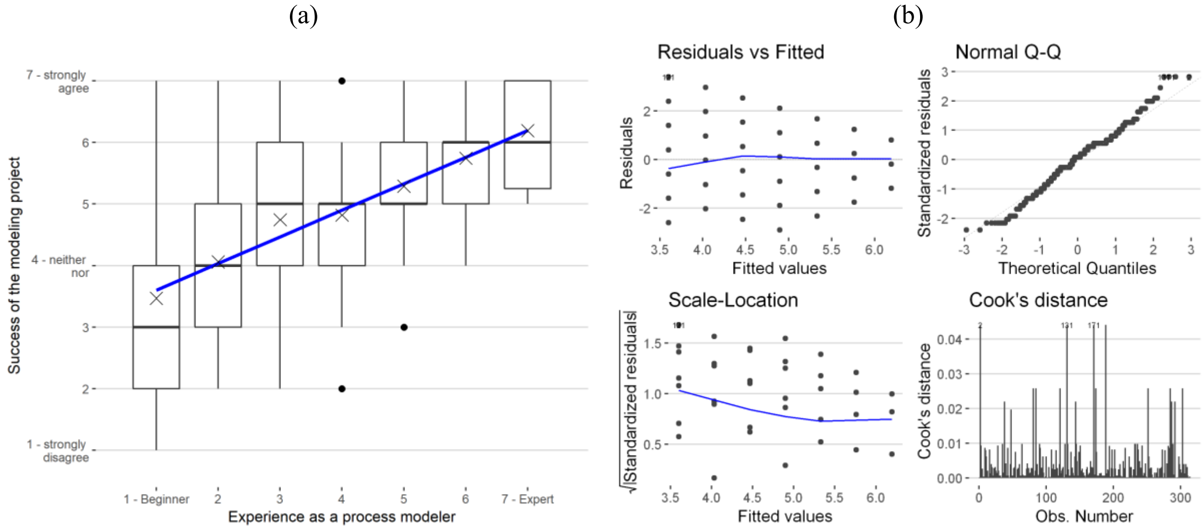

Figure 36: Experience level of process modelers as significant factor for the success of a modeling project.

Thus, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.43193*, adding a more experienced process modeler (evaluated based on a scale, cf. Table 2) means that the success of the process modeling project increases by the abovementioned estimate. Assuming a mean *of 3.46* for a process modeling project to be successful with only less skilled process modelers (beginners) being involved (leftmost value on the x-axis in Figure 36a), a process modeler with *the skill-level 2* would increase the success of the process modeling project by the value of the estimate to *3,89193*. The residuals in Figure 36b indicate that the regression worked well for our data. Besides linear regression, we include density plots in Figure 37. While we are well aware that it is statistically inappropriate to deploy a density plot on ordinal data, we provide the diagrams as a useful tool for analysts to explore the data. Accordingly, in Figure 37, one can see at first glance that experienced process modelers are usually involved in highly successful modeling projects. This both holds true for the variable *ExperiencePMYears* (a) as well as for the variable *ExperiencePMScale* (b).

Figure 37: Density plot showing the relation of experience in process modeling and success of the modeling project.

Hypothesis 2: Experience in BPM has a significant influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression to prove a statistically significant impact of the variable *ExperienceBPM*, i.e. years of BPM experience, on the variable *success*. Referring to the boxplot in Figure 38a, we do not observe a significant relationship between the two variables. That is, there is *no linear dependency* between the variables. Consulting the model's *coefficients*, however, we can observe that there is a strong significance score (***) for some of the experience levels. In fact, the linear dependency only does not apply for the group of most experienced BPM experts (experience in BPM greater than 15 years). The residuals in Figure 38b indicate that the regression worked well for our data. The density plot in Figure 39 additionally shows that there is a relationship between the experience of the involved stakeholder in BPM and the overall success of the modeling project. Analogous to Figure 38a, the plot shows that process modelers with 6 to 10 years of experience in BPM are most often involved in highly successful modeling projects. However, there is little evidence that the data does not perfectly meet the conditions of equal variance (Scale-location). This means that the distribution of data points does not form an evenly distributed scale-location. However, we can attribute this effect to the outliers that we can identify as black dots.

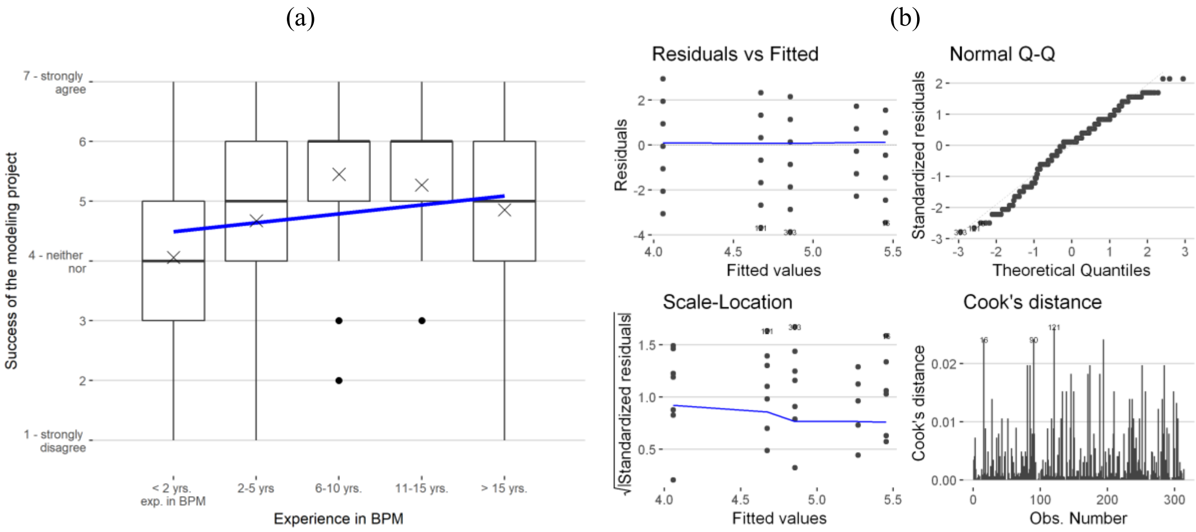

Figure 38: Experience in BPM as significant factor for the success of a modeling project.

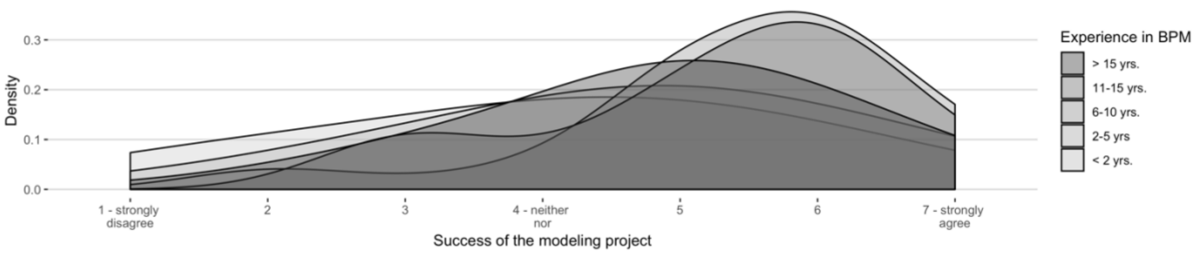

Figure 39: Density plot showing the relation of experience in BPM and success of a modeling project.

Hypothesis 3: The clear communication of goals has a significant influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression to prove a statistically significant impact of the variable *CommunicationGoals*, i.e. the clarity of goal communication by management as observed by the target audience, the respondents, on the variable *success*. Referring to the boxplot in Figure 40a, we can observe a significant relationship between the two variables. Further, consulting the linear regression model's residuals, we can observe the strongest significance score (***) with a *p-value* of *6.69e-12*. We can conclude that there is a relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.37134*, adding a more experienced process modeler (evaluated based on a certain amount of years, cf. Table 2) means that the success of the process modeling project increases by the abovementioned estimate. That is, assuming a mean of *3.83* for a process modeling project to be successful with only no goals being communicated beforehand (leftmost value on the x-axis in Figure 40a), moving rightwards on the x-axis to the score 2 would increase the success of the process modeling project by the value of the estimate to *4.20137*. The residuals in Figure 40b indicate that the regression worked well for our data. The density plot in Figure 41 additionally shows that there is a relationship between the communication of goals and the overall success of the modeling project. However, regarding the density of the plot, the significance seems to be less pronounced.

