Leveraging Big Data for M&A: Towards Designing Process Mining Analyses for Process Assessment in IT Due Diligence

Completed Research Paper

Introduction

In a world of rapid organizational and technological change, mergers and acquisitions (M&A) is an important strategy to ensure competitiveness. 2021 has been a record year for M&A, with the global volume reaching $5.1 trillion (PwC, 2022). But while the global M&A volume is rising, studies also show that M&A transactions are prone to high failure rates of 80% (Cartwright, 2013) in terms of meeting the expected financial goals and creating lasting value. This illustrates that many M&A transactions fail to realize the expected benefits, such as increasing efficiencies in scale and scope, acquiring external knowledge, and providing new product offerings (Berens, Mertes, et al., 2013).

One reason for frequent M&A failure rates is the buying organization's incomplete assessment of the target organization (Boeh, 2011). Thus, due diligence (DD) is considered an approach to decrease this risk by allowing the buyer to analyze and understand the target's situation and value creation before closing the deal (Lucks & Meckl, 2015). In particular, in the last decade, information technology due diligence (IT DD) has gained importance and is seen as fundamental for M&A success (Lucks & Meckl, 2015). During IT DD, the buyer is focused on learning about the target's IT infrastructure regarding the associated value, future reliability, opportunities, and risks (Koch & Menke, 2013).

However, as IT is increasingly interwoven with organizational value-creation processes (van der Aalst, 2016), buyers need not only to understand the target's IT infrastructure but also the underlying IT-enabled business processes to ensure M&A success (Henningsson & Yetton, 2013; Wilting & Pernegger, 2019). In particular, research shows that the success of IT integration depends on a deep understanding of how the target's IT resources enable their business processes and what opportunities and liabilities are associated (Boland et al., 2013; Henningsson & Yetton, 2013). Conversely, an inadequate understanding of the target's IT-enabled business processes during IT DD can lead to inadequate process and IT harmonization and integration, thus, resulting in detrimental effects on post-merger performance (Schönreiter, 2018). Hence, understanding the target's IT-enabled business processes in structure, performance, and implications for synergies, integration, and standardization is critical for M&A success (Henningsson & Yetton, 2013; Henningsson et al., 2019).

However, assessing the target's IT-enabled business processes was traditionally not considered part of the IT DD and came only recently into the focus of research and practice (Wilting & Pernegger, 2019). Accordingly, research on IT DD gives limited guidance on how and based on what information sources the buyer can assess the value of the target's IT-enabled business processes. This practical problem is accompanied by calls for future research on how IT DD can incorporate new areas of investigation, such as business process digitalization, automation, and standardization (Turuk & Moric Milovanovic, 2020; Wilting & Pernegger, 2019). In addition, information sources traditionally employed during IT DD, such as organization manuals, documentation, and employee interviews (Berens, Hoffjan, et al., 2013; Wilting & Pernegger, 2019), are limited in their capacity to provide comprehensive information that reflects the target's IT-enabled business processes as they are executed in reality, thus, increasing the risk of incomplete, outdated, or unnecessary information (Harvey & Lusch, 1995; Wright & Altimas, 2015). Consequently, it remains unclear how the IT DD can operationalize and assess the target's IT-enabled business processes.

Process mining (PM) represents a promising approach for discovering, monitoring, and improving business processes by leveraging data that is already available in information systems (IS) and is increasingly used by organizations to reveal and understand their business processes (van der Aalst, 2016). To this end, PM not only allows for the in-depth analysis of processes in one organization but also for the cross-organizational, comparative analysis of similar processes in different organizations (van der Aalst et al., 2012). Consequently, by applying PM, organizations can learn about their own and another organization's processes as they are executed in reality (van der Aalst et al., 2012). Against this backdrop, we propose that PM might be a valuable approach to facilitate the assessment of IT-enabled business processes in the context of IT DD as it offers a data-driven, objective analysis of the target's processes while also enabling the comparative analysis of processes of the buy- and sell-side. Nevertheless, studies on the organizational use of PM have only recently emerged, and the technology has not been studied in the context of M&A and IT DD thus far. We, therefore, pose the research question: *How can process mining support the assessment of IT-enabled business processes in the context of IT DD?*

To address this research question, we follow a design science research approach (DSR) (Hevner, 2007). Drawing on literature and 12 expert interviews, we (1) reveal and operationalize the requirements for process assessment in the context of IT DD (i.e., assessing process flow and complexity, the relevance of the process, financial and customer-oriented impact of the process, process digitalization and automation, conformance of buyer's and target's process, and standardization of the buyer's process), (2) demonstrate the applicability of PM to measure the operationalized requirements by implementing PM artifacts based on real data, and (3) derive eight design principles and four enabling factors to guide the design, implementation, and use of PM for process assessment in the context of IT DD. As a result, our study contributes to research on M&A and IT DD and the organizational use of PM and provides practitioners with design knowledge and a prototypical PM artifact to leverage PM for process assessment in IT DD.

Related Work

IT Due Diligence (IT DD)

Inherent to M&A transactions is the initial information asymmetry between the organization intending to buy, that is, the buyer, and the organization intending to divest, that is, the target, since the target has greater knowledge about the organization of interest than the potential buyer (Boeh, 2011). Hence, *DD* aims to reduce this information asymmetry by allowing the buyer to review information about the target and decide how to proceed with the transaction (Boeh, 2011). The DD review encompasses financial information, legal status, operating model, asset and business valuation, environmental conditions, management, human resources, and IT (Harvey & Lusch, 1995; Lucks & Meckl, 2015). Since organizations' value-creation processes are increasingly interwoven with and enabled by IT, the IT DD has gained importance in the last decade as a success factor in M&A (Lucks & Meckl, 2015).

The *IT DD* refers to the buyer's analysis of the target's IT infrastructure in terms of associated value, future reliability, opportunities, and risks (Harvey & Lusch, 1995; Koch & Menke, 2013; Lucks & Meckl, 2015). As such, conducting IT DD serves primarily three goals, that is, (1) *risk and cost assessment*, (2) *benefit and synergy assessment*, and (3) *the development of integration scenarios*. First, the IT DD aims to estimate pre- and post-acquisition operating IT costs and the costs for the post-merger IT integration project (Koch & Menke, 2013). Some identified costs might be considered risks or deal breakers, resulting in aborting the deal (Koch & Menke, 2013). Besides financial risks, the target's IT function can impose operational, legal, compliance, and dependency risks (Henke & Boller, 2016). Second, the IT DD yields insights into risks and opportunities in terms of synergy and restructuring potentials that are either directly rooted in the target's IT, such as lower infrastructure costs, or enabled by IT, such as reduced logistics costs through optimization of shipment processes (Boland et al., 2013). Third, the IT DD lays the foundation for post-merger integration (PMI) by developing and assessing integration scenarios concerning integration depth and compatibility with the buyer's IT landscape (Lucks & Meckl, 2015). To this end, research has shown that developing IT integration scenarios is facilitated by a deep understanding of how the target's IT resources enable their business processes (Henningsson & Yetton, 2013).

