CAUSES AND CONSEQUENCES OF FRAGMENTED PROCESS INFORMATION: Insights from a Case Study

Completed Research Paper

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Abstract

Having access to the right information is vital to the effective and efficient execution of an organization's business processes. A major challenge in this regard is that information on a single process is often spread out over numerous models, documents, and systems. Despite the potential consequences of this situation, there is a lack of insights on how to mitigate its impact. Against this background, we conducted an explorative case study to analyze the causes and consequences of the fragmentation of process information. We found that the widespread fragmentation of information had a considerable impact on the investigated organization. In particular, fragmentation led to severe maintenance issues, reduced process execution efficiency, and had a negative effect on the quality of process results. Our findings provide useful insights for both practice and research on how to mitigate the negative aspects associated with the fragmentation of process information.

Keywords

Process Information, Information Management, Organizational Efficiency, Noncompliance

Introduction

Processes within organizations can be highly complex chains of inter-related steps, involving numerous stakeholders and information systems. Due to this complexity, having access to the right information is vital to the proper execution and effective management of an organization's business processes. We refer to such information, which describes the execution of a process or some of its individual steps, as *process information*. This type of information contributes to the efficient execution of processes (Kettinger et al. 1997), compliance to rules and regulations (Andrade et al. 2016), and the enhancement and redesign of processes (Jung et al. 2007). A major issue in this context is that the information related to a single process is often spread out over a variety of models, documents, and systems (Van der Aa et al. 2015). For example, organizations can use multiple process models to capture different perspectives on the same process (Weidlich et al. 2009). Furthermore, information on the same process may also be stored in other types of *informational artifacts*, such as textual documents (Phalp et al. 2007) and checklists (Reijers et al. 2017). In the remainder of this paper, we shall refer to the phenomenon of information on the same business process being spread out over multiple informational artifacts and over various locations as the *fragmentation of process information*.

The fragmentation of process information can pose considerable challenges to organizations. The spread of information over different artifacts can increase the effort required to access desired or necessary information because users may have to browse through numerous systems and documents. Such cases can compromise the efficiency and effectiveness of process execution and decision-making (Browning

2010). Furthermore, fragmentation can result in the provision of *incorrect* process information to users. This problem can occur when different artifacts contradict each other, which mainly occurs when they have been developed independently (Rahm and Bernstein 2001). The information in artifacts may also lose its validity over time if artifacts are not updated to reflect process changes (Weidlich et al. 2012). When users execute a process based on invalid information, they may perform the process in an incorrect manner, resulting in business process *noncompliance* (Alter 2015). This can have severe consequences for organizations, including reduced productivity (Bagayogo et al. 2013), a loss of control over business processes (Sadiq et al. 2007), and even financial penalties imposed by authorities (Lu et al. 2007). Despite the severity of these issues, it is not understood why the fragmentation of process information actually occurs in organizations and what its full consequences are (Van der Aa et al. 2015). Obtaining such insights is highly important, because it would allow both researchers and managers to develop solutions that mitigate the negative aspects associated with the fragmentation of process information.

To address this gap, this paper sets out to answer the following research question: *What are the causes and consequences of the fragmentation of process information?* To answer this question, we conducted an explorative case study within the procurement department of a globally operating manufacturing company in the food industry. We performed this case study by mainly using a combination of semi-structured interviews and an in-depth exploration of the process documentation of this organization. We found that the fragmentation of process information was pervasive in the investigated organization. We identified several key causes of this, such as the existence of informational artifacts that serve different *informational needs* and support different *purposes*. The consequences of this fragmentation were found to be severe: fragmentation led to maintenance issues, inefficient process execution, and had a negative effect on the quality of process results. An important contribution of this paper lies in the understanding that our study provides regarding the causes of fragmentation. Specifically, while some of the identified causes of information fragmentation can be regarded as unavoidable, others can and should be avoided by organizations. By recognizing such avoidable causes of fragmentation, its negative impact can be considerably reduced. As a result, this paper provides important implications for both research and practice to deal with the downsides of fragmentation in order to improve the efficiency and effectiveness of organizations and their business processes.

The remainder of this paper is structured as follows. We first discuss the theoretical background on the documentation of process information. We then elaborate on our research methodology, providing a description of the context for our case study and the data collection procedure. Afterwards, we describe our findings, reporting on the causes and consequences associated with the fragmentation of process information. Then, we reflect on the implications of our work for research and practice. Finally, we conclude the paper by summarizing our results and discussing directions for future research.