(a) (b)

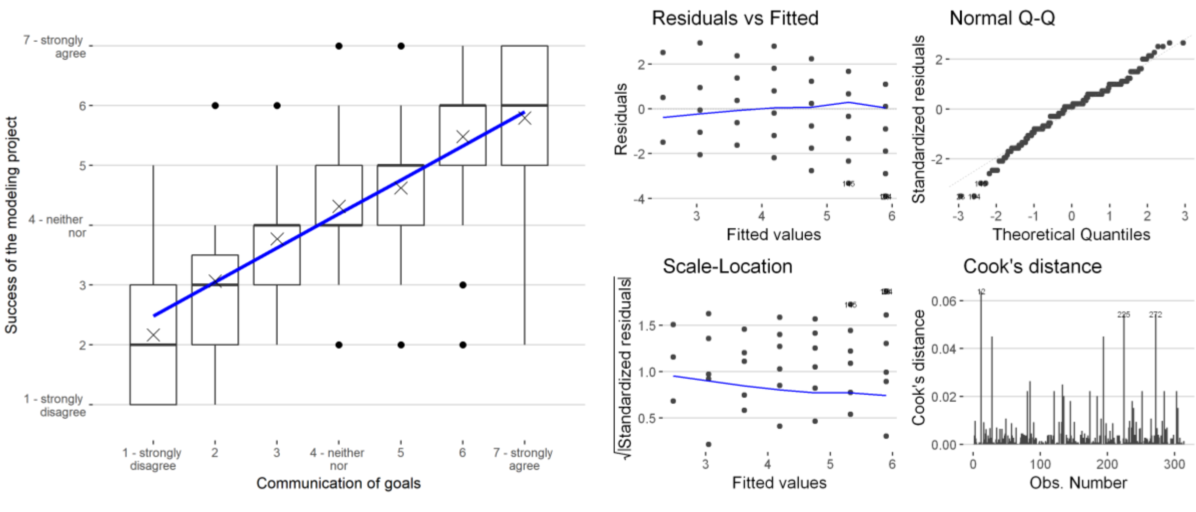

Figure 40: Communication of goals as significant factor for the success of a modeling project.

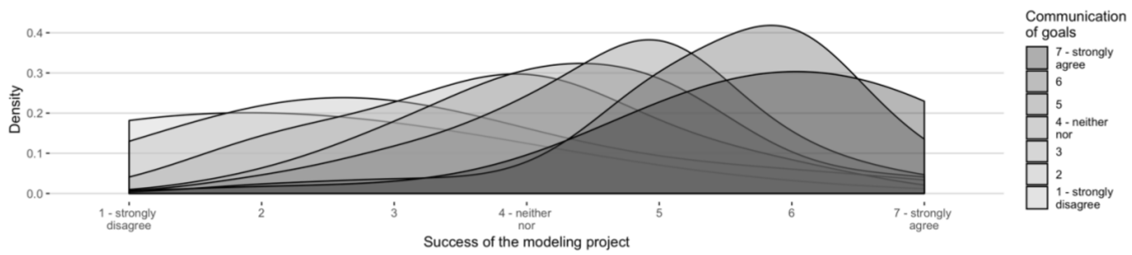

Figure 41: Density plot showing the dependency of a project's success on the communication of goals.

Hypothesis 4: Top management support has a significant influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression to prove a statistically significant impact of the variable *TopManagementSupport* on the variable success. Referring to the boxplot in Figure 42a, we can observe a significant relationship between the two variables. Further, consulting the linear regression model's coefficients, we see the strongest significance score (***) with a *p-value* of *<2e-16*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. That is, assuming a mean of *2.17* for a process modeling project to be successful with no top management support at all (leftmost value on the x-axis in Figure 42a), moving rightwards on the x-axis to the score 2 would increase the success of the process modeling project by the value of the estimate to *2.6621*. The residuals in Figure 42b indicate that the regression worked well for our data. However, there is little evidence that the data does not perfectly meet the conditions of linear dependency (Normal Q-Q) and that the condition of equal variance might be missed (Scale-location). The latter means that the distribution of data points does not form an evenly distributed scale-location. However, we can attribute this effect to the outliers that we can identify as black dots. The density plot in Figure 43 additionally visualizes that there is a relationship between the success of the modeling project and existing management support.

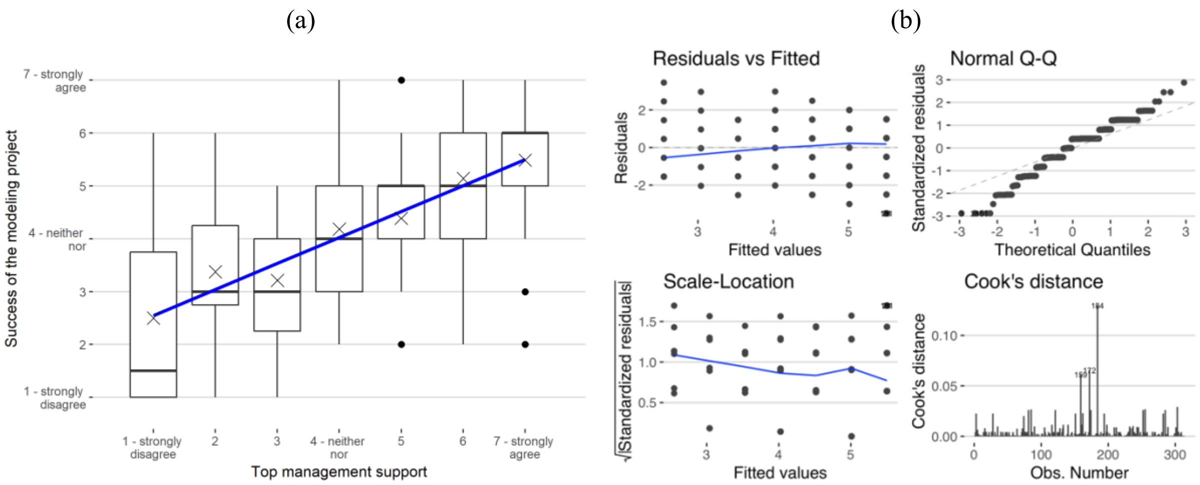

Figure 42: **Top management support as significant factor for the success of a modeling project.**

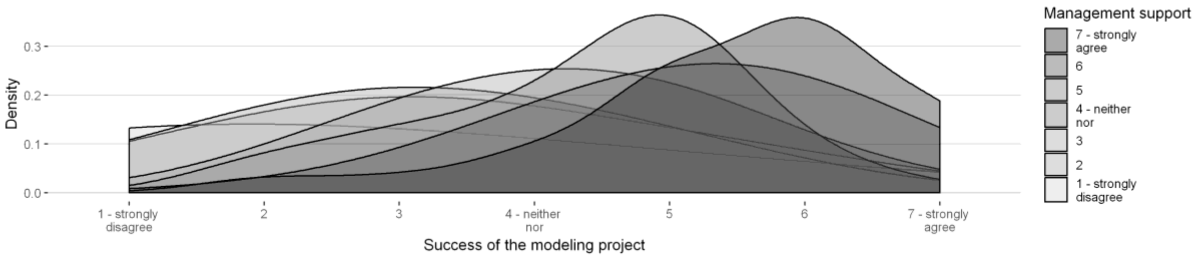

Figure 43: **Density plot showing the dependency of a project's success on top management support.**

Hypothesis 5: The importance of the modeling project has a significant influence on its success.

To evaluate this hypothesis, we ran a simple linear regression model with the independent variable *ImportancePMProject* on the dependent variable *success*. We found a significant relationship between the two variables (cf. Figure 44a).

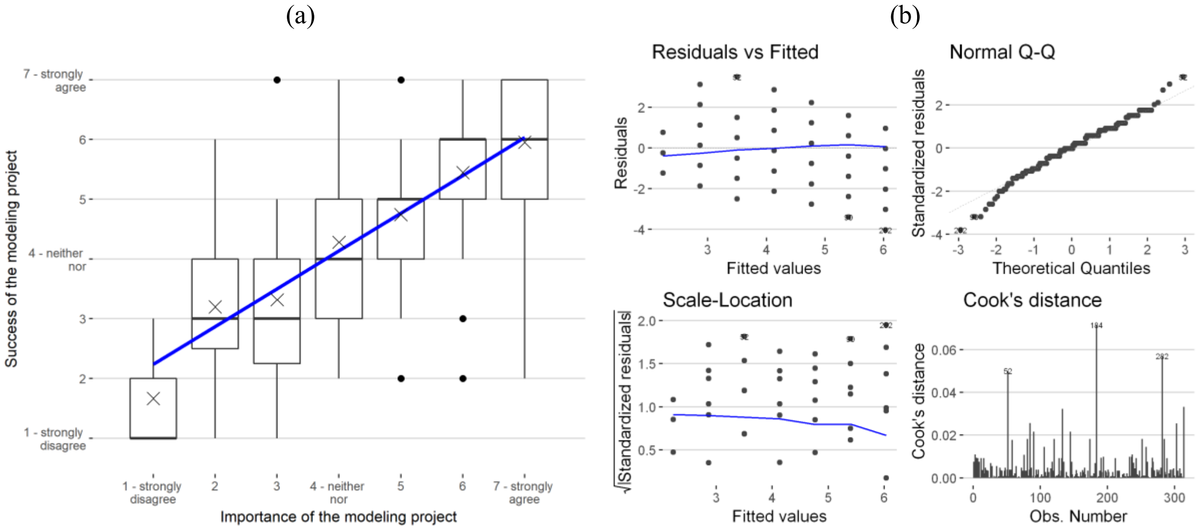

Figure 44: Importance of the modeling project as significant factor for its success.

Consulting the model's coefficients, we can observe the strongest significance score (***) with a *p-value* of *<2e-16*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.63268*, the success of the modeling project increases by the value of the estimate when the importance of the modeling project would range at the next higher level of the Likert scale (2) that labels the x-axis in Figure 44a. That is, assuming a mean of *1.67* for a process modeling project to be successful without any communication of its importance (leftmost value on the x-axis in Figure 44a), we can improve the success of the process modeling project by the value of the estimate to *2.30268* by better communicating the project's importance and, thus, moving rightwards on the x-axis to the score 2. The residuals in Figure 44b indicate that the regression worked well for our data. In the following, we further provide the density plot for this hypothesis in Figure 45.