Assessment of IT-Enabled Business Processes in the Context of IT DD

The assessment of the target's IT-enabled business processes (henceforth called *processes*) was traditionally not considered part of the IT DD (Wilting & Pernegger, 2019) until it became the focus of research and practice in recent years due to two reasons. First, organizational value-creation processes are inextricably interwoven with IT. Thus, the target's efficiency, scalability, and application of innovative digital process designs are becoming important factors to consider when assessing the value of a potential M&A transaction (Wilting & Pernegger, 2019). Second, understanding the target's processes is required for designing and evaluating IT integration scenarios (Koch & Menke, 2013) since the buyer has to decide on either *renewing*, *taking over* one side's, *standardizing* similar, or *preserving* both sides' IT and processes for the newly formed organization (Wijnhoven et al., 2006). Consequently, research indicates that depending on the chosen integration approach, the inadequate harmonization and integration of the buyer's and target's processes in the—often time-pressured—PMI phase can have detrimental effects on the post-merger performance (Schönreiter, 2018). Hence, understanding the target's processes in terms of their structure, performance, and implications for PMI, such as opportunities for synergies, integration, and standardization, is a critical success factor for M&A (Henningsson & Yetton, 2013).

Nevertheless, research on IT DD gives only limited guidance on process assessment. Only recently, the first studies point toward additional focus areas in IT DD to account for process assessment. In particular, research suggests investigating the continuous support of business processes through IT and the cross-functional integration, performance, automation, and standardization of processes (Turuk & Moric Milovanovic, 2020; Wilting & Pernegger, 2019). However, research in this area is sparse and fragmented, so we lack a systematic understanding of how to conduct process assessment in the context of IT DD and how to operationalize the assessment. This is exacerbated by the underlying lack of standardized key performance indicators (KPIs) to operationalize the goals of IT DD, such as synergies or risks (Boland et al., 2013; Koch & Menke, 2013).

In addition, it remains unclear what information sources the buyer can rely on to conduct the process assessment. Traditionally, IT DD draws, on the one hand, on documentation provided by the target, such as organization manuals, internal presentations, reports, and documentation of standard processes, and, on the other hand, on information acquired through personal exchange, such as employee interviews and observations (Berens, Hoffjan, et al., 2013; Wilting & Pernegger, 2019). However, both information sources are limited in providing objective, comprehensive information that reflects processes as they are executed in reality, thus, increasing the risk of incomplete, outdated, or unnecessary information (Harvey & Lusch, 1995; Wright & Altimas, 2015). In particular, business process management (BPM) research cautions about the limited value of manually crafted process documentation or personal insights to assess organizational processes since these tend to reflect idealized processes and experiences disconnected from reality (Kohlbacher & Gruenwald, 2011; van der Aalst, 2016).

In sum, assessing the target's processes and their implications on the PMI recently emerged as critical factors for buyers to consider during IT DD. However, the approach to and operationalization of process assessment in the context of IT DD remains unclear. In addition, traditional approaches to IT DD are limited in the comprehensiveness of their results. Against this backdrop, scholars from the IT DD field have called for exploring novel approaches to support IT DD and, in particular, process assessment (Wilting & Pernegger, 2019). To this end, a promising approach might emerge from the field of process analytics.

Process Mining (PM)

PM is a relatively young big data analytics technology aimed at discovering, monitoring, and improving business processes by leveraging data that are already available in organizations' IS (van der Aalst, 2016). It is rooted in machine learning and data mining on the one hand and process modeling and analysis on the other hand. Building on these disciplines, PM allows for not only a KPI-oriented view of organizations but also a process-oriented method of evaluating and advancing organizations by establishing a link between real processes and process models (van der Aalst, 2016).

To this end, PM leverages the digital traces found in IS as every activity performed in the system is sequentially recorded in its databases as an event (van der Aalst et al., 2012). These events can be used to reconstruct *event logs* that represent the processes as they happen in the organization's IS in reality. Therefore, each event must relate to an activity, that is, a well-defined step in the process, and to a case, that is, a specific instance of the process, such as an order or invoice (van der Aalst, 2016). Moreover, any kind of additional information related to the cases can be logged and analyzed, for example, the user who executed an event or the cost associated with the process step (van der Aalst et al., 2012). Organizations can use these event logs to perform three basic types of PM. First, organizations can *discover* the actual flow of processes without having any knowledge of the processes beforehand. Second, organizations can *check the conformance* of actual processes with a desired process model. Third, they can *enhance* already existing process models to encompass characteristics of the discovered real process (van der Aalst, 2016).

Since PM only emerged in the mid-90s, research thus far has primarily focused on advancing the technological basis, such as improving the design of discovery algorithms and event logs (Thiede et al., 2018), while only recently the organizational use of PM came into focus (Badakhshan et al., 2022). In this light, studies have shown that PM is increasingly used by organizations across industries, such as public administration, production, and healthcare (Thiede et al., 2018), and for various processes, ranging from standardized sub-processes in accounting to customized end-to-end processes across the supply chain (Eggers et al., 2021). In addition, studies report on the implementation of PM for specific use cases, that is, applying PM to a specific process with specific goals, such as uncovering fraudulent activities in auditing (Jans et al., 2014) or measuring process performance in manufacturing (Lau et al., 2009). While the research focuses on single PM use cases in single organizations and provides deep insights into the structure and value of specific processes, scholars from the field of PM point toward the additional potential of PM to assess processes across organizations (van der Aalst et al., 2012).

This approach is referred to as *cross-organizational PM*. It allows for either the analysis of cross-organizational processes in a *collaborative setting*, that is, multiple organizations are involved in the same process, such as in a supply chain, or the analysis of cross-organizational processes in a *comparative setting*, that is, multiple organizations each perform (variations of) the same process such as administrative processes in multiple municipalities (van der Aalst et al., 2012). By applying PM in cross-organizational settings, organizations can compare processes, learn from one another, and identify variations, best practices, and root causes for weaknesses (van der Aalst et al., 2012). Despite the indisputable potential of cross-organizational PM, its application in research and practice remains scarce (Thiede et al., 2018), with a few notable exceptions comparing similar healthcare processes across hospitals (Partington et al., 2015) or analyzing cross-organizational production processes (Tönnissen & Teuteberg, 2019).

Method

Overall Research Approach

Our study was motivated by the observation that even though buyers in the context of M&A transactions need to assess the target's (IT-enabled) processes to account for the ever-increasing importance of digitalized operations, the IT DD as the pre-deal analysis of the target's IT infrastructure does not account for assessing the target's (IT-enabled) processes. As the assessment of processes only recently came into the focus of IT DD, research lacks insights on how to operationalize and conduct the process assessment. Addressing this shortcoming, our study employs DSR to ensure practical relevance and scientific rigor (Hevner, 2007) while developing a novel, useful *IT artifact* based on PM for supporting the process assessment in IT DD and *design knowledge* to guide the artifact's construction by specifying the relationship between the problem and solution space (Baskerville et al., 2018). Thus, our study follows one of the core principles of IS research, which is to generate knowledge about how the application of IT can address organizational problems (Hevner et al., 2004).