Theoretical Background

A *business process* refers to a chain of events, activities, and decisions that add value to an organization and its customers (Dumas et al. 2013). Such processes exist everywhere, from non-profit organizations to multinational enterprises. For these organizations, it is important to externalize information on their business process in the form of process documentation. Process documentation can, for instance, help to improve the understanding of an organization's processes (Browning and Ramasesh 2007), for the specification of information system requirements (Kettinger et al. 1997) , and to support organizational analysis and re-design initiatives (Fettke 2009). A variety of representation formats can be used to capture process information in informational artifacts (Wolter and Meinel 2010), including process models (Davies et al. 2006), unstructured natural language descriptions (Phalp et al. 2007), spreadsheets (Krumnow and Decker 2010), and checklists (Reijers et al. 2017).

These representation formats generally have their own merits and intended stakeholders. Therefore, information related to a single process can be spread over multiple information artifacts in different representation formats. Figure 1 depicts a classical example of this situation. It shows three artifacts capturing information on a simplified loan application process: (1) a process model, (2) a textual work instruction, and (3) a checklist.
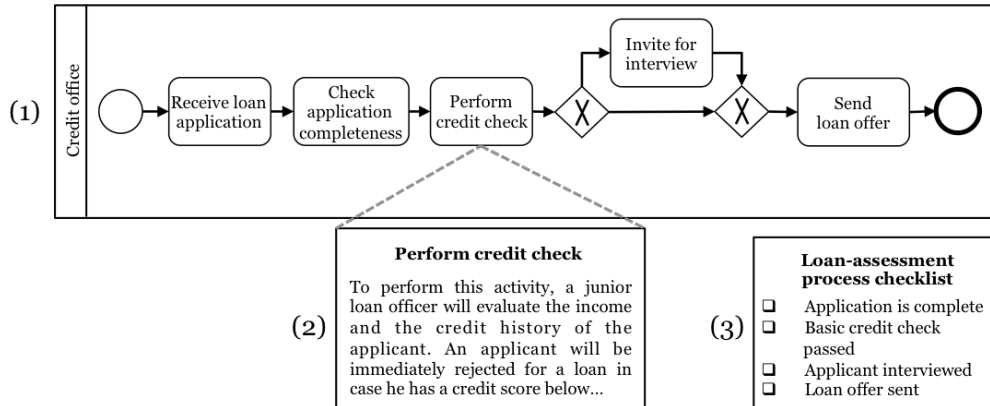
Figure 1 - Loan application process with fragmented process information

Several studies have investigated the merits associated with different representation formats. Browning (2010) considers a set of 15 different process representation formats (referred to as *views*) relevant to project management settings. In this work, it is being assessed how well these views are aligned with different *purposes* for which users need to access process information. The alignment between a view and a purpose is determined based on the informational attributes that the view provides compared to the attributes that are relevant to the particular purpose. This *purpose-view alignment* builds on task-technology fit (TTF) theory (Goodhue and Thompson 1995). TTF argues that a technology (i.e. a means to accomplish a task) will improve a user's performance if it matches the task's requirements well. TTF considers the characteristics of a technology as a combination of its *informational content* and its *representation format*. Whereas Browning (2010) emphasizes the former aspect, Figl and Recker (2016) focus on the latter. Their research with students shows that cognitive style and task setting (i.e. purpose) affect user preferences of textual representations versus process models. The influence of user preferences on the choice for model or text-based process representations has also been identified by Recker et al. (2012) and Chakraborty et al. (2010). Similarly, Krumnow and Decker (2010) found that others prefer *spreadsheets* over process models due to their familiarity with general purpose tools such as Microsoft Excel.

The aforementioned works provide important insights into the suitability of process representation formats for specific purposes and users. However, these works mainly provide insights from experimental settings, where users are presented with several alternative representation formats to perform a specific task, i.e. the formats are considered in isolation. There is no reflection on how or why these representation formats co-exist in practical settings, let alone that these questions are investigated. Furthermore, existing research does not consider the negative impact that the existence of multiple informational artifacts can have on organizations. This impact manifests itself through the co-existence of different representation formats, process perspectives, and storage locations. To bridge this research gap, we use this paper to investigate the causes and consequences of the fragmentation of process information.

Research Methodology

To answer our research question, we conducted an exploratory case study, closely following Yin (2013). In this section, we describe the context in which this study was performed and the data collection procedure.