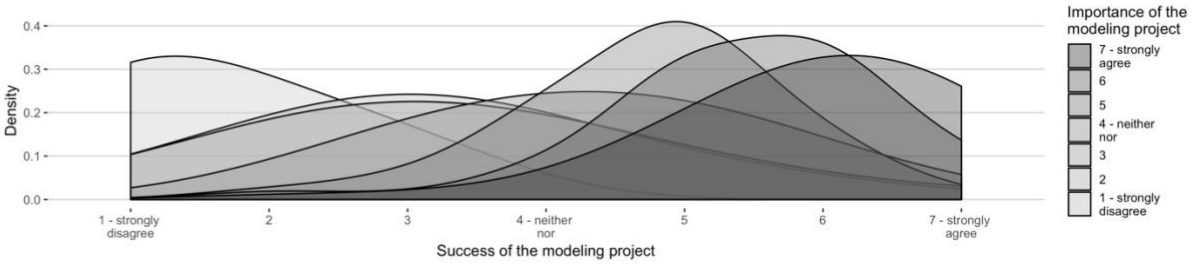

Figure 45: Density plot showing the dependency of a project's success on the project's importance.

Hypothesis 6: The compliance with conventions used in the modeling project is a characteristic with significant influence on the modeling project's success.

To evaluate this hypothesis, we ran a simple linear regression model with the independent variable *ComplianceConventions*, i.e. the compliance of the created models with the project conventions, on the dependent variable *success*. We found a significant relationship between the two variables (cf. Figure 46a).

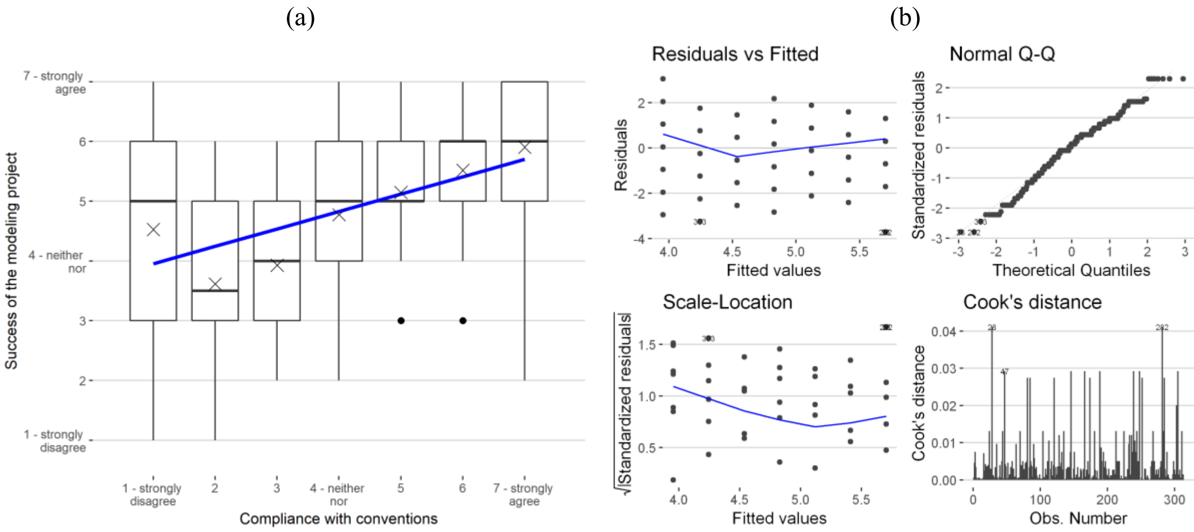

Figure 46: Compliance with conventions as significant factor for the success of a modeling project.

Consulting the model's coefficients, we can observe the strongest significance score (***) with a *p-value* of *4.74e-13*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.2916*, the success of the modeling project increases by the value of the estimate when stakeholders would comply with conventions to a larger extent. That is, assuming a mean of *4.53* for a process modeling project to be successful without any compliance with conventions (leftmost value on the x-axis in Figure 46a), we can improve the success of the process modeling project by the value of the estimate to *4.8216* by better adhering to corporate modeling conventions and, thus, moving rightwards on the x-axis to the score 2. The residuals in Figure 46b indicate that the regression worked well for our data. However, there is little evidence that the data does not perfectly meet the conditions of equal variance (Scale-location). This means that the distribution of data points does not form an evenly distributed scale-location. However, we can attribute this effect to the outliers that we can identify as black dots. We can justify the deviations in the scale-location by its outliers. Below, we additionally provide the density plot for this hypothesis in Figure 47.

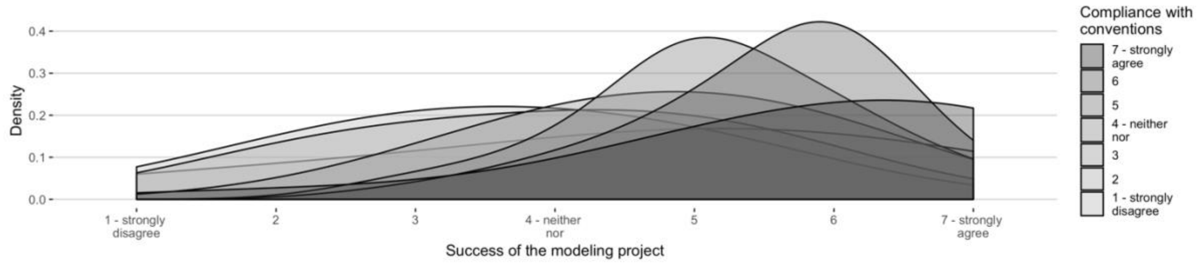

Figure 47: Density plot showing the dependency of a project's success on the compliance with conventions.

Hypothesis 7: The usability of the modeling project's results is a characteristic with significant influence on the success of the modeling project.

To evaluate this hypothesis, we ran a simple linear regression model with the independent variable *Usability*, the clarity and comprehensibility of the project outcomes, on the dependent variable *success*. We found a significant relationship between the two variables (cf. Figure 48a).

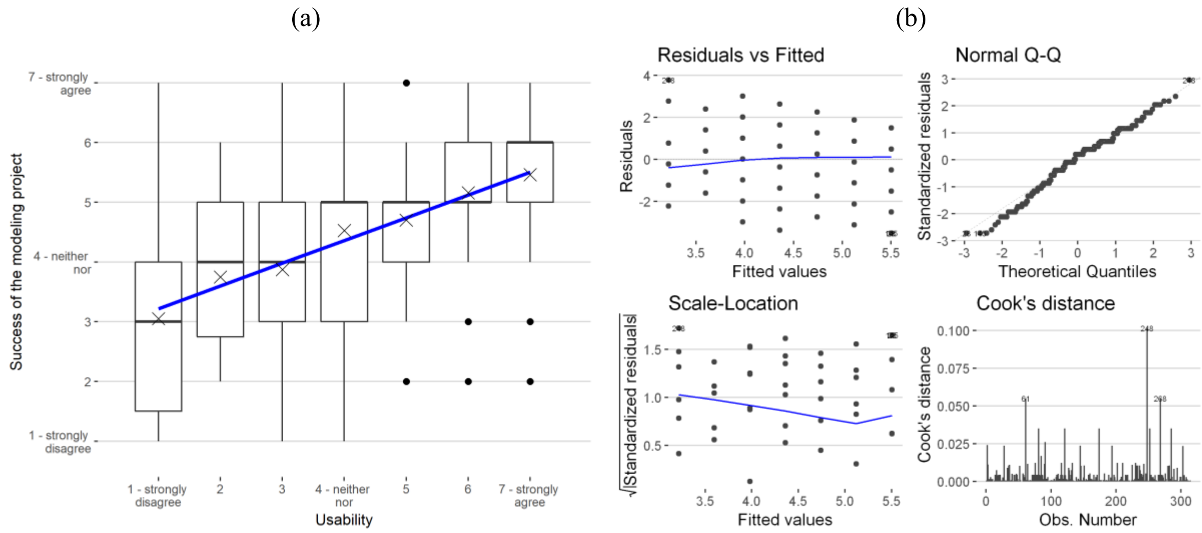

Figure 48: Usability of results as significant factor for the success of a modeling project.

Consulting the model's coefficients, we can observe the strongest significance score (***) with a *p-value* of *<2e-16*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.38063*, the success of the modeling project increases by the value of the estimate when the usability of the project's results would be of greater importance from the beginning. That is, assuming a mean of *3.05* for a process modeling project to be successful without compliance with any objectives regarding the outcome's usability (leftmost value on the x-axis in Figure 48a), we can improve the success of the process modeling project by the value of the estimate to *4.8216* by increasing awareness for usability-related requirements and, thus, moving rightwards on the x-axis to the score 2. The residuals in Figure 48b indicate that the regression worked well for our data. Again, we can justify the deviations in the scale-location by the outliers that are included in Figure 48a as black dots. In the following, we present the density plot for this hypothesis in Figure 49.

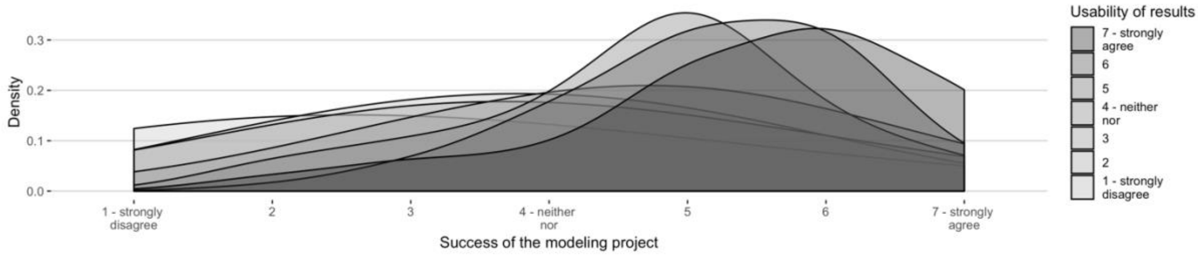

Figure 49: Density plot showing the dependency of a project's success on the result's usability.