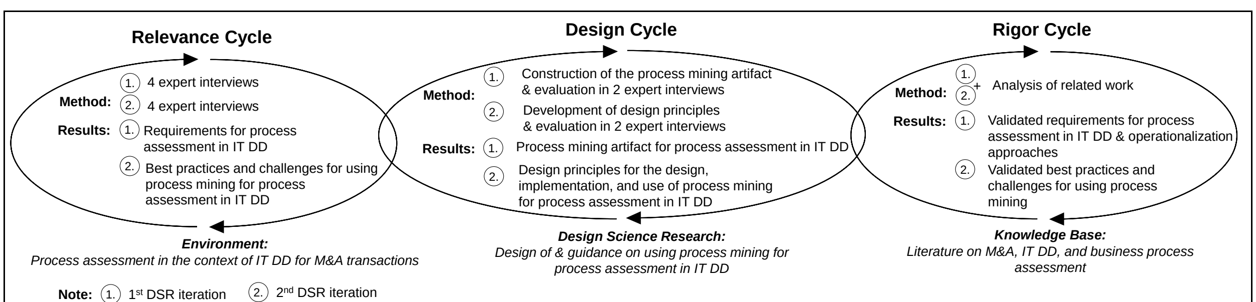

Figure 1. DSR research approach (own representation based on Löhe and Legner (2014) and Hevner (2007))

To this end, we iteratively follow the three cycles of design DSR (see Figure 1), that is, the *relevance cycle* to connect our study with real-world problems, i.e., process assessment in the context of IT DD, the *rigor cycle* to incorporate the existing knowledge base, i.e., knowledge on IT DD and techniques for process assessment, and the *design cycle* to develop and evaluate our IT artifact and the corresponding design knowledge (Hevner, 2007). We conducted two iterations of all three cycles. In the first iteration, we focused on designing PM analyses for process assessment in IT DD based on an in-depth understanding of the underlying requirements from literature and practice. In the second iteration, we focused on deriving design principles to guide the design and use of PM for process assessment in IT DD.

First DSR Iteration

The first DSR iteration focused on designing PM analyses to support process assessment in the context of IT DD. To this end, as there is only scant knowledge about process assessment in IT DD in the literature, we started the first DSR iteration with the *relevance cycle* to develop an in-depth understanding of the requirements. As expert interviews are an established method to analyze problems in DSR (Österle et al., 2011), we conducted four semi-structured interviews (Myers & Newman, 2007) with experts from the field of IT DD who had each conducted between five and 30 IT DDs in their careers (see Table 1 for an overview of all interviews conducted in the DSR). The interviews mainly focused on the interviewees' experience in IT DD, what information sources and tools they rely on to perform IT DD, how they currently approach the analysis of the target's processes in the context of IT DD, what challenges they experience, and how they wished to be supported. The interviews were conducted by phone due to geographical restrictions on the interviewees' side and in German, the native language of the interviewees, but we translated quotes into English for the purpose of this article. After transcribing the 263 minutes of taped interviews, we analyzed the qualitative data based on an inductive coding approach (Gioia et al., 2013) to understand the requirements for process assessment in IT DD. Throughout the analysis procedure, by relating similar codes to establish concepts (Gioia et al., 2013), six requirements emerged, that is, understanding the target's *process flow and complexity*, the *relevance of the process*, *financial and customer-oriented impact* of the process, *digitalization and automation* of the process, *conformance* between the buyer's and target's process, and *standardization* of the buyer's process.

Next, we initiated the *rigor cycle* to validate the identified requirements for process assessment in IT DD grounded in literature. In addition to related work from the field of M&A and IT DD, we also accounted for books and grey literature from practitioners in the domain of M&A and IT DD to comprehensively understand the requirements for process assessment. The literature analysis confirmed the requirements identified in the relevance cycle; for example, the literature showed that the assessment of process complexity in terms of variety and duration should be acknowledged in IT DD (Wright & Altimas, 2015), which relates to the requirement of understanding the target's process flow and complexity expressed by the experts, or that the comparison of the target's and buyer's processes facilitates IT DD (Koch & Menke, 2013), which relates to the requirement of understanding conformance between the buyer's and target's processes expressed by the experts.

Building on the validated requirements for process assessment in IT DD, we then engaged with literature on business process assessment to operationalize the requirements. While there is a lack of guidance on operationalizing process assessment in IT DD, the field of BPM has long studied how to measure business processes (Leyer et al., 2015). To this end, business process measurement is concerned with "*the continuous observation of predetermined performance indicators for the purpose of attaining process targets*" (Leyer et al., 2015, p. 227). Importantly, process performance is a multi-dimensional construct that requires the integration of different performance indicators (Leyer et al., 2015). Acknowledging the need for multi-dimensional measurement and the fragmented landscape of process performance indicators, we drew on the most recent literature review by van Looy and Shafagatova (2016). This study synthesizes the current body of knowledge on process performance indicators by operationalizing and categorizing them based on the Balanced Scorecard (BSC) (Kaplan & Norton, 1996) as a well-established approach to organizational performance measurement that considers the dimensions of *financial*, *customer*, and *internal business process* performance, and performance related to *learning and growth*. Drawing on the framework of operationalized process performance indicators (van Looy & Shafagatova, 2016), we then operationalized the identified requirements for process assessment in IT DD.

First, we selected and, if necessary, adapted process performance indicators from the framework corresponding to the identified requirements, such as the indicator *on time delivery rate* to operationalize the performance of customer-centric processes or *conformance to specifications* to operationalize the degree of process standardization. During the procedure, it emerged that the identified requirements and selected indicators correspond to the dimensions of process performance proposed by the framework (van Looy & Shafagatova, 2016), allowing us to structure the requirements and indicators. In particular, the *flow* and *relevance* of the process are reflected in the internal process performance, the *financial and customer-oriented impact* of processes is reflected in the financial and customer performance, and the *digitalization, automation, and scalability* of the process are reflected in the learning and growth performance. In addition, since the dimensions primarily focus on process performance, we inductively identified the need for a further dimension in IT DD that does not measure process performance but *conformance*, reflecting the conformance of similar processes at the buyer and target. The comprehensive list of operationalized requirements for process assessment in IT DD is presented in the first results chapter.

Last, we engaged in the *design cycle* to design PM analyses that meet the requirements for process assessment in IT DD identified in the relevance cycle and based on the operationalization derived in the rigor cycle. We implemented the analyses employing real process data from four organizations using the Celonis PM software. The second results chapter presents details on the data and the analyses. Concluding the design cycle, we conducted evaluation interviews with two experts that lasted 169 minutes. The interviews encompassed a presentation of the implemented PM analyses and expert feedback regarding efficacy, quality, and utility (Hevner et al., 2004). From the qualitative analysis of the interviews emerged the need for additional process performance indicators, in particular, *financial volume affected by late* deliveries and *invoices,* to indicate process impact on the target's working capital as a relevant factor of M&A deal negotiation.

