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How Process Models Change Business Processes in Organizations: From Planned to Emergent Change

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Research Paper

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Abstract

This paper examines how the use of process mining in organizations can promote change in real-world business processes via data-based process models. Drawing on routine dynamics research, we conceptualize process models as artifacts that organizational members can use to change the business processes (i.e., routines) which they perform, and we theorize how such change is possible. Our arguments (a) suggest an emergent change approach to process mining, (b) advance social business process management by unpacking the social influence of process models, and (c) suggest guidelines for practitioners that apply process mining in organizations.

Keywords: Change, Transformation, Business process management, Artifacts, Practice, Organizational routines, Routine dynamics.

1 Introduction

In recent years, process mining has gained increasing attraction (Munoz-Gama et al., 2022; Tiwari et al., 2008; van der Aalst, 2011b, 2016, 2022; van der Aalst et al., 2011). Process mining uses digital event logs to generate insights about real-world business processes. In this endeavor, process analysists and process owners usually create and use process models, i.e., visual representations of the flow of activities in a business process (Avila et al., 2020). Subsequently, they design interventions to change business processes. Process mining, for instance, can help to identify bottlenecks and waiting times in the customer journey, which can then be used to optimize the underlying order-to-cash or procure-to-pay business processes (vom Brocke et al., 2021). One of the promises of process mining, thus, lies in its capacity to stimulate change in real-world business processes in organizations.

While it has been argued that the use of process mining in organizations can change real-world business processes (e.g., Dumas et al., 2018), process mining research has rarely elaborated how these changes are possible or why processes do not change as intended by process analysts and process owners. This is surprising, as a recent study conducted by 'Deloitte' has identified the improvement of business processes—and thus their change—as the most important expectation in the use of process mining (Galic and Wolf, 2021). Prior research has focused on how process mining algorithms can technically account for changes in business processes (Bose et al., 2011; Maaradji et al., 2017; Yeshchenko et al., 2019) or how using process mining in research can generate novel scientific insights about business process change (Grisold et al., 2020b; Mahringer, 2022). A good understanding of how process mining leads to change in business processes, however, is still missing.

In this paper, thus, we elaborate how process mining may lead to change in real-world business processes. For the sake of clarity and precision, we limit our argumentation to a certain scenario: how business processes change when their participants are exposed to a process model generated through process mining algorithms, or when they compare such a model with an existing process model. This,

for instance, could happen when participants collectively reflect on their process in a workshop or when process models are shown in digital dashboards to process participants. There are also empirical examples that reveal the practical importance of this scenario. When 'Uber' started using process mining, for instance, digital dashboards for end users played a central role (Rowlson, 2020). Similarly, at 'Bosch', workshops with stakeholders in the roll-out area were central to the success of process mining (Buhrmann, 2020). While clearly relevant, however, our arguments may not be immediately applicable to other scenarios in which process participants do not have any access to process models, or in which process mining influences business process change in different ways (e.g., a process owners gives orders on how to change the process). In sum, we examine the question, '*how can process models generated through process mining change business processes in organizations?*'.

To answer our research question, we draw on research on organizational routines—commonly labelled 'routine dynamics' (Feldman, 2016; Feldman et al., 2021; Feldman et al., 2016). This stream of research defines organizational routines as "repetitive, recognizable patterns of interdependent actions, carried out by multiple actors" (Feldman and Pentland, 2003, p. 95), and examines how routines are dynamically carried out in practice. Seen this way, an organizational routine equals a repetitive business process (Grisold et al., 2022; Wurm et al., 2021). Routine dynamics scholars have focused on how organizational routines change over time (Feldman, 2000), and they also showed that artifacts play a major role in routine change (e.g., Bapuji et al., 2019; D'Adderio, 2014, 2021; Kiwan and Lazaric, 2019). Because process mining creates and refines artifacts (e.g., visualizations of process models that reflect real-world routines/business processes), the insights from routine dynamics research may be suitable to better understand how the process models generated in the use of process mining in organizations change business processes.

Drawing on these insights, we challenge the predominant assumption in process mining research that process participants execute changes in their business process as *planned* by process analysts and owners. Instead, we offer an *emergent* view on change, in which process participants react to impulses generated by process models. These impulses may influence how they carry out a business process, but not in a deterministic way.