Case Study Context

For our case study, we chose a Dutch company from the food sector that belongs to the global top 5 within its industry. The company is active in more than 25 countries and employs over 20,000 people, with annual revenues over $11 billion. The company is currently in the process of deploying a long-term

strategy focusing on sustainable growth and value creation. An important component of this strategy is the implementation of a *single way of working* across all its locations. This means that, in the long run, employees around the world should work using standardized processes, rules, and guidelines.

Our case study focused on the global procurement and process improvement departments of the organization. We selected these departments because the organization was aware that they were facing issues related to the availability and maintenance of process information. Together, these departments encompass 23 processes. These processes involve core tasks, such as the ordering of products, as well as support tasks such as the provision of systems training and internal audits.

The ongoing implementation of the standardization of processes makes the selected organization and departments well suited for our research goal. The efforts involved in standardization of processes have revealed that the organization is struggling with several problems caused by the fragmentation of process information. Some of the issues are broadly notable, i.e. in the daily operation of the departments, whereas other issues have become particularly apparent in the context of the efforts to redesign and standardize the processes.

Data Collection

In order to collect the data to answer our research question, we collected data during an eight-week period in April and May of 2016, in which one of the researchers spent three days per week at the headquarters of the organization. The data collection procedure consisted of three main steps.

First, we gained insights into the way in which process information is captured for the investigated processes. For this we combined semi-structured interviews with document analysis. The interviews served as a means to identify the locations in which process information was stored and to gain an overall impression of the contents of the informational artifacts. In order to obtain a holistic view on the available process information, we fueled the discussion by asking employees to consider specific scenarios relevant to their position. This was done by raising questions such as "*Which documents should be updated in case a process changes?*" or "*How do new employees learn how they should conduct their work?*". A subsequent document analysis provided us with detailed insights into the exact process information contained in the documents. For this document analysis, we had broad access to documents contained in numerous internal systems, such as knowledge management systems and process model repositories.

Second, we discussed causes and challenges of the fragmentation of process information with employees. For this we combined semi-structured interviews with informal discussions. These were held with nine employees, each having a different role in the organization. In particular, we interviewed four process participants (involved in different processes), a process manager, an employee responsible for quality assurance, and two employees involved in the technical implementation and maintenance of processes. The variety of roles held by the interviewees provided various perspectives on the usage of process information in the organization. The insights obtained in the first step provided important input for this part of the analysis. Specifically, these insights allowed us to discuss why certain choices with respect to the documentation of processes were made.

Third and finally, in the notes that resulted from the previous step, we identified reasons for capturing process information in a certain artifact (i.e. causes of fragmentation) and consequences of having multiple artifacts for the same process (i.e. consequences of fragmentation) that were mentioned by the interviewees. We grouped these causes and consequences into several categories by identifying cases with shared characteristics. As a result, we obtained 3 main causes and 3 consequences of the fragmentation of process information.

Findings

This section presents the findings of our study. We first discuss the main causes of fragmentation that we observed in the organization and also illustrate the extent of the fragmentation that resulted from these causes. Second, we elaborate on the consequences of the fragmentation of process information that we observed for the investigated processes.

Causes of Fragmentation

We identified 3 main causes of the fragmentation of process information, i.e. reasons for the existence of multiple documents describing the same process: (i) users have different informational needs, (ii) multiple representation formats are used to support various purposes, and (iii) employees are unaware of how to properly capture process information.

Users have different informational needs. A main reason for the fragmentation of information over various informational artifacts was found to be the different informational needs of users. Rather than capturing the information required by various users in a single, all-encompassing artifact, the majority of investigated processes were documented using artifacts that provide different informational contents. These differences can be defined along two main dimensions:

First, informational artifacts differ in the *level of detail* that they provide to users. Some artifacts, for instance *process models* and *textual process descriptions*, provide a high-level view on an entire process. They describe all steps of the process and also, in particular, emphasize the inter-relations between these steps. Artifacts that provide such a holistic view on a process are specifically of interest to users who require an overview of the process. This includes managers, as well as IT personnel responsible for the technical implementation of the process. By contrast, other artifacts only provide information on specific parts of the process. The most common of these are the *work instructions* that were used in nine of the investigated processes. These artifacts provide fine-granular insights into how one or more steps in a process should be executed. Work instructions are particularly useful for users who perform the actual work in a process. For these users, it is more important to understand how to execute certain tasks, than to understand the whole process. Because each work instruction provides insights into only a specific part of a process, multiple work instructions are typically associated with the same process, resulting in further fragmentation of process information. Lastly, we also observed several artifacts that combined high-level with low-level process information. We shall refer to such artifacts as *hybrid process documentation*.