Interviewee	Role	Experience	Duration	DSR Iteration
Expert A	Senior Consultant Transaction Advisory	15 IT DDs	90 mins.	1st
Expert B	Senior Manager Transaction Advisory	30 IT DDs	90 mins.	1st
Expert C	Partner and Director of IT Audits	5 IT DDs	41 mins.	1st
Expert D	Senior Manager Transaction Advisory	20 IT DDs	42 mins.	1st
Expert E	Consultant IT M&A	5 IT DDs	59 mins.	2nd
Expert F	Consultant Transaction Advisory	20 IT DDs	45 mins.	2nd
Expert G	Director of IT Consulting	>100 IT DDs	62 mins.	2nd
Expert H	Senior Manager Technology M&A	>80 IT DDs	60 mins.	2nd
Expert A	Senior Consultant Transaction Advisory	15 IT DDs	85 mins.	1st (evaluation)
Expert B	Senior Manager Transaction Advisory	30 IT DDs	84 mins.	1st (evaluation)
Expert E	Consultant IT M&A	5 IT DDs	36 mins.	2nd (evaluation)
Expert I	Process Mining Specialist	>25 PM impl. projects	42 mins.	2nd (evaluation)

Table 1. Overview of the expert interviews conducted in the DSR approach

Second DSR Iteration

The second DSR iteration focused on deriving design principles (Gregor et al., 2020) to guide the design and use of PM for process assessment in IT DD. We started with the *relevance cycle* by conducting additional six semi-structured interviews (Myers & Newman, 2007) with experts from the field of IT DD who had conducted between five and over 100 IT DDs in their careers. The interviews focused on the interviewees' experience in IT DD, their experience with using PM or other BDA techniques in the context of IT DD, and potential challenges and best practices when designing, implementing, and using PM for IT DD. If the interviewees were inexperienced with PM, we presented them with the implemented analyses from the first DSR iteration. Again, the interviews were conducted via phone and in German, with quotes being translated for this article. After transcribing the 226 minutes of taped interviews, we analyzed the qualitative data based on an inductive coding approach (Gioia et al., 2013) to reveal best practices and guidelines for leveraging PM for process assessment in IT DD. Four enabling factors emerged from the analysis: *establishing pre-deal exclusiveness*, *prioritizing processes*, *jointly evaluating analyses*, and *accounting for synergies with other DD streams*. In addition, the experts emphasized the importance of designing *cross-organizational PM analyses* where possible and ensuring *data access* at the target.

We then initiated the *rigor cycle* to validate and complement the best practices identified in the relevance cycle. Since no prior research reports on the use of PM for IT DD, we relied on related literature about the organizational use of PM to identify principles for PM implementation. In particular, the analysis revealed the importance of *data anonymization* for PM in sensitive settings, such as the pre-deal M&A phase, and the need for *merging process data* for performing cross-organizational PM analyses.

In the *design cycle*, iterating between the results from the rigor and relevance cycles and informed by the operationalized and implemented PM analyses from the first DSR iteration, we synthesized the emerging knowledge in eight design principles (Gregor et al., 2020) and four enabling factors to guide the design and use of PM for process assessment in IT DD. We evaluated the resulting design knowledge in two additional interviews with IT DD and PM experts. The third results chapter presents the final results.

Results

Operationalization of Process Assessment in IT DD

In the first cycle of our DSR approach, we inductively synthesized and operationalized buyers' requirements for assessing the target's processes in IT DD based on insights from related work and expert interviews (see Figure 2). The operationalized requirements then served for the first design cycle, which yielded the prototypical implementation of PM analyses for IT DD. We briefly outline the identified requirements and their operationalization in the following.

Dimensions of Process Assessment	Process Assessment Indicators*	Requirements for Process Assessement in the Context of IT DD*
Internal Process Performance (van Looy & Shafagatova, 2016)	Process model incl. process variants Number of cases in the system Average process cycle time	• „[…] how is the **process supported by the systems**?“ (Expert A) • **Complexity** of the target's processes in terms of variety and duration (Wright & Altimas 2015)
	Number of process users Average number of users per day Manual users per case Cases per manual user	• „[…] **how many users** are regularly using the systems? That is relevant for licensing.“ (Expert C) • **Relevance** of the target's systems in terms of their use (Koch & Menke 2013)
Financial & Customer Performance (van Looy & Shafagatova, 2016)	Financial volume processed On time delivery rate Invoicing cycle time Financial volume affected by late deliveries Financial volume affected by late invoicing	• Identification of the target's key processes based on **financial volume** (Wright & Altimas (2015) • „[…] we want to see how the target's process is creating **value** and **satisfaction for the customer**“ (Expert B) • Performance of the target's **customer-centric** processes (Andriole 2007)
Learning & Growth Performance (van Looy & Shafagatova, 2016)	Overall automation rate Automation rate per activity Overall manual change rate Overall change rate Overall rework rate	• „[…] we need a standardized way of measuring the target's rate of **process digitalization** and **automation**“ (Expert B) • Process automation and digitalization (Wilting & Pernegger 2019) • „[…] identify **best practices** to increase the the **efficiency** and production **volume** of the buyer“ (Expert C) • „[…] currently we don't have the information to assess **whether a process is automated in what system**“ (Expert B) • „[…] evaluating **how well the target's process steps are digitalized** is a core question of IT DD“ (Expert B)
Conformance (inductive)	Number of target-side cases conforming to buy-side processes Number of conformance violations of target- and buy-side processes Type of conformance violations of target- and buy-side processes	• „[…] understand the target's ERP system use in terms of **conformance with the buyer's processes**“ (Expert A) • **Comparison** of target and buyer's processes (Koch & Menke 2013) • „[…] identify the **faster, more efficient process** by comparing buyer and target“ (Expert C) • „[…] we want to analyze **synergies** due to cost savings that can be achieved by integrating the target's ERP or CRM systems into the buyer's" (Expert D)
	Number of buy-side cases conforming to standard process model Number of buy-side conformance violations with standard process model Type of conformance violations of buy-side processes and standard process model	• „[…] not every buyer has documentation of their own processes ready, so sometimes it might even be necessary to **conduct an "IT DD light" on the buyer's side**" (Expert D)

*based on van Looy & Shafagatova (2016) and inductively derived from the expert interviews

*inductively derived from the literature analysis and expert interviews

Figure 2. Framework of indicators for the assessment of IT-enabled business processes in the context of IT DD

During IT DD, the buyer intends to assess the target's process landscape to reveal potential process-related risks, opportunities, and synergies for the impending M&A deal. First, the buyer wants to understand the target's *process flow and complexity* regarding process variants and case volume, cycle times, and support by the underlying IT to develop a basic understanding of the target's process landscape. In addition, analyzing the process landscape should reveal the target's best practice process designs, for example allowing for more efficient throughput times or higher production volume, that could be valuable for the buyer to adopt. Second, the buyer is interested in the *relevance of the process* in terms of regular users in the process. This indicates whether the process will likely continue after the PMI and supports the estimation of necessary licenses for the underlying IT. Third, the buyer intends to evaluate the *financial and customer-oriented impact of the process* in terms of financial volume processed and implications of the process performance for the customer, for example, related to customer satisfaction, to assess how the process contributes to value creation. Fourth, the buyer must understand the target's *process digitalization and automation* to determine the target's degree of digitalization and potential for learning about and acquiring best practices for efficient, scalable, and adaptable operations. Fifth, the buyer is interested in developing process integration scenarios by *comparing similar processes at the buyer and target* to reveal the degree of standardization, deviations, and synergies as factors influencing PMI. Last, the buyer aims to analyze their *process landscape in terms of standardization* to identify risks for PMI.