The article is structured as follows. First, we review the conceptual relationships between process mining and business process change in prior research. Second, we review routine dynamics research, and specifically the role of artifacts in routine change. Third, we examine how process mining and business processes/organizational routines can conceptually be linked. Fourth, we use these conceptual relationships to explain how process models may change real-world business processes. Fifth, we discuss the implications of our arguments for theory and practice.

2 Process Mining and Business Process Change

Process mining is a subfield of the research discipline of business process management. It bridges data mining (i.e., data science) and process modeling techniques (i.e., process science) (van der Aalst, 2016). Process mining can be defined as a "technology to visualize, analyze and improve business processes" (Grisold et al., 2020a, p. 370). It is used to "discover, monitor, and improve real processes" (van der Aalst, 2012, p. 1). Process mining, thus, extracts information from digital event logs and visualizes, analyzes, or optimizes business processes of the organization (van der Aalst, 2011a).

Three different types underpin process mining (van der Aalst, 2016, 2021). First, *discovery* refers to techniques that use event data from event logs and automatically create an initial process model applying an algorithm (e.g., α-algorithm). The result of process discovery is a new process model. Second, *conformance checking* means assessing to what extent a real executed process matches or differs from an existing model of the same process. The result of conformance checking is a comparison of the process instance and an already existing process model. Third, *enhancement* aims to extend or improve existing process models. An existing model can be optimized or repaired based on the diagnosis from conformance checking. This is where process enhancement differs from conformance checking: while conformance checking only involves a comparison between a process model and event logs, process enhancement includes concrete optimizations to an existing model, leading to a revised model (van der Aalst, 2011b, 2016).

We can distinguish three different relationships between process mining and business process change. First, business process change can be seen as a methodological problem that process mining algorithms need to address from a technical point of view. While early process mining research struggled to grasp change in business processes, more recent research has tremendously advanced in this regard. An example are methods to measure 'concept drift' (Yeshchenko et al., 2019). Such changes occur due to exogenous factors (e.g., seasonal fluctuations or increasing demand), and/or when process participants perform business processes in a different way than in the past (Maaradji et al., 2017). As a consequence, process mining scholars started to develop methods and techniques to identify and tackle concept drifts in business processes. Yeshchenko et al. (2019), for instance, propose a technique called 'Visual Drift Detection' to capture and manage changes in business processes.

Second, process mining can be used to better understand change as a phenomenon (Wurm et al., 2021). Grisold et al. (2020b), for example, suggest that process mining can be used to better understand change. They argue that it offers algorithms that help to inductively theorize about changes in business processes, which then may promote "imagination, sense-making and creativity" (p. 5495) of researchers. Mahringer (2022) also suggests that analyzing event logs and visualizing their results can promote a process of discovery, which may enable scholars to generate novel scientific insights—for instance, about change.

Third, business process mining can be seen as a practice in organizations that changes specific real-world business processes. van der Aalst et al. (2011), for instance, suggest that process mining enables the (re-)design of real-world business processes. To this end, actors create a new process model, implement the new model, or change an existing model, and enact it in the organization. As the process is being monitored, actors can iteratively change the business process.

Seen this way, process mining scholars take a *planned approach* to change (Orlikowski, 1996). By 'planned' we mean that the real-world business process represents an object that can deliberately be changed by process analysts and owners. Intended changes, thus, will smoothly translate into change in real-world business processes. This echoes Beverungen (2014, p. 191), who notes that "the BPM field tends to assume implicitly that business processes are deterministic machines that can be purposefully designed and implemented in the organization in a top-down process." Research has also shown that some process mining practitioners assume that process changes take place as planned. Badakhshan et al. (2023), for instance, interviewed such practitioners. One of those practitioners describes how changes smoothly follow from the results of process mining, which reveals this mindset.