Hypothesis 8: The company's degree of process orientation has a significant influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression model with the independent variable *ProcessOrientation*, i.e. whether the respondents considered their company process-oriented, on the dependent variable *success*. We found a significant relationship between the two variables (cf. Figure 50a).

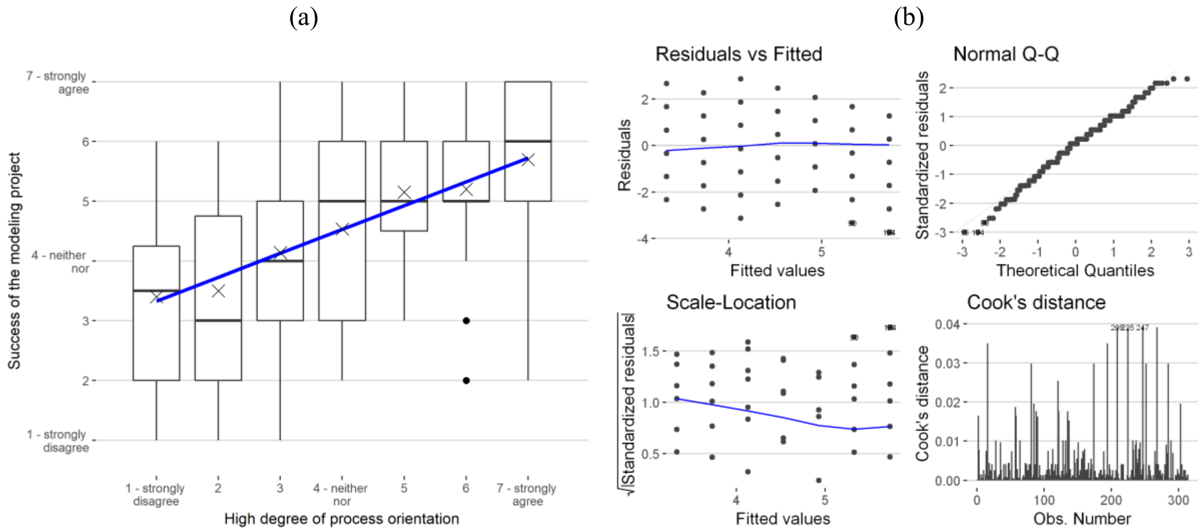

Figure 50: Process orientation as significant factor for the success of a modeling project.

Consulting the model's coefficients, we can observe the strongest significance score (***) with a *p-value* of *<2e-16*. Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.39930*, the success of the modeling project increases by the value of the estimate as soon as the company's degree of process orientation increases. That is, assuming a mean of *3.4* for a process modeling project to be successful without any process orientation (leftmost value on the x-axis in Figure 50a), the success of the project soars by the value of the estimate to *3.7993* when the company increases its degree of process orientation and, thus, move rightwards on the x-axis to the score 2. The residuals in Figure 50b indicate that the regression worked well for our data. We can justify the deviations in the scale-location by the outliers that are shown in Figure 50a as black dots. In Figure 51, we provide the density plot for this hypothesis.

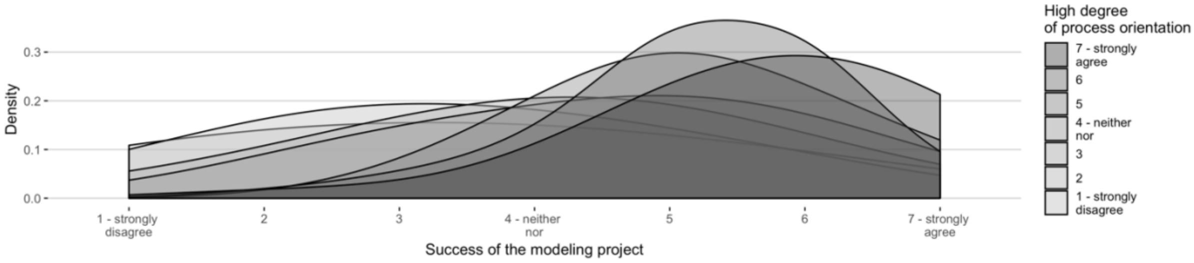

Figure 51: Density plot showing the dependency of a project's success on the degree of process orientation.

Hypothesis 9: The number of interfaces and dependencies of the company's processes has a significant *negative* influence on the success of a modeling project.

To evaluate this hypothesis, we ran a simple linear regression model with the independent variable *Complexity*, i.e. the number of interfaces and dependencies of the company's processes, on the dependent variable *success*. We found a significant relationship between the two variables (cf. Figure 52a). Consulting the model's coefficients, we can observe the strongest significance score (***) with a *p-value* of *<2e-16*.

(a) (b)

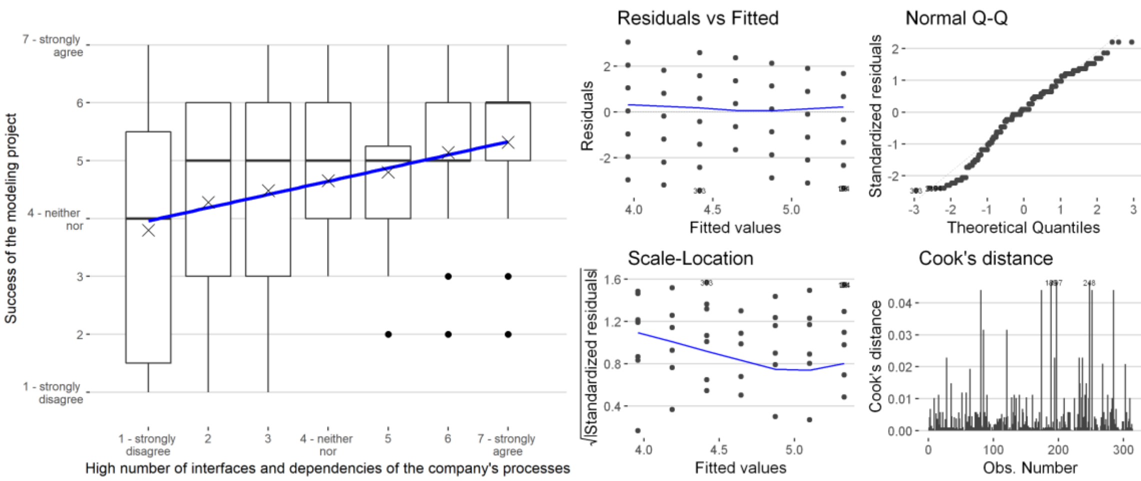

Figure 52: Complexity as significant factor for the success of a modeling project.

Consequently, we can conclude that there is a linear relationship between the predictor variable and the dependent variable that is statistically significant. With an *estimate* of *0.22813*, the success of the modeling project increases by the value of the estimate as soon as the company's number of interfaces and dependencies increases. That is, assuming a mean of *3.8* for a process modeling project to be successful without any complex dependencies between the company's processes (leftmost value on the x-axis in Figure 52a), the success of the project rises by the value of the estimate to *4.02813* when the complexity of the company's processes increases and, thus, move rightwards on the x-axis to the score 2. The residuals in Figure 52b indicate that the regression worked well for our data. We can justify the deviations in the scale-location by the outliers that are included to Figure 52a as black dots. The density plot in Figure 53 shows the correlation of the project's success and the internal structures' complexity.

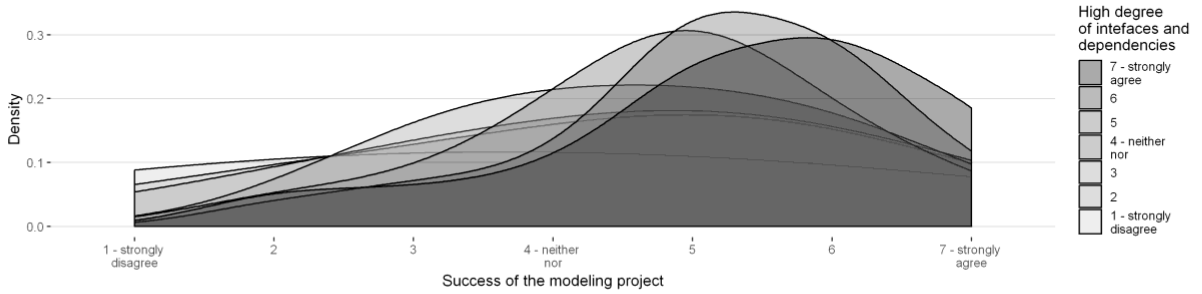

Figure 53: Density plot showing the dependency of a project's success on the complexity of processes.

At first, this result is counter-intuitive as it rejects our hypothesis since the correlation is positive. Yet, it can be rationalized by the fact that if projects are known to be complex, companies invest more into the project to be prepared. Hence, complexity is a factor in project success as it is significantly and positively correlated. However, we cannot assume a causal relationship with project success, i.e. the more complex the project, the more successful the project.