The identified requirements were then operationalized to enable the assessment of processes in IT DD. To this end, each requirement is reflected in multiple process performance indicators derived from the process performance framework of van Looy and Shafagatova (2016) and inductively from the expert interviews. For example, the *process flow and complexity* are operationalized through the discovery of the corresponding process model and its variants, the number of cases in the system, and the average process cycle time. In contrast, the *comparison of the buyer's and target's process landscape* for the purpose of process integration scenarios is operationalized through the number and types of conformance violations between similar processes at the buyer and target. The identified requirements and their operationalization are structured along the dimensions of process performance as indicated by van Looy and Shafagatova (2016), that is, *internal business process performance*, *financial & customer performance*, and *learning & growth performance* as well as the inductively identified dimension of process *conformance*. The comprehensive operationalization is displayed in Figure 2.

Demonstration of Process Assessment with Process Mining in IT DD

Building on the framework of indicators that resulted from the first rigor and relevance cycles, we then engaged in the first design cycle by developing prototypical PM analyses to demonstrate the applicability of PM for process assessment in IT DD. The demonstration is based on real, anonymized process data from four organizations (see Table 2) that we used for two M&A scenarios. The first scenario is based on the order-to-cash (O2C) process data of Company A (buyer) and B (target) from the German mechanical engineering sector. The second scenario is based on purchase-to-pay (P2P) process data of Company C (buyer) and D (target) from the engineering industry. In all cases, data originated from the companies' ERP system, i.e., SAP S/4 HANA. We decided to focus on O2C and P2P as organizational core processes that prevail across industries to enhance the transferability of our results. In addition, we chose to analyze the O2C, respectively, P2P processes of buyer and target in cross-organizational PM analyses to facilitate the comparison of buyer and target. Thus, in both scenarios, the buyer and target process data were merged into one combined data model serving as the basis for the PM analyses. Building on the framework of indicators that we developed earlier, we implemented multiple analyses for each scenario reflecting the four dimensions of process assessment (see Figure 2) in the Celonis PM software using the same process performance indicators for the buyer (right side of the analysis) and the target (left side of the analysis). It is to be noted that, except for the conformance analysis, the analyses could also be performed separately.

Name	Industry	Revenue/2016	Role	Process	Dataset size	Dataset timeframe
Company A	Mechanical engi.	>$4 billion	Buyer	O2C	1,480,000 cases	07/2016-05/2017
Company B	Mechanical engi.	>$200 million	Target	O2C	132,000 cases	06/2016-05/2017
Company C	Engineering	>$200 million	Buyer	P2P	191,000 cases	02/2016-03/2017
Company D	Engineering	>$200 million	Target	P2P	885,000 cases	09/2016-10/2017

Table 2. Datasets used for demonstrating the process mining analyses

For the sake of brevity, we will only illustrate the demonstration by highlighting relevant results from the analysis of *internal process performance*, *conformance*, and *learning & growth performance*.

Internal Process Performance

The PM analysis of the *internal process performance* consists of a comparison of the buyer's and target's *process flow and complexity*, enabled by the discovery of the process graphs, process variety, volume, and duration, and the comparison of the *relevance of the process* at buyer and target, enabled by the analysis of the number of users and cases in the system. Accordingly, Figure 3 illustrates the comparison of the buyer's and target's *process flow and complexity* in the cross-organizational PM analysis for the O2C scenario. As evident from the analysis, the buyer's O2C process (right side)—happening for over 1.4 million orders logged in the system for the specific time period—presents as rather streamlined with 5,100 distinct process variants. Conversely, the target (left side)—handling only 132,000 orders in the specified time period—demonstrates over 25,000 different variants of executing its O2C process in the ERP system.

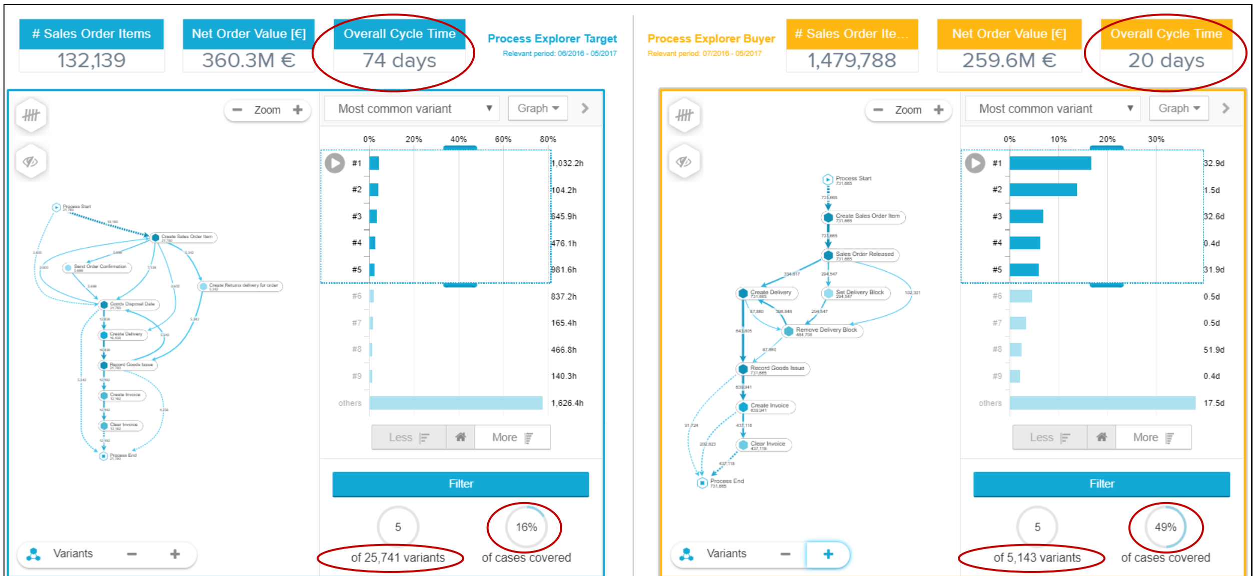

Figure 3. Process mining analysis for the *internal process performance* dimension for the O2C process of buyer and target

While the five most common process variants for the buyer represent the way that nearly 50% of its orders are processed, the same number of variants just covers 16% of the orders in the target's system. This indicates a highly specialized O2C process on the target's side, which also results in a considerably longer sales cycle of 74 days compared to 20 days at the buyer. This raises critical questions about how the target's process can be integrated into the buyer's process and the underlying IT. Can the buyer's IT support the target's specialized process variants? Would it be advisable first to standardize the target's processes in a standalone solution and only integrate it after the number of variants has decreased? By doing so, could the sales cycle of the target be accelerated so that synergies in terms of process efficiency could be realized through the merger?