Scholars, however, also recognized that changing business processes does not always work out as intended. The implementation of a new technology, for instance, can lead to unintended changes in business processes (Berente et al., 2016; Grisold et al., 2020a). Moreover, process participants do not always enact a process model as it has been designed. Scholar, thus, started to emphasize the social dimension in business process management (Batista et al., 2017; Stein Dani et al., 2022; Suša Vugec et al., 2018; Zerbato et al., 2022), which may enable a better understanding of why planned changes often do not materialize. Pereira et al. (2019), for instance, investigate the "human aspect of change" (p. 1565) and how individuals' resistance can influence change in the context of business process management. Similarly, Suša Vugec et al. (2018), argue that process participants are often unwilling to change their business processes or lack the understanding that other alternatives may be advantageous. van der Aalst (2019) notes that "users need to know how these process models are generated before interpreting them." In a similar vein, Beverungen (2014, p. 198) observed that "users are free to decide how to perform business processes in their day-to-day work." How precisely a process model is taken up by the participants of a business process in a way that changes the business process, however, has not yet been examined in detail. To examine this question more closely, we draw on routine dynamics research, which has shown how artifacts (e.g., process models) can change real-world business processes.

3 The Role of Artifacts in Routine Change

Most work in organizations is carried out through organizational routines (Feldman, 2000). Routine dynamics research has empirically studied routines in various settings, such as customer support (Pentland and Rueter, 1994), hiring in student housing organizations (Feldman, 2000), software development (Mahringer, 2019), garbage collection (Turner and Fern, 2012), or pharmaceutical

packaging (Dittrich et al., 2016). Dittrich (2021) provides an overview of the contexts in which routines have been studied. Following Wurm et al. (2021), we equal organizational routines and business processes because both are (repetitive) "sequences of action for carrying out organizational work" (p. 513) (see also Grisold et al., 2022).

Routine dynamics scholars found that, contrary to the mainstream assumption, routines can change tremendously over time through their endogenous dynamics (Feldman et al., 2021). To explain these dynamics, routines can be conceptualized as processes of performing and patterning (Danner-Schröder and Geiger, 2016; Feldman, 2016). *Performing* refers to the "specific actions taken by specific people at specific times" (Feldman and Pentland, 2003, p. 101) and in specific locations. *Patterning*, by contrast, refers to how a repetitive, recognizable pattern of action is created, maintained, and changed over time. Patterning does not reflect merely a cognitive act but happens in action. For instance, when the performance of a routine deviates from what participants think is acceptable, they may flag the deviation and ask others to stick to the typical pattern (LeBaron et al., 2016). The patterning of routines, however, usually involves multiple ways to perform a routine, some of which are more frequent and others that are less frequent. Pentland et al. (2020) refer to this as the 'space of possible paths'—a concept that embraces the multiple ways that a routine could be performed. The notion of 'path' equals a 'process variant' in process mining research (La Rosa et al., 2017). Patterning can also be a motor for change, because it may generate novel paths that actors can use (Goh and Pentland, 2019).

Artifacts also play a central role in routine dynamics research (D'Adderio, 2011, 2021; Pentland and Feldman, 2008). We examine the role of artifacts, because the visualization of a process model is an artifact which may promote routine change. Scholars have shown how artifacts can promote routine change. D'Adderio (2014), for instance, examined how actors replicated routines in a different context. After the routines had been transferred, actors started to change them. The author finds that artifacts, such as engineering change requests, supported those changes. Similarly, Bapuji et al. (2019) show how artifacts—i.e., a bathroom basket for placing used towels, a hook for towels to be reused, and a corresponding sign with instructions—changes routines. Kiwan and Lazaric (2019) examine how the introduction of a robot in surgery routines changes those routines fundamentally, and Berente et al. (2016) reveal how the implementation of an ERP system changes routines. Pentland and Feldman (2008) argue that redesigning artifacts does not always change routines in intended ways. We apply those insights on how artifacts can influence routine change to the more specific case of visualizations of process models as a result of using process mining algorithms in organizations. Next, we examine the conceptual relationships between routines and process mining.

4 How Process Mining Changes Business Processes

In this section, we first explain the conceptual relationships between process mining and organizational routines. Subsequently, we suggest two different mechanisms of how process models may lead to change in business processes, which we label 'focusing' and 'exploring'.