4.3 Hypothesis Testing Using Multiple Linear Regression

Now that we have tested the independent variables for their impact on the success of a modeling project by using simple linear regression (cf. Section 4.2), this section applies multiple linear regression which allows us to model the relationship between multiple explanatory variables. In the sections above, we already identified the independent variables with the greatest explanatory power to the dependent variable (cf. Section 4.1) and implemented further statistical tests that proved each independent variable to have significant impact on the success of a process modeling project (cf. Section 4.2). On the one hand, these results emphasize that companies are well advised to achieve highest possible ratings for each independent variable. On the other hand, however, it is very likely that only few companies can achieve these demands due to constraints in resources or budget. Therefore, this section provides some supplementary content on how certain groups of the aforementioned independent variables affect the success of a process modeling project.

To this end, we first ran a multiple linear regression including all variables that proved to be significant to the dependent variable based on their scores from simple linear regression (cf. Section 4.2). As the linear regression proved the process modeler's experience in BPM to have no significant influence on the success of a process modeling project, we excluded the variable *ExperienceBPM* from the multiple regression. In addition, we excluded the variable

ExperiencePMScale and limited the multiple regression model to the more significant variable *ExperiencePMYears*. Table 3 provides an overview of the variables that we included to our analysis in the column *variable name*. We further provide the results from running multiple linear regression to Table 3. We include their *significance*, *p-value*, and *estimate*. It is noticeable, that the variable's p-values are indicating different significance scores as calculated in Section 4.2. This is due to the fact that this section's model examines multiple variables at the same time and computes their relative impact on a project's success, whereas simple linear regression (cf. Section 4.2) examines the impact of only one independent variable to explain the dependent variable's change at a time.

Table 3: Multiple linear regression on statistically significant variables.

Variable name	Estimate	p-value	Significance
ExperiencePMYears	0.09816	0.016029	*
CommunicationGoals	0.17088	0.000311	***
TopManagementSupport	0.13515	1.03E-03	**
ImportancePMProject	0.34087	2.54E-11	***
ComplianceConventions	0.0794	0.009817	**
Usability	0.083	0.022969	*
ProcessOrientation	0.07963	0.035235	*
Complexity	-0.07514	0.034885	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9271 on 305 degrees of freedom; Multiple R-squared: 0.6012, Adjusted R-squared: 0.5907, F-statistic: 57.48 on 8 and 305 DF, p-value: < 2.2e-16

Looking at the different significance scores in Table 3, we can observe that the importance of a process modeling project has the greatest impact on its success, while compliance with conventions and the respective process modeler(s) experience shows only little impact. Additionally, the evaluation shows that the complexity, i.e. a company's number of process-related interfaces and dependencies, has a negative impact on the success of a process modeling project. While this variable's impact was positive when considered in isolation, multiple linear regression reveals that this variable can jeopardize a modeling project's success.

Practical example. Let us assume a company does not care about any of the abovementioned variables. In this case, we can assume that the survey was answered with the worst possible answer scores (1) for all significant variables included to Table 3. In fact, querying our data reveals 4 participants who responded accordingly. As expected, the respondents also strongly disagreed with the process modeling project's success. Assuming a mean of *1* for a process modeling project to be successful without any support of the abovementioned variables, we can increase its success most by *communicating its importance* among stakeholders. Exemplarily, increasing the importance of the project by one point on the variable's scale (cf. Table 2 in Section 4.1), the *success* of the modeling project would *increase* by the variable's *estimate* to *1.34087*. The same applies to all other variables. However, since there is a negative impact caused by the variable *complexity*, an increasing number of process-related interfaces and dependencies would *reduce* the probability of the process modeling project to be successful by the variable's estimate.

Concluding remarks. Figure 54 concludes this Section by providing a heatmap summarizing the variables individual impacts on a process modeling project's success (a), as well as insights into measures determining the statistical reliability of the multiple linear regression model (b) computed above. The heatmap's axes include the names of the variables that we observed (x-axis), their response options (y-axis) and a legend, which uses colors to inform about the impact of a single variable on the success of a process modeling project based on our empirical observations.

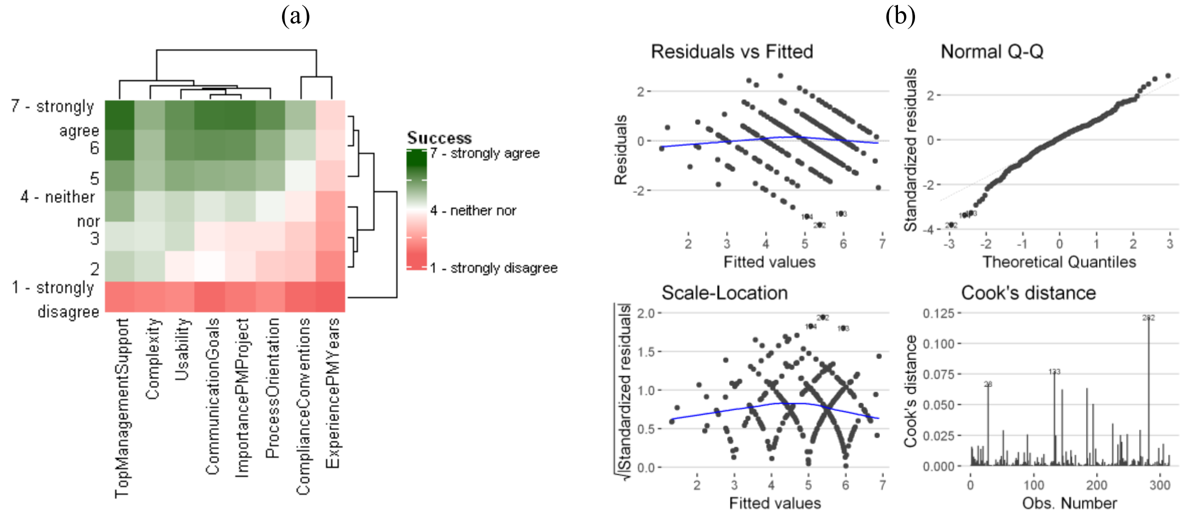

Figure 54: Heatmap (left) and residuals plot (right) for multiple linear regression.

4.4 Dimensionality Reduction Using Factor Analysis

We conclude this report's analysis with some summarizing multiple linear regression models that are ran on groups of variables. We do this, since companies rarely have the resources or the dedication to engage with more than a few variables mentioned in the previous Sections at a time. To this end, we engage exploratory factor analysis (EFA), which allows us to determine the variability among observed variables. In doing so, we can identify a reduced set of factors that mainly reflect the variable's observations. Seeking to identify the ideal number of factors, we rely on the work of Ruscio and Roche (2012) who recommend to compare the variable's eigenvalues. We found a total of two factors to be appropriate for representing the variations in the data. However, we decided to use four factors, as this amount still represents a valid number of factors according to the requirements determined by Ruscio and Roche (2012) and is more compatible with our data. By aggregating the variables to four factors, we seek to provide companies with a decision support on which variables they could initially focus to kickstart optimization efforts quickly. For this purpose, we considered the initially suggested two factors to be too general. According to Shaw and Ke (2005), the minimum sample size that is required for achieving excellent-level criterion for four factors is 110 to 180. With a sample size of 314, we exceed this amount by far. Table 4 shows the factors that we identified by deploying EFA in its first column, while the second column includes the variables assigned to the respective factors. Since the factors represent unobserved latent variables, their names are fictional. However, we endeavored to derive their names from the meaning inherent to the variables included to each factor. The remainder of Table 4 refers to the results of multiple linear regression. Each multiple linear regression model examines the joint variations of each factor (*factor group*) and, thus, runs on the variables that EFA identified as related to each other (*variables included*). Consequently, estimate, p-value, and significance score are only valid under the assumption that the factor's variables are considered as mutually interfering each other.

Table 4: Multiple linear regression on groups of statistically significant variables.

Factor Group	Variables included	Name of factor	Estimate	p-value	Significance
2	ExperiencePMYears	Experience			
1	CommunicationGoals	Management-support	0.27225	2.96e-09	***
1	TopManagementSupport		0.16019	0.000184	***
1	ImportancePMProject		0.36563	4.32e-13	***
4	ComplianceConventions	Usability	0.20083	2.60e-07	***
4	Usability		0.30410	1.11e-11	***
3	ProcessOrientation	Process-orientation	0.38209	<2e-16	***
3	Complexity		0.03902	0.393	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9271 on 305 degrees of freedom, Multiple R-squared: 0.6012, Adjusted R-squared: 0.5907, F-statistic: 57.48 on 8 and 305 DF, p-value: < 2.2e-16

We exclude the factor *experience* from this analysis as it does not include multiple variables. For further insights on this variable's significance and its impact on a modeling project's success, refer to the variable's simple linear regression in Section 4.2.

4.5 Analysis of Factors Using Multiple Linear Regression

This Section provides insights on how the individual factor groups introduced in Section 4.4. affect the success of a process modeling project. To this end, we conduct multiple linear regression on each factor group. We visualize the model's results using scatter plots and heatmaps. In doing so, we want to provide decision support for companies that do not have the resources to engage with more than a handful of variables at a time.

4.5.1 Impact of Management Support on the Success of a Process Modeling Project

This factor group contains the variables *CommunicationGoals, TopManagementSupport,* and *ImportancePMProject* (cf. Table 1 for further details). As summarized in Table 4, the multiple regression model reveals that each variable shows significant impact on the success of a modeling project. The variable *ImportancePMProject* shows the strongest impact on a process modeling project's success yielding an estimate of 0.36563 with a p-value of 4.32E-13. In the following, we visualize the linear dependencies of the variables involved using a three-dimensional scatter plot. Although we ran multiple regression based on all three explanatory variables mentioned above, we are not able to include these variables into one single plot. Thus, we provide scatter plots for each possible combination of those variables. The scatter plot further visualizes the regression line as a surface.