Conformance

The PM analysis of the *conformance dimension* aims at understanding the rules that the respective business processes of the buyer and the target follow and whether and how they align. Figure 4 shows the conformance check results for the conformance of the target's O2C process to the buyer's O2C process.

The target's O2C process shows conformity to the buyer's most common O2C process variants (covering 80% of its cases) for only 34% of the sales orders. With over 80 different violations of conformance to the buyer's O2C process occurring, the non-conformant process flows also take considerably longer (81 days with violations compared to 62 days without violations), and each case requires a larger number of processing steps (almost 10 steps with violations compared to 6 steps without violations). To shed more light on the violations, the analysis presents the buyer with a breakdown of which of the target's activities are non-conformant with the standard process and how often they occur. Drawing on this information, the buyer can investigate the non-conformant activities that are not supported by the buyer's IT to determine if they are required and should be accounted for in the PMI or if these activities should not be part of the integrated process landscape. If the analysis points toward keeping the process in the PMI, as a next step, the buyer could define measures and estimate costs for standardizing the target's current system in a standalone approach for preparing the integration. An alternative approach could be to keep the buyer's and target's systems standalone and operate two independent platforms with their own standard processes.

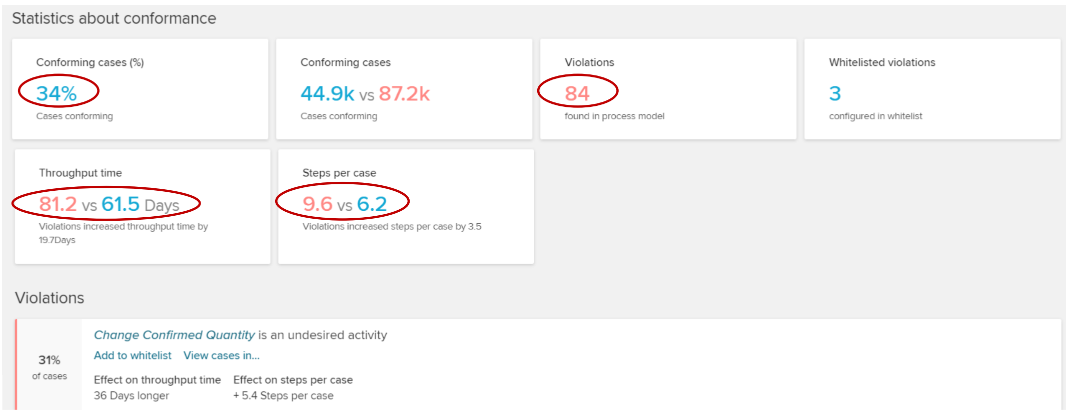

Figure 4. Process mining *conformance* analysis of the buyer's and target's O2C processes

Learning & Growth Performance

The PM analysis of the *learning & growth performance* dimension investigates the automation and digitalization efforts of the buyer and target in comparison. Accordingly, Figure 5 illustrates the cross-organizational analysis of the buyer's and target's P2P processes. It shows that the target's overall low automation rate is at just 1% compared to the buyer's 6% automation rate, with automation being calculated as the share of process steps executed by an automated system user. For further examination, the table below indicates all activities included in the organizations' P2P processes along with the respective automation rate.

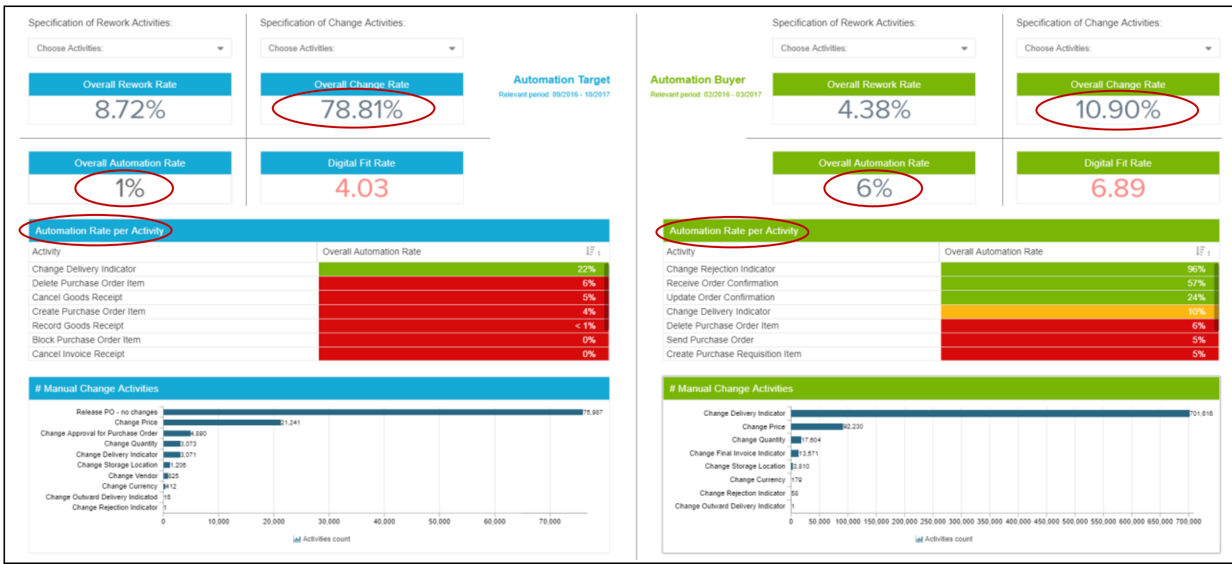

Figure 5. Process mining analysis of the *learning & growth* performance dimension of the buyer's and target's P2P processes

Based on this information, the buyer can identify activities that are already well automated—which could imply potential best practices and synergies to leverage during the integration—and activities with the potential to be automated. Ideally, the buyer and target are complementary in the automation of certain activities so that during the integration, the automation of the future organization can be optimized. Additionally, the manual change and rework rate are indicators of the organization's process efficiency and scalability. Rework includes activities such as cancellations or deletions of orders which ultimately cause all actions performed up to this step to be futile. Change activities refer to any action that changes the state of an order after it has been created, which leads to longer and more costly sales cycles. The analysis shows that the target has a high manual change rate of almost 79% (compared to 11% at the buyer). Hence, the buyer might investigate why these frequent changes are necessary and whether the target's IT is not designed in accordance with the real process flow, possibly threatening the integration.

Design Principles for Process Assessment with Process Mining in IT DD

Based on our operationalization, demonstration, and evaluation of PM for process assessment in IT DD that resulted from the first DSR cycle, we focused the second DSR cycle on developing design principles to provide prescriptive knowledge to scholars and practitioners for the design, implementation, and use of PM analyses for IT DD. Informed by literature and additional expert interviews, we derived eight design principles for the design and implementation of PM in IT DD and four additional enabling factors (see Figure 6).