Following Beverungen (2014), we use a conceptual approach to examine our research question (Mora et al., 2008). More specifically, we apply knowledge developed in research on routine dynamics to the process mining field. Such an approach is suitable to offer a 'new way of seeing' phenomena and providing alternative explanations for certain observations, which potentially offer fruitful impulses for future empirical research. Moreover, such conceptual work is well-suited to connect routine dynamics and business process research more closely (e.g., Mahringer, 2022; Mendling et al., 2021; Pentland et al., 2021; Wurm et al., 2021).

4.1 Conceptual Relationships Between Process Mining and Organizational Routines

Figure 1 illustrates how process mining and organizational routines (i.e., real-world business processes) are related. Routines can be conceptualized as processes of patterning and performing. As people perform an organizational routine, they also *enact* its patterns (Feldman, 2016). Put differently, the actions of routine participants create and recreate the repetitive patterns of an organizational routine. How the routine is patterned, vice versa, constrains or enables how it is performed. For instance, actors can use patterning to *constrain* the ways that a routine is performed (Danner-Schröder and Geiger, 2016;

LeBaron et al., 2016). A practical example is verbally signaling that a colleague does not conform to the typical pattern and asking him or her to get back on track. Alternatively, patterning can make new or rare paths visible and, thus, *enable* novel performances (Goh and Pentland, 2019). It may trigger a process of reflection (Dittrich et al., 2016) that leads actors to perform the routine in a different way.

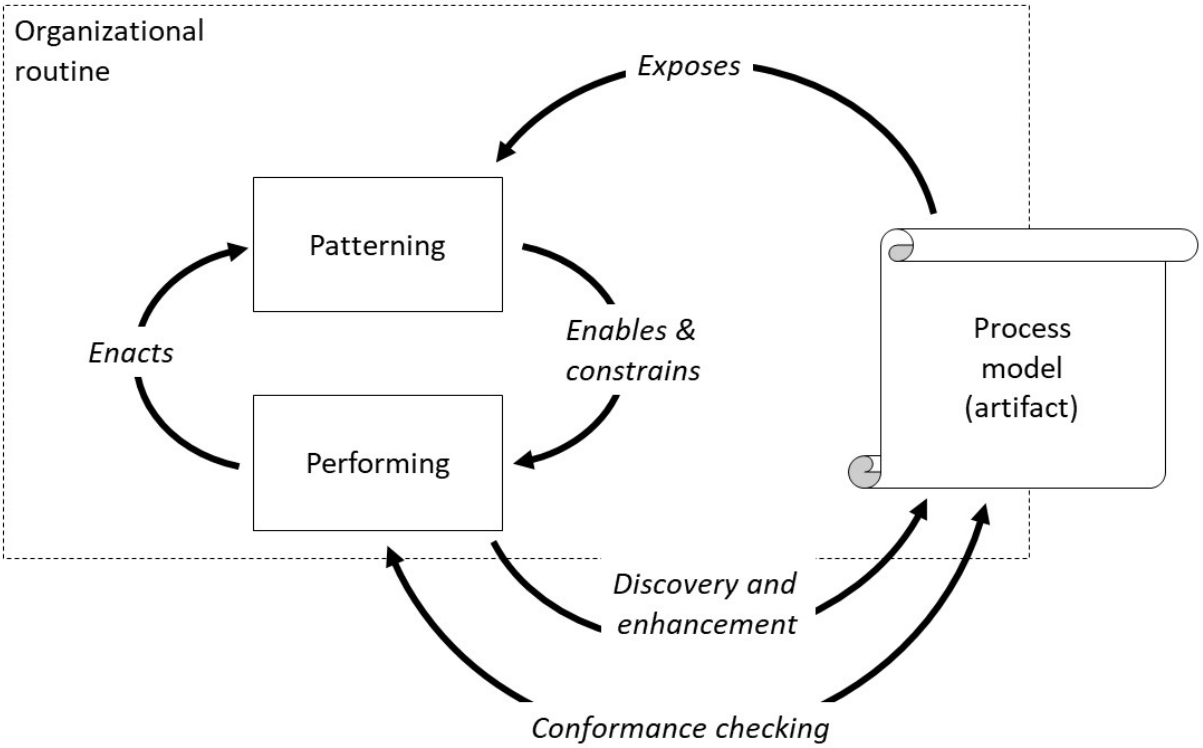

Figure 1. The relationship between routines and process mining.