Second, informational artifacts provide information on different *process perspectives*. Two important perspectives in this context are the *technical* and the *operational* perspective. For instance, some process models (especially the ones modeled in ARIS) are primarily intended for the implementation of processes and therefore emphasize the technical perspective of a process. They include details about the applications that are used and the IT systems that should be accessed. For instance, for a *purchase-to-pay* process, we found that users who were interested in a operational view regarded these process models as technical documentation. They instead preferred to work with textual documents that focused on non-technical information.

Multiple representation formats are used to support various purposes. The informational artifacts used by the organization were intended to support different purposes. The users of information found that these different purposes are better supported through the use of a variety of representation formats. As a result, process information was fragmented over artifacts using formats such as *natural language text*, *process modeling notations*, *spreadsheets*, *PowerPoint* slides, and *checklists*. This situation includes cases in which artifacts using different formats provide the same (or interchangeable) process information. For example, we found cases were work instructions describing the same process step were provided in the form of a text document, a PowerPoint slideset, *and* as an instructional video.

The main identified purposes of informational artifacts can be categorized as: (i) to provide reference information, (ii) implement processes, (iii) support teaching, and (iv) guide process execution. Many informational artifacts serve as a *reference* document that provides users with information on how a process or certain process steps should be executed. This category includes (non-technical) process models and textual documents such as work instructions and hybrid process documentation. The main artifacts that support the *implementation* of processes are the aforementioned (technical) process models in ARIS. These models form the basis for the automation of (parts of) processes and the provision of users with the right information and applications necessary to perform the next process step. Other informational artifacts were primarily used as *teaching* aids. For such cases, PowerPoint slides, videos or dedicated *e-learning* tools were used in various processes, because users and teachers were familiar with the use of such formats in these settings. Finally, we identified artifacts, in the form of checklists, whose primary purpose was to *guide process execution*, used by quality assurance personnel. These checklists were used as a means to ensure that all the necessary steps were performed during auditing procedures.

Employees are unaware of how to properly capture process information. Fragmentation of process information also occurred in many cases because employees did not know where or how to capture process information. This resulted mainly from a lack of uniform guidelines related to the documentation of process information. For instance, there are no uniform guidelines on where to store and how to structure the stored information in knowledge management systems (e.g. SharePoint). Because of this, process information often became spread out over numerous systems. Furthermore, the interviewees also described a lack of guidelines or templates that define how process information should be captured within the informational artifacts themselves. Due to this, many informational artifacts were created in an *ad hoc* fashion. This is particularly problematic for representation formats that can be freely structured, such as spreadsheets and natural language texts. As a result of this lack of standardization, even informational artifacts that are intended to serve the same purpose in the same format were found to have considerable differences. We observed this especially for textual work instructions. The structure and contents of these documents differed greatly, even for work instructions related to the same process. The impact of these causes was amplified because different stakeholders often created informational artifacts independently from each other.

The combined lack of standardization on where to store information and how to capture information inside the informational artifacts resulted in a situation where process information is hard or nearly impossible to find. Because of this, employees created redundant informational artifacts, which contained information that had already been captured elsewhere. The inability to find process information thus further increased the fragmentation of process information in a self-reinforcing manner.

All of the aforementioned causes contribute to a situation in which process information is spread over numerous informational artifacts and contained in a broad variety of formats. Furthermore, these informational artifacts are stored in different locations. To illustrate the observed extent of fragmentation, consider the numbers from Table 1. This table provides an overview of the informational artifacts used to capture information on a *purchasing approval* process. This process was one of the processes for which we observed a high degree of process-information fragmentation, as is illustrated in the table. In total we identified approximately 100 informational artifacts relevant to this approval process. We categorized these artifacts according to 10 different information type-format combinations. Due to the severity of the fragmentation for these and other investigated processes, the organization was facing several considerable problems, which we discuss next.

Table 1 - Overview of informational artifacts for a purchasing approval process

Information Type	Format	Quantity
Process Model	EPC	1
Process description	Text	5
	Slide set	1
Work instruction	Text	30+
	Spreadsheet	2
	Slide set	30+
	Video	15
	E-learning module	1
Hybrid process documentation	Text	20+
	E-learning module	1

Consequences of Fragmentation

In this section we elaborate on three main problems that the organization faces as a result of the fragmentation of process information: (i) maintenance problems, (ii) inefficient process execution, and (iii) process quality issues.