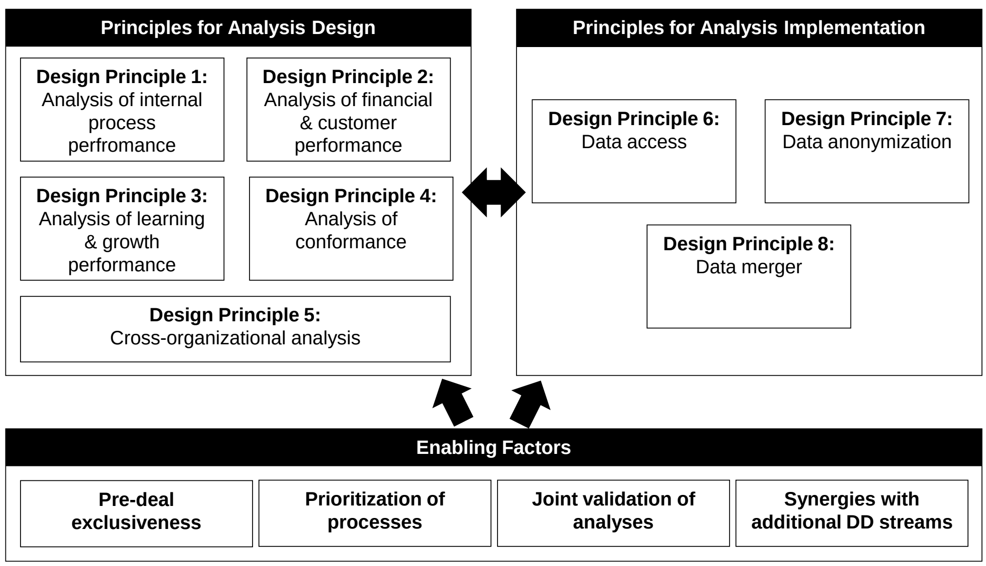

Figure 6. Design principles and enabling factors for the design and implementation of process mining for process assessment in IT DD

First, we propose five design principles for designing PM analyses for process assessment in IT DD. *Design Principle 1* recommends that the buyer gain insights into the target's internal process performance regarding process complexity, relevance, and flow by designing PM analyses to discover the process model, variants, volume, cycle times, and users. Incorporating these indicators in PM analyses establishes an overview of the target's process landscape. Additionally, it is "*extremely valuable for the buyer to direct the focus toward critical process areas that require improvement or standardization, that are non-conformant to regulations and could become a liability or that, in contrast, are suitable for integration*" (Expert E). As the buyer often intends to grow their operations after the M&A transaction is finalized, it has become "*a fundamental requirement of buyers to understand the flow and performance of the target's internal processes*" (Expert F) which, however, was traditionally difficult to measure due to a lack of data and analytical tools (Expert E).

Design Principle 2 advises the buyer to determine the financial and customer-oriented impact of the target's processes by designing PM analyses measuring the financial volume handled in the process, the financial volume impacted by late activities and the impact of invoicing and delivery times on the customer.

Evaluating these indicators with PM allows the buyer to understand how the target's processes influence their financial situation and customer satisfaction, which is of interest for negotiating the deal volume. In particular, the deal volume depends on, for example, future investments required to optimize processes detrimental to the working capital or negatively influencing the customer experience (Expert F). This is illustrated by an account of Expert G, who implemented PM in the context of IT DD. The analyses revealed that the target frequently failed to realize early payment discounts. When discussing these results with the target, they disclosed purposefully withholding payments to increase liquidity, which could have skewed the negotiated deal volume.

Design Principle 3 proposes the buyer assess the potential for growing and learning from the target in terms of process digitalization and automation by designing PM analyses that measure the overall and activity-specific automation rate and rework and manual change rates. Analyzing these indicators with PM allows the buyer to determine the target's status of digitalization and potential for acquiring superior process knowledge, such as process automation, that will benefit the future merged organization. For instance, one expert pointed out how the PM analyses would have supported a buyer from the pharmaceutical industry "*who were interested in acquiring a German plant to learn about their highly automated and optimized processes*" (Expert G).

Design Principle 4 recommends that the buyer develop process integration scenarios by designing PM analyses that measure the conformance of similar processes at the buyer and target. Through evaluating the process conformance between buyer and target, the buyer can "*determine which of the target's processes can be supported by the buyer's systems or vice versa, and which processes share enough similarities to be integrated during the PMI*" (Expert E). As a result, the conformance analysis allows for the identification of synergies but also integration risks. Accordingly, the buyer and the target both have potential profit from the analyses. Awareness of synergies allows the target to increase the price and the buyer to pay a premium on the deal volume (Expert F). This can differentiate between losing and closing the deal, especially if several buyers are interested in the target, outbidding each other (Expert E).

Design Principle 5 advises the buyer to facilitate the use of PM as outlined before by designing the analyses in a cross-organizational approach for benchmarking the buyer's and target's processes. Even though all PM analyses can be implemented separately, the demonstration showed that the cross-organizational PM analysis with the same indicators of the same process at buyer and target allows for "*the identification of key similarities and differences of the processes at a glance, while without PM we either don't have the database to derive such insights at all or we have various, potentially inaccurate, documents*" (Expert G).

In addition to principles for designing PM analyses for process assessment in IT DD, we derived three design principles for guiding the implementation. To this end, *Design Principles 6, 7, and 8* recommend that the buyer ensure access to the required process data by identifying corresponding source systems at the target, anonymizing the data, and—where possible—merging them with the buyer's data of a similar process into one data model to facilitate comparability. Depending on the source systems, the access to and pre-processing of process data can be uncomplicated, such as for "*commons SAP systems that support the firm's core processes and rely on a standardized data structure, so that accessing, preparing and integrating the data can be done quickly*" (Expert I). However, merging data from different source systems might result in technical as well as conceptual challenges when comparing the processes, which requires more elaborate PM techniques (van der Aalst et al., 2015). In addition, the target might be reluctant to share their process data due to the sensitivity of the information, which can be addressed through data anonymization or privacy-preserving algorithmic techniques (Mannhardt et al., 2019).

Last, we identified additional enabling factors that support buyers in applying PM in IT DD. First, complications with accessing the target's process data can be alleviated with contractual measures, such as establishing a degree of *pre-deal exclusiveness* that minimizes the target's risk when sharing sensitive data, which can also facilitate an open dialogue between buyer and target when preparing, performing, and evaluating the PM analyses. This dialogue is particularly valuable for identifying and *prioritizing critical processes* at the target prior to the analyses. As the IT DD usually is performed in a limited timeframe, concentrating analysis efforts on particular areas of interest for the buyer increases the likelihood of creating valuable insights. In addition, joint *validation meetings* between the buyer and target after the analyses have been performed to discuss and interpret the results can contribute toward understanding their implications on the M&A transaction. Finally, the experts pointed toward the importance of leveraging the PM analyses for synergies with other DD areas, such as operational DD and financial DD, that can, on the one hand, contribute knowledge to deriving implications from the analyses and, on the other hand, can enhance their assessments with findings from PM.