Process mining activities relate to the performances of organizational routines. As people perform an organizational routine, including certain digital tools, they create digital event logs. These event logs can be used for process discovery, conformance checking and enhancement. First, *process discovery* is typically used to generate a process model in the first place. This process model provides a visualization of how a routine is performed. Yet, note that this visualization provides a partial view on the routine, because it can only visualize actions and contextual information that are tracked in the event logs (Mahringer and Pentland, 2021). Second, *conformance checking* compares event logs generated through routine performances with an ideal type process model. Here, the artifact, for instance, may consist of a double-layered visualization that exposes deviations between what should be done and what is currently done, which is shown in a digital dashboard. Conformance checking can be used to either adapt an existing process model that is not aligned with process instances (i.e., descriptive approach), or to change routine performances that are not aligned with an ideal type process model (i.e., normative approach) (van der Aalst, 2012). Third, *enhancement* attempts to improve the process model. For instance, actors may recognize that the performance of an organizational routine involves more aspects than captured in their process model. Hence, they attempt to enhance the process model with further information, such as who performs certain actions.

We view the process model as an artifact that can both be part of an organizational routine and exogenous to the routine. If routine participants use a process model as they perform a routine, the process model can conceptually be situated ‘within’ the routine (D'Adderio, 2011). For instance, a customer support routine may involve a process model if support staff uses a dashboard with a process model to perform it. However, there may also be aspects of a process model that are not accessible to routine participants (e.g., when the analysis of digital event logs happens in a different department compared to where the process is being performed, and only selected aspects of the process model are

made available to process participants), which suggest that the process model can conceptually be situated 'outside' the routine. For the sake of clarity, we focus on the part of the process model that is accessible to routine/process participants.

Moreover, we suggest that a process model has the potential to *expose* how a routine is and could be patterned. The pattern of a routine is not easily visible to routine participants (Huising, 2019), but process models can provide visualizations of those patterns. When actors use those visualizations to constrain or enable their performances, the process model influences how the routine is performed. Hence, the process model can feed back into the routine performance (van der Aalst, 2021). We next use those conceptual relationships to explain two different mechanisms how process mining can promote business process change.

4.2 Changing Business Processes Through Focusing and Exploring

The conceptual relationships elaborated in the prior section can be used to explain how and why process models generated through process mining can change business processes. We suggest two social mechanisms, which we label 'focusing' and 'exploring'. First, *focusing* means that exposing the pattern of a routine through a process model leads process participants to concentrate on fewer paths (i.e., variants). As actors focus on these paths, the performances of the routine become less varied over time. Pentland et al. (2020) call this effect 'contracting' the space of possible paths, and suggest that contracting represent one way that a routine can change. For example, a process model may reveal that actors perform a routine in varying ways, but they value standardization due to efficiency gains and compliance standards. This insight may lead them to identify the most efficient ways to perform the routine and subsequently stick to these paths.

Second, process mining can lead to change through *exploring*. By exploring we mean that the process model exposes various paths of how participants could perform a routine. Seeing those paths may foster curiosity and lead actors to perform the routine in a different way. Exposing the pattern of the routine, thus, enables the exploration of new paths, which then changes the routine or business process over time. As Dumas et al. (2018, p. 75) argue, "process participants typically perform quite specialized activities in a process such that they are hardly confronted with its full complexity." Exploring shows how exposing participants to this complexity may facilitate change.

Empirical work supports these arguments. Huising (2019), for instance, studied process redesign initiatives in organizations. She shows how visualizing business processes revealed their space of possible paths, including actions that did not matter for intended outcomes, workarounds, and double work. As a consequence, actors felt empowered to change their business processes, such as possibilities to create more efficient processes (i.e., focusing). Similarly, Golden-Biddle (2020) examined how participants analyzed their patient care processes and patient flows in a hospital. As they visualized these processes, they started to see bottlenecks, problematic handoffs, and breaking points. These unexpected observations led participants to explore new ways of performing the process, leading to a more collaborative approach to patient care.