The following labeling applies to all 3D scatter plot's labeling for their axes and legend: *1 – strongly disagree, 2, 3, 4 – neither agree nor disagree, 5, 6, 7 – strongly agree*

Figure 55a portrays the linear dependency of the two explanatory variables *CommunicationGoals* and *ImportancePMProject*, evaluated according to their impact on the *success* of a project. Additionally, Figure 55b shows the regression's coefficients indicating that the regression worked well for our data.

(a) (b)

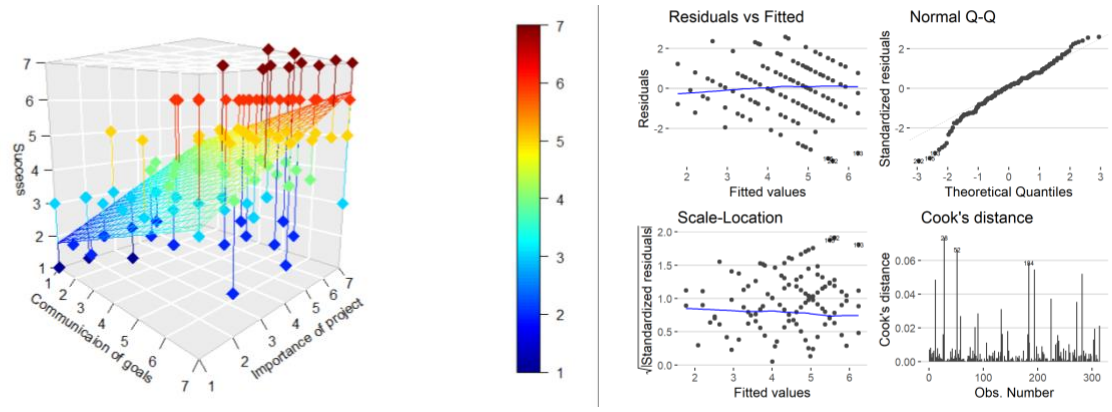

Figure 55: Scatter plot (left) and residuals plot for multiple linear regression (right).

Finally, Figure 56 draws a heatmap including the distinct data points that represent the respondents' assessments. Based on this figure, one can learn about possible outliers and quickly overview the distribution of the data.

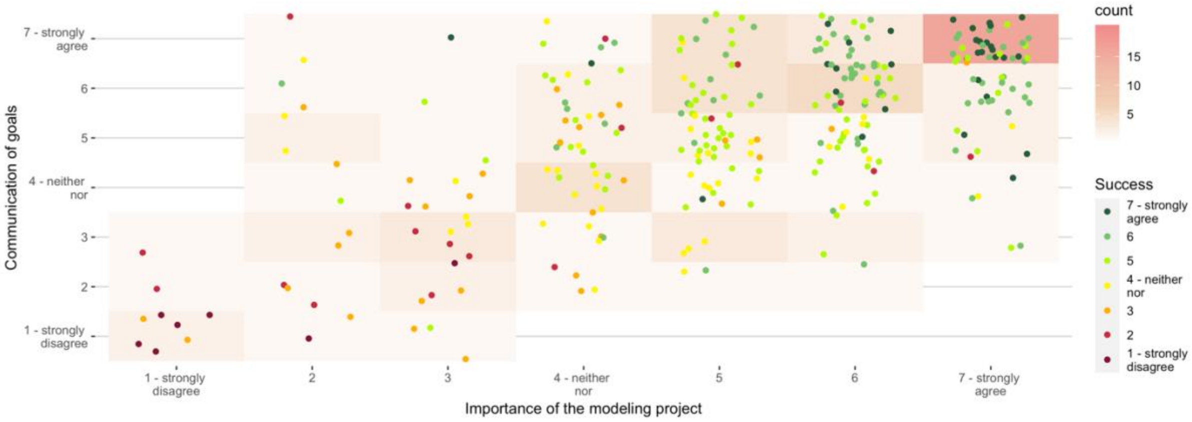

Figure 56: Heatmap plotting the data points for importance of a modeling project, communication of goals, and respective success of the overall project.

Figure 57a illustrates the linear dependency of the two explanatory variables *CommunicationGoals* and *TopManagementSupport* (cf. Table 1 for further details), evaluated according to their impact on the success of the overall project. In addition, Figure 57b shows the regression's coefficients which show that the regression worked well for our data.

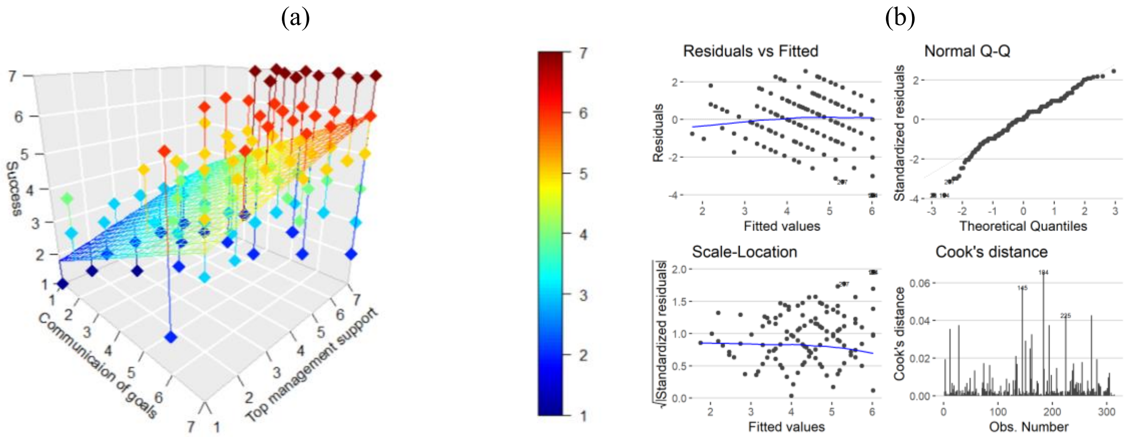

Figure 57: Scatter plot (left) and residuals plot for multiple linear regression (right).

Figure 58 provides a heatmap including the distinct data points that represent the respondents' assessments. The abstract overview enables the reader to learn about possible outliers and to quickly overview the distribution of data points.

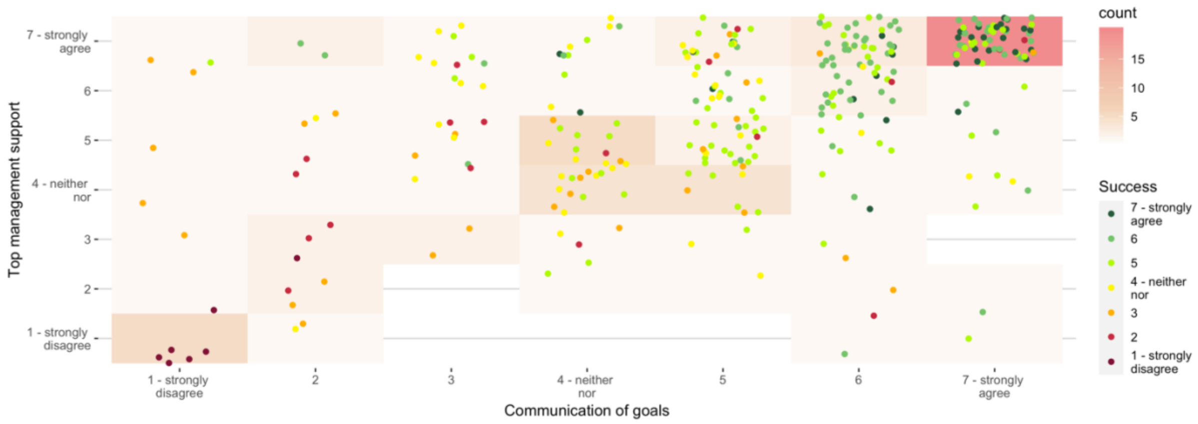

Figure 58: **Heatmap plotting the data points for communication of goals, top management support, and respective success of the overall project.**

Figure 59a illustrates the linear dependency of the two explanatory variables *ImportancePMProject* and *TopManagementSupport* (cf. Table 1 for further details). We use a scatter plot to illustrates the linear dependency of the two explanatory variables, evaluated against the variables' impact on the success of the overall modeling project. From the graphical representation, we can already see that there is a linear dependency between the variables that is statistically significant. However, we can also observe an outlier stating that one respondent reported about great project success (6) although there was virtually no communicated importance of the project and no support of management.