Discussion and Limitations

Our study was motivated by the observation that we currently lack knowledge on assessing the target's processes in the context of IT DD, even though process assessment is becoming an increasingly important part of IT DD. Addressing this challenge, we engaged in a DSR approach and (1) revealed and operationalized the requirements for process assessment in the context of IT DD, (2) demonstrated the applicability of PM to measure the operationalized requirements by implementing PM artifacts based on real data, and (3) derived eight design principles and four enabling factors to guide the design, implementation, and use of PM for process assessment in the context of IT DD. In the following, we discuss the implications and contributions of our findings to research and practice and their limitations.

First, we contribute to research on IT DD (Harvey & Lusch, 1995; Koch & Menke, 2013) by revealing and operationalizing thus far largely unknown requirements for process assessment in IT DD and by presenting PM as a tool for execution. Even though research in recent years has acknowledged the importance of assessing the target's IT-enabled processes as part of IT DD (Wilting & Pernegger, 2019) to account for the relevance of IT-enabled processes for organizational and PMI performance (Henningsson & Yetton, 2013; Schönreiter, 2018), thus far, we lacked an understanding of how to conduct and operationalize the assessment. To this end, drawing on insights from literature and practice, we reveal dimensions and corresponding indicators to assess the target's processes in the context of IT DD. As a result, we create a more nuanced understanding of IT DD as not only the assessment of the target's IT infrastructure but as the assessment of the target's IT infrastructure *and enabled processes* to reflect their inextricable interrelations in contemporary organizations. In addition, we demonstrate PM as a suitable IT artifact to execute the assessment while overcoming the limitations in comprehensiveness and objectivity of traditional information sources in IT DD, such as documentation and employee interviews (Wright & Altimas, 2015). In contrast, PM provides data-based, objective insights that reflect the reality of the target's processes, thereby introducing unprecedented transparency to the IT DD. These results resonate with prior research pointing toward the potential of BDA technologies to aid decision-makers in M&A transactions through increased transparency (Lau et al., 2012). Our study showed that the transparency introduced through PM might benefit the buyer and the target, as it allows highlighting opportunities grounded in the target's processes, such as efficient production processes, that warrant a higher deal volume. Concurrently, the PM analysis might shed light on process-related risks that the target would prefer not to disclose. As a result, we encourage scholars to study how the use of analytics technologies such as PM in IT DD changes the collaboration and negotiation patterns in the pre-deal phase.

Second, we contribute to research on the role of IT in M&A (Henningsson et al., 2019) as we demonstrate cross-organizational PM as a technique to support the development of post-merger IT integration scenarios by revealing alignment between the target's IT and their business processes as well as opportunities and risks for the integration of the buyer's and target's processes. In particular, research on M&A points toward the importance of business-IT alignment for the success of post-merger IT integration, which is reflected by how the newly formed organization's IT enables its business processes (Mehta & Hirschheim, 2007). However, developing and evaluating scenarios of how business-IT alignment and IT integration will unfold in the newly formed organization is considered challenging and requires the systematic assessment of what side provides the "better" IT and processes, which currently lacks systematic guidance (Schönreiter, 2018). To this end, we introduce cross-organizational PM as a technique to measure the support of the target's and buyer's business processes through IT as well as the performance, automation, standardization, and conformance of their processes. Scholars in the field of M&A might leverage these data-driven insights to explore how different configurations of business-IT alignment on the buyer and target side can be incorporated into integration scenarios and how different integration scenarios impact PMI performance. Accordingly, we also encourage scholars to investigate the potential of applying PM to the PMI phase.

Third, we contribute to research on the organizational use of PM (Badakhshan et al., 2022; Thiede et al., 2018) by providing a PM artifact, design principles, and enabling factors for the design, implementation, and use of PM in the context of IT DD. While early research on PM focused primarily on advancing the technological basis, only recently, the organizational use of PM came into research focus (Badakhshan et al., 2022). Still, the cross-organizational use of PM, for example, to compare processes across organizations, has received scant attention in research thus far (Thiede et al., 2018). Thus, we provide insights into the design, implementation, and use of cross-organizational PM analyses grounded in real process data and based on validated requirements. In particular, we demonstrate the data preparation, design, and implementation of cross-organizational PM for the use in IT DD and derive design principles to provide scholars and practitioners with design knowledge when implementing PM in this setting. In this light, we also point toward challenges that might emerge when applying cross-organizational PM in a particularly sensitive setting such as IT DD, where the information asymmetry between buyer and target is considered not only an obstacle but also an advantage (Boeh, 2011). To this end, our study gives first indications on how to address these challenges, for example, through establishing the contractual basis for sharing sensitive process data and anonymizing data when possible, which might be helpful in other sensitive cross-organizational contexts where organizations could learn from each other while preserving critical private information, such as in public administration or health. We, therefore, encourage scholars to build on our findings and further study technical and sociotechnical measures to facilitate cross-organizational PM.

Consequently, our research provides practitioners with a systematic understanding of how to approach process assessment in the context of IT DD by giving an overview of dimensions to consider and corresponding indicators to measure when assessing the target's (and potentially also the buyer's) processes in the pre-deal phase of an M&A transaction. Our framework of operationalized process assessment dimensions gives practitioners the flexibility to focus the process assessment on particular dimensions of interest depending on the context of the M&A transaction, for example, focusing on process standardization and conformance to regulations in the highly regulated fields of banking or pharmaceutical. In addition, we provide practitioners with design knowledge and a prototypical PM artifact to support the process assessment in IT DD with PM as a data-driven and, compared to the traditional approaches of interviews and the analysis of documentation, efficient approach to creating process transparency.

We acknowledge that our research is subject to several limitations that open up avenues for future research. First, even though we grounded the analysis of requirements and operationalization of indicators for process assessment in IT DD in related literature and practice, the topic of process assessment only recently came into the focus of IT DD. Thus, additional requirements and indicators might emerge with time as process assessment becomes an integral part of IT DD in practice, which we encourage scholars to account for by collecting empirical data in the field on process assessment in the context of IT DD. Second, even though we demonstrated the applicability of PM to support the process assessment in the context of IT DD based on real process data, the demonstration was focused on only two processes, O2C and P2P. While these are core processes of value creation at every organization, it would be worthwhile for future research to investigate and derive insights from the application of PM to assess industry-specific processes that are of interest in M&A transactions, such as production processes.

Conclusion

Driven by the digital transformation of organizations, in the context of M&A, assessing a target's IT-enabled business processes is becoming an increasingly important factor for buyers to consider during IT DD. However, research and practice lack knowledge on how to operationalize and conduct this assessment. Addressing this challenge, our study synthesizes and operationalizes the requirements for process assessment in the context of IT DD, demonstrates the applicability of PM to conduct the process assessment, and provides design knowledge to guide the design, implementation, and use of PM for process assessment in the context of IT DD. We hope that the findings of our study serve as a starting point for scholars and practitioners alike to develop a deeper understanding of process assessment in the context of IT DD and to explore the possibilities of PM as a novel technological approach to support IT DD.

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