While both studies look at non-digital process models, generating a process model from digital event logs likely has comparable effects. However, we also acknowledge that there are differences between manually derived process models and process models generated through process mining algorithms. First, process models generated through process mining are more dynamic (e.g., 'live visualizations') than their manual counterparts (Dreher et al., 2021). As Figure 1 suggests, focusing and exploring change the performances of routines, which may then also change the process model through renewed iterations of discovery, conformance checking and enhancement. Hence, process mining offers the possibility to promote continuous change of the business process. Second, process models visualized in digital dashboards can often be used more interactively than their physical counterparts. Dumas et al. (2018), for instance, argue that certain parts of a process can be hidden in sub-processes, enabling process participants to collapse and un-collapse elements of a business process. Such a technical design may prevent participants from exploring some parts of the process (if they do not 'un-collapse' it in the digital dashboard) or it may guide their exploration to specific parts of the process, which may promote change as actors explore the process in depth. Third, the process models generated through process mining may be less aligned with how process participants view their work as opposed to their manually

derived counterparts. As Beerepoot et al. (2023, p. 3) note, a key problem in business process management is "work not being recorded as it is executed in real life." On one hand, this may lead to issues in making sense of the process model (Aysolmaz et al., 2022), potentially leading to unexpected outcomes. On the other hand, the misalignment of process participants' view on their business process and the process model may reveal aspects that participants did not see before or that they took for granted. However, how these two competing dynamics (i.e., enabling change by revealing aspects that have remained unconsidered versus constraining change through issues in sensemaking) play out against each other lies beyond the scope of this article, but offers an exciting avenue for future research. It may also be worthwhile to elaborate how misrepresentations influence the change of business processes.

5 Conclusions

While prior research has focused on how process mining algorithms can account for change in business processes or how using process mining in research can support scientific insights into change, we focused on how the process models generated through process mining in organizations can change real-world business processes. Drawing on routine dynamics research, we conceptualize process models as artifacts that influence business process/routine change. We suggest that process mining generates process models from performances of certain routines. These process models, then, expose how routines are being patterned, which may enable or constrain subsequent performances of the routine. Process mining can promote change in organizational routines/business processes either because participants focus on fewer paths (making the routine pattern less varied over time) or because they explore novel or less frequent paths.

We next discuss how these arguments contribute to research on process mining, social business process management, and process mining in practice. Our work closely aligns with Beverungen (2014), but it also advances this work by focusing on organizational change more specifically. On a more abstract level, our article establishes a connection between routine dynamics and business process research (e.g., Mahringer, 2022; Mendling et al., 2021; Pentland et al., 2021; Wurm et al., 2021).

5.1 Advancing an Emergent Change Approach to Process Mining

While most prior research in process mining, and business process management more generally, adopts a *planned* change approach (Beverungen, 2014), our model advances an *emergent* change approach (Feldman and Pentland, 2003; Orlikowski, 1996) in this context. Figure 2 shows how these approaches differ. The planned change approach assumes that process owners and analysts (or the algorithms they employ) extract data about real-world business processes and use these data to create process models. Subsequently, they redesign the model or advance a different process model which, when implemented, changes the business process according to the model. This approach assumes that the changes that process analysts and owners suggest are smoothly implemented, changing the business process as intended. Such an approach, however, falls short of explaining why business processes often do not change as intended (Suša Vugec et al., 2018).

This paper, by contrast, advances an emergent change approach in the context of process mining. Drawing on insights from routine dynamics research (Feldman, 2000; Feldman and Pentland, 2003), such an approach takes the aims, intentions, understandings, and emotions of actors performing the business process, i.e., the process participants, into consideration. As process participants have agency, they can decide to not adopt the intended change, use workarounds, or implement it differently (Pentland and Feldman, 2008).

Through this perspective, the process model is not deterministic, but it provides impulses for process participants performing a business process. An impulse means that a process model offers a perspective on a process that its participants did not see before. For instance, it may uncover a bottleneck in the process or extensive waiting time between events that participants did not see in their everyday work. Moreover, a process model could reveal a new possibility, such as connecting two events that previously were unconnected. These things can easily perish in the complexity of everyday work, but the process model provides a simplified visualization to uncover such aspects. Process participants, then, can decide to ignore impulses, but they can also use them to change the business process over time. We suggested

that, in the context of process mining, such impulses can influence the performance of routines because process models expose the patterns of these routines to participants, which may lead them to focus on fewer paths or explore new paths as they perform routines.