Maintenance problems. The fragmentation of process information has led to considerable maintenance problems. The organization struggles to keep its documented process information up to date with process changes. We observed two specific issues related to this:

First, the organization has to invest considerable effort in the maintenance of its process information, part of which has been recognized as unnecessary by the interviewees. This problem partially originates from the sheer number of informational artifacts that sometimes exist related to a single process. However, the main cause of maintenance issues is that there is a lack of traceability between process information contained in these artifacts. As indicated above, it is often unclear where the information related to a single process is stored. In order to successfully propagate a process change in all relevant informational artifacts, employees must manually determine which information in which artifacts must be updated. As a result, one of the interviewees stated that "*sometimes a small change can mean tremendous effort.*" This required effort was recognized as *unnecessarily high*. Several interviewees stated that links between information contained in different artifacts should be established in order to simplify the maintenance task. Furthermore, part of the effort invested in the creation and maintenance of informational artifacts can also be regarded as unnecessary because some information is never used. This problem can be largely attributed to the lack of oversight about where process information is stored. As an interviewee involved with quality assurance remarked "*everything is stored in SharePoint and then forgotten.*"

Second, the effort involved in maintaining process documentation lead to outdated process information. This problem is largely due to the fact that there are only limited resources available for the maintenance. As an ARIS consultant remarked on his task to maintain process models: "*we have very few resources and time to do so.*" Furthermore, due to the aforementioned lack of traceability among process information, it also occurs that informational artifacts become outdated because no one is aware that these need to be updated. The extent of this problem is illustrated well by a recent cleaning of the documentation related to a subset of the investigated processes, which resulted in the deletion of 120 obsolete documents. It is also highly problematic in this regard that information users are sometimes not aware that process information has become outdated. For example, one interviewee responsible for the propagation of changes related to *purchase-to-pay* processes was "*highly surprised*" to learn that documents in SharePoint contained outdated process information.

Inefficient process execution. The fragmentation of process information was found to have a negative influence on the efficiency of processes. Cases of inefficient process execution occurred because users struggled to or could not find the *right* process information to perform their tasks. This happened for several reasons.

First, users needed considerable time to find the information that they were looking for. They have to search through numerous informational artifacts with non-uniform informational content, spread over different locations. Second, some information that users required had simply not been (sufficiently) documented. Due to the ad-hoc manner in which some informational artifacts were created, the authors of artifacts chose not to document information that did not appear to be relevant for them. For instance, an interviewee—who oversees a process that provides reports (in the form of spreadsheets) related to strategic decisions—described the following: "*some process steps are not included* [in the textual process descriptions]*, because they seemed natural to the designer. This leads to problems when working with the spreadsheets.*" Due to these issues, the interviewee spent a significant amount of time cleaning up errors in these reports. The lack of documentation guidelines also resulted in problems for other processes. For instance, a procurement manager acknowledged that he heavily relies on undocumented knowledge when performing his tasks. As a result, when he is absent, his replacement fails to do certain tasks that should actually be performed on a daily basis.

These issues caused by the fragmentation of process information resulted in situations where considerable more time, effort, and, therefore, costs were required for the execution of the organization's processes than necessary. These problems can be seen as affecting the *internal* quality of the processes. Next, we discuss cases where the *external* quality of processes was negatively affected, referred to as the process quality.

Process quality issues. Similar to the way in which inefficient process execution was caused, the inability of users to access necessary or the right process information resulted in cases where the final outcome of a process was negatively affected. In the above, we mentioned the situation where a process

owner spent considerable time correcting mistakes in spreadsheets, resulting from the incorrect execution of a reporting process. While in these cases only the internal process quality was affected, not all mistakes can be caught and corrected in this manner. As a result, management sometimes received incorrect reports on strategic decisions made by the purchasing department. In another case, we learned about situations in which an employee used an outdated process specification while creating purchase orders. Due to this, the issued purchase orders contained incorrect supplier reference numbers. Ultimately, this led to extra costs incurred by the organization in order to clear up these problems with the supplier.

Discussion

These findings illustrate that the fragmentation of process information can have considerable consequences on efficiency (of process execution as well as maintenance) and on the quality of the results provided by processes. The majority of the problems can be attributed to the inability of users to access the right information. This inability manifests itself in different ways: necessary information can be hard to find, outdated, or not captured at all. These problems are partially caused by the large number of informational artifacts used per process. If this number decreases, then users have to search through less documents to find the information that they desire. Furthermore, we have observed clear cases where informational artifacts do not provide any use because they are either redundant or have become obsolete. Cleaning up such informational artifacts can partially address the problems caused by the fragmentation of process information.