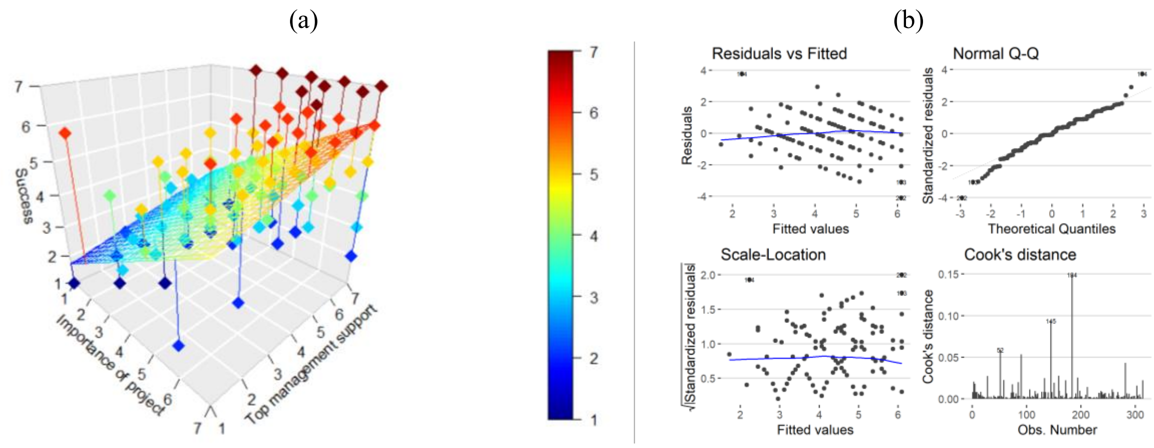

Figure 59: **Scatter plot (left) and residuals plot for multiple linear regression (right).**

Figure 59b shows the regression's coefficients indicating that the regression worked well for our data. Ultimately, Figure 60 provides a heatmap including the variable's data points that represent the respondents' assessments.

Figure 60: Heatmap plotting the data points for importance of a modeling project, top management support, and respective success of the overall project.

4.5.2 Impact of Usability on the Success of a Process Modeling Project

The second factor group contains the variables *ComplianceConventions* and *Usability* (cf. Table 1 for further details). As summarized in Table 4, the multiple regression model's results indicate strong significances for each variable. The variable *Usability* shows the strongest impact on a process modeling project's success in this factor group. The multiple linear regression yields an estimate of 0.30410 with a p-value of 1,11E-11 for this variable. In the following, we visualize the linear dependencies of the involved variables using a three-dimensional scatter plot (cf. Figure 61a). The scatter plot further contains a regression plane seeking to virtualize the regression model's regression line as a surface.

(a) (b)

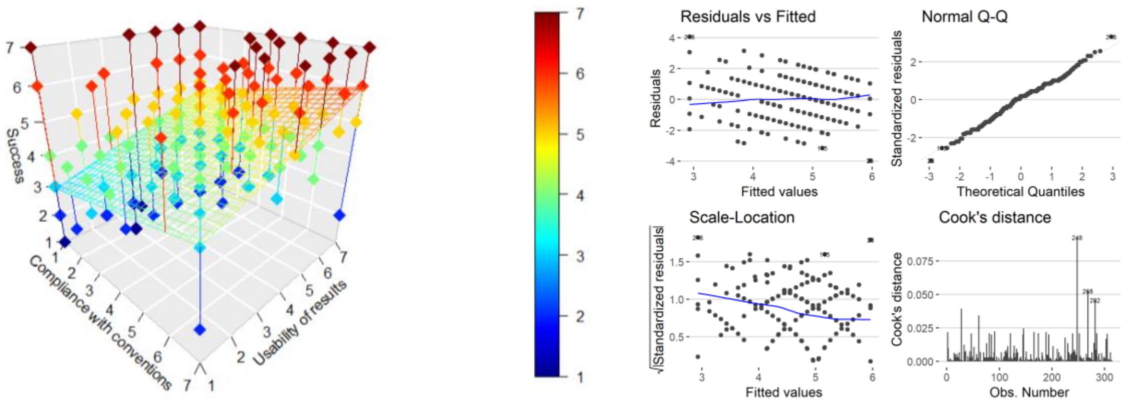

Figure 61: Scatter plot (left) and residuals plot for multiple linear regression (right).

Further, Figure 61b shows the regression's coefficients indicating that the regression worked well for our data. Finally, Figure 62 draws a heatmap including the distinct data points that represent the respondents' assessments.

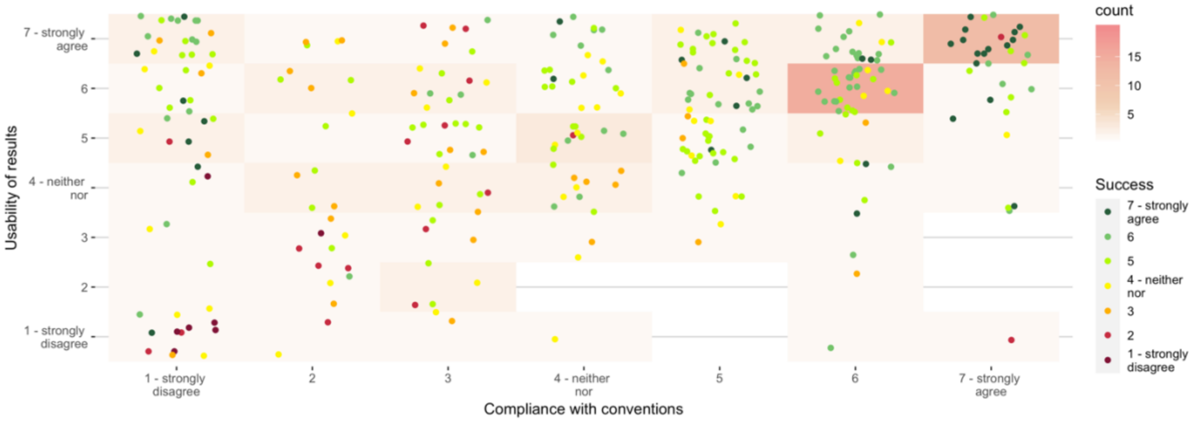

Figure 62: Heatmap plotting the data points for compliance with conventions, usability of results, and respective success of the overall project.

4.5.3 Impact of the Company's Degree of Process Orientation on the Success of a Process Modeling Project

This factor group contains the variables *ProcessOrientation* and *Complexity* (cf. Table 1 for further details). As summarized in Table 4, the multiple regression model's results indicate strong significances for the first variable. The variable *Complexity*, however, shows no significant impact on a process modeling project's success in this factor group. On the contrary, a high degree of process orientation can benefit the modeling project. The multiple linear regression yields an estimate of 0.38209 with a p-value of <2e-16 for this variable. In the following, we visualize the linear dependencies of the involved variables using a three-dimensional scatter plot (cf. Figure 63a). The scatter plot further contains a regression plane seeking to virtualize the model's regression line as a surface.

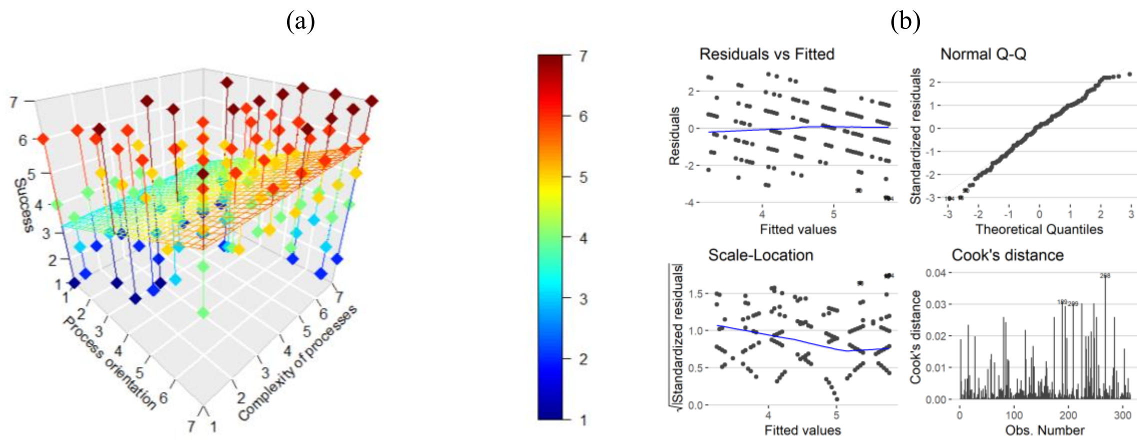

Figure 63: Scatter plot (left) and residuals plot for multiple linear regression (right).

Further, Figure 63b shows the regression's coefficients indicating that the regression worked well for our data. Finally, Figure 64 draws a heatmap including the distinct data points that represent the respondents' assessments.

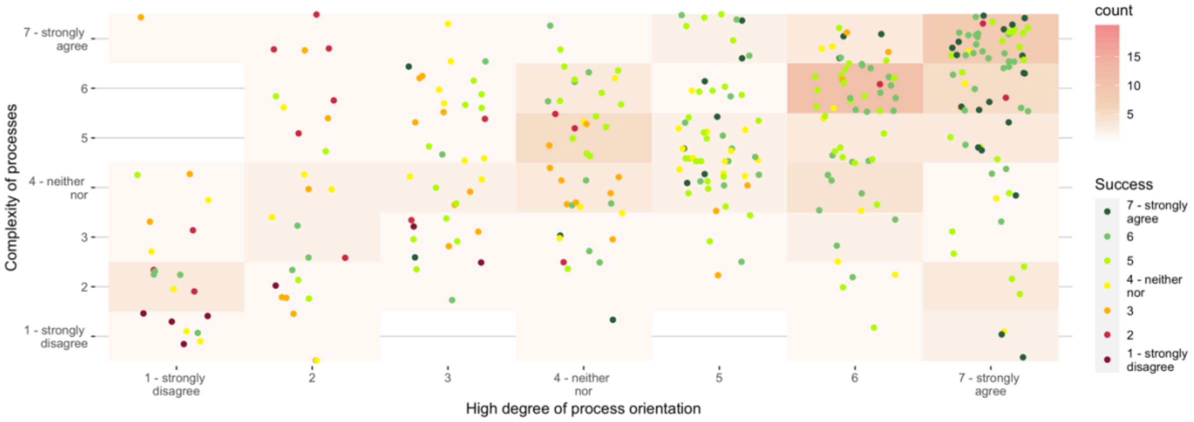

Figure 64: Heatmap plotting the data points for degree of process orientation, complexity of processes, and respective success of the overall project.