Nevertheless, we argue that a general solution to the consequences of information fragmentation is not to reduce the number of informational artifacts to a bare minimum. As we observed in the discussion on the causes of fragmentation, there are several good reasons to maintain multiple informational artifacts for a process. For instance, by maintaining artifacts that provide different levels of detail and different perspectives, artifacts can be specifically designed for particular stakeholders. In these cases, users only receive the information that is relevant to their interests. Therefore, we think that it is worthwhile to accept the situation that multiple informational artifacts are necessary for the efficient and effective execution of processes. Then, to address the consequences of fragmentation, it is important to support organizations in dealing with situation. In the next sections, we discuss how research and practice can strive to achieve this.

Implications for Research

The results from our study show that people use various representation formats to capture process information. Interestingly, our findings with respect to the *use* of representation formats in practice are not fully in line with insights about the *preferences* of users. In particular Figl and Recker (2016) argue that users consistently prefer process models over other representation formats. A possible explanation is that some types of process information might simply be better captured using other representation formats. Here, more research is needed to better understand the connection between representational preferences and different types of process information. An alternative explanation is that people are either not sufficiently aware of the possibilities provided by formats such as process models or not familiar with their use. The latter is supported by the fact that many people from our case study considered process models as too complex. Possible solutions to this problem are, for instance, provided by the Cognitive Theory of Multimedia Learning (Mayer 2002).

Our results also illustrate the need for tools and techniques that allow organizations to more effectively deal with the use and maintenance of process information in various formats. Research has proposed concepts such as *data warehouses* as general solutions to provide users with information in various formats (Chaudhuri and Dayal 1997). However, the introduction of such warehouses is associated with considerable implementation efforts. Other works, instead, provide support to deal with specific instances of process-information fragmentation. Examples include techniques for the propagation of changes throughout various process models (Weidlich et al. 2012), a querying technique that considers both textual and model-based process information (Leopold et al. 2016), and a technique for the comparison of textual descriptions and process models (Van der Aa et al. 2017). However, these works address only a few specific scenarios, which leaves numerous opportunities for the development of other techniques.

Implications for Practice

The findings of our study show that it is important for organizations to have a good overview about which process information has been documented and where. This requires organizations to establish guidelines and procedures that govern the way in which information is documented and maintained. The importance for such measures is well-illustrated by the impact that the presentation of our findings had on the investigated organization since the case study was conducted. Managers where surprised by the situation, in particular by the gaps that existed in the documented process information. This led to the introduction of guidelines that ensure that processes are documented in a standardized manner and that process information is maintained appropriately. We expect that the introduction of such guidelines can also be highly beneficial to other organizations.

The results of our study also provide useful insights that support establishing such guidelines. In particular, our findings indicate that different information needs of users and the variety of purposes for which process information can be used should be taken into account when determining how to capture process information. By considering such factors, documentation guidelines can be designed in a way such that stakeholders have access to the information that they need in the appropriate representation format.

Conclusion

In this paper, we investigated how the fragmentation of process information manifests itself in practice. In particular, we identified several causes and consequences associated with the spread of process information over a variety of informational artifacts. To obtain these results, we conducted an explorative case study in the procurement department of a large manufacturing company in the food industry. Our study revealed how widespread the fragmentation of process information can be in an organization and that it can have considerable consequences. We observed that process information was stored in a broad variety formats, in numerous locations, and sometimes in more than 100 informational artifacts per process. We identified three main causes of this fragmentation. Some of these causes can be regarded as unavoidable, because they (should) allow users to access the information they need more easily. However, other forms of fragmentation, most notably caused by lacks of standardization and guidelines, could be avoided. The investigated organization suffered from several consequences due to the fragmentation. Most importantly, the difficulty to find information and the existence of outdated information led to maintenance issues, inefficient process execution, and reduced quality of the process results.

While the findings of our study provide interesting insights related to the fragmentation of process information, we acknowledge that there are limitations to our study. Most importantly, the findings are based on a single case study. As a result, we cannot unconditionally extrapolate our results to other organizations. This holds in particular with respect to the types of informational artifacts and the representation format that we observed in the investigated organization, which might be specific to the organization. The causes and challenges are expected to be much less organization-specific, and thus more generally present. Therefore, we believe that our study provides important insights that can help both industry and research to reduce the negative effects caused by the fragmentation of process information.

In future work, we aim to further investigate the fragmentation of process information in other organizations and, based on the insights from these studies, further develop its theoretical basis.

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