5 Management Summary

With this report, we gave an overview of current success factors of process modeling in practice. We conducted this survey between July 2nd and September 6th, 2017 and gathered a total of 314 responses. Respondents were acquired per email and the participating companies stem from various industries and sizes. Asking a total of 42 questions, we were able to extract 42 variables that underlay this report's extensive analysis. To not (further) overstrain the complexity of this report, we limited our evaluations to eight variables after we presented the current implementation of BPM and process modeling in practice relying on descriptive statistics. We divided the descriptive evaluations to an organizational perspective, a methodical and technological perspective, and a cultural perspective. Focusing on the organizational perspective, we found that quite a large amount of companies is not yet implementing best practice recommendations that we know from established literature (Becker et al. 2013; Becker et al. 2000; Kohlborn et al. 2014; Mendling et al. 2010; Trkman 2010). Exemplarily, the majority of companies surveyed did not yet implement a central responsibility that supervises and tracks process management or process modeling activities. Additionally, despite its proven usefulness, only roughly half of the respondents report that their companies frequently use modeling conventions. Even less do control if process modelers actually comply with present conventions. From a methodological and technological point of view, it was particularly noticeable that most companies still use flow charts to represent business processes. Albeit flow charts might be supplementing to other notations as we allowed multiple answers on the choice of modeling standards, the number of companies using the very basic notation is considerably high. Further, this the report revealed that less than 50 % of companies provide their employees with access to a centrally available modeling software or platform. In addition, roughly half of the companies that use software do integrate it into their IT infrastructure. The cultural perspective revealed that companies hardly offer any training courses to build process modeling skills. This was only true for about 41 % of companies surveyed.

Beyond descriptive analysis, we conducted several statistical analyses aiming to achieve factors with a significant impact on the success of a process modeling project. Based on a stepwise regression analysis, the survey data revealed 8 out of 42 variables to have a significant influence on a process modeling project's success. These variables summarize *years of process modeling experience, BPM experience*, the *clear communication of goals*, *the availability top management support*, *the importance of the project*, *the compliance to conventions*, *the result's usability*, *the degree of process orientation of the company*, and *process complexity*. Refer to Table 1 in Section 4.1 for further information on the variables. Using simple linear regression, we could verify the significance of each variable except *BPM experience* and *process complexity*, where the hypothesis had to be rejected. Besides simple linear regression, we also ran a multiple linear regression model to scrutinize the relationship between the explanatory variables. The model evaluating the variables mutual dependencies showed that the *importance of a process modeling project* has the strongest impact on the success of a process modeling project. While simple linear regression first revealed a unexpected positive estimate for the *complexity* of a company's processes, this variable's impact turns negative for the summarized consideration. Eventually, dimensionality reduction serves to identify a smaller group of latent variables that still have explanatory power for its included variables. Relying on explanatory factor analysis, we were able to define four distinct factor groups – *experience, management support, usability & process orientation* – that respectively included one, two, or three variables, each of which was previously already identified as significant to the success of a process modeling project. To determine the factor groups' impact on the success of a process modeling project, we conducted multiple linear regression models with the variables inherent to them (cf. Table 4). In doing so, we provide decision support for companies that have limited resources or budget and, thus, are must naturally limit a modeling project's optimization to a smaller subset of variables.

Particularly the descriptive part of this report shows some shortcomings of current procedures towards the implementation of process modeling projects in practice that can lead to inconvenient project outcomes. In this respect, we suggest that research must catch up with reports on possible success factors in process modeling and not only focus on syntactic and semantic guidance by providing respective best practice solutions and recommendations. In contrast, comprehensive and, above all, practically applicable recommendations must be given to enable companies to fundament their process modeling projects on a sound organizational as well as technological infrastructure, while simultaneously being provided with methodical and systematic approaches that yield project success. Besides general implications, we encourage research to engage on providing contextual recommendations similar to Fischer et al. (2019) that allow companies to get more detailed recommendations based on their individual contexts.

Eventually, we emphasize the need for further reports that reveal the status quo in practice. As we can observe in this report, the generality of companies is far from doing process modeling in an extent that research would perceive as best practice. We must therefore conduct further quantitative and qualitative research on the topic to shed light on existing grievances, drawing attention on them, and finally provide adequate and practice-oriented guidance.

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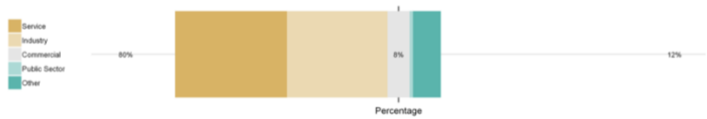
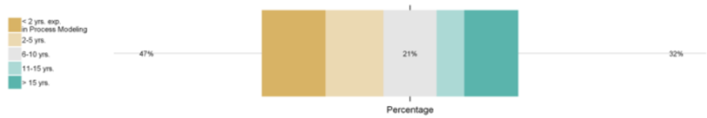
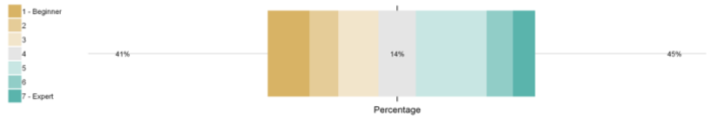
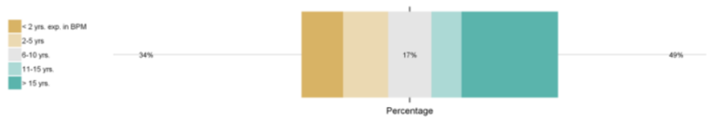
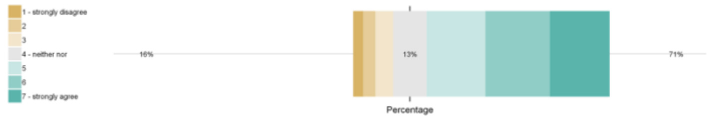
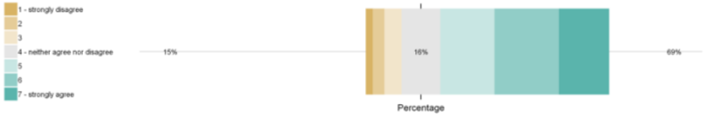
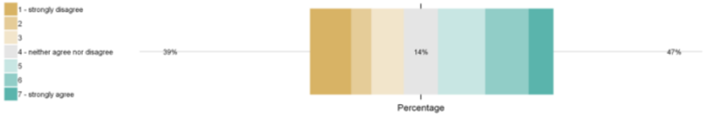
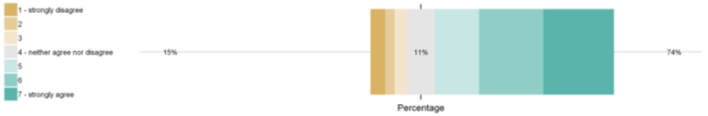
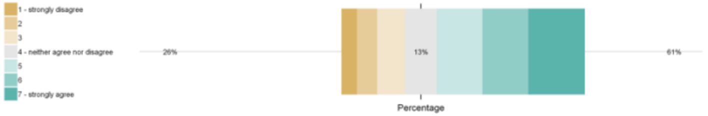
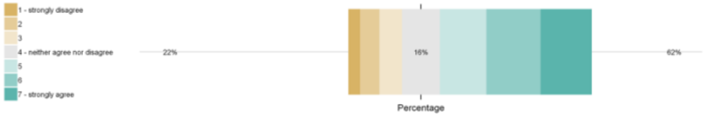
Appendix

Table 5: Predictive variables including description, likert plot, and mean.

Variable name	Description	Response options	Likert plot	Mean
Sector	Sector of the surveyed company. (cf. Section 2.2)	- Service - Industry - Commercial (- Public) - Other		/
ExperiencePM Years	Years of experience in process modeling. (cf. Section 2.3)	- less than 2 years - 2 to 5 years - 6 to 10 years - 11 to 15 years - more than 15 years		2.8
ExperiencePM Scale	Years of experience as a process modeler from beginner to expert. (cf. Section 2.3)	- 1 – Beginner - 2 … 6 - 7 – Expert		3.9
Experience BPM	Years of experience in business process management. (cf. Section 2.3)	- less than 2 years - 2 to 5 years - 6 to 10 years - 11 to 15 years - more than 15 years		3.4
Communication Goals	Communication of the modeling project's objective by management. (cf. Section 3.2.2)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		5.1
TopManagement Support	Top management actively supported the modeling project. (cf. Section 3.1)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		5.7

ImportancePM Project	The modeling project was of great importance for the respondent's company. (cf. Section 3.3)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		5.1
Compliance Conventions	Guidelines and conventions were complied with during modeling. (cf. Section 3.1)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		4.1
Usability	The clarity and comprehensibility of the results of the modeling project was a factor. (cf. Section 3.3)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		5.3
ProcessOrientation	The company you work for is process-oriented. (cf. Section 3.1)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		4.8
Complexity	Number of interfaces and dependencies of the company's processes (cf. Section 3.3)	- 1 – strongly disagree - 2 … 6 - 7 – strongly agree		4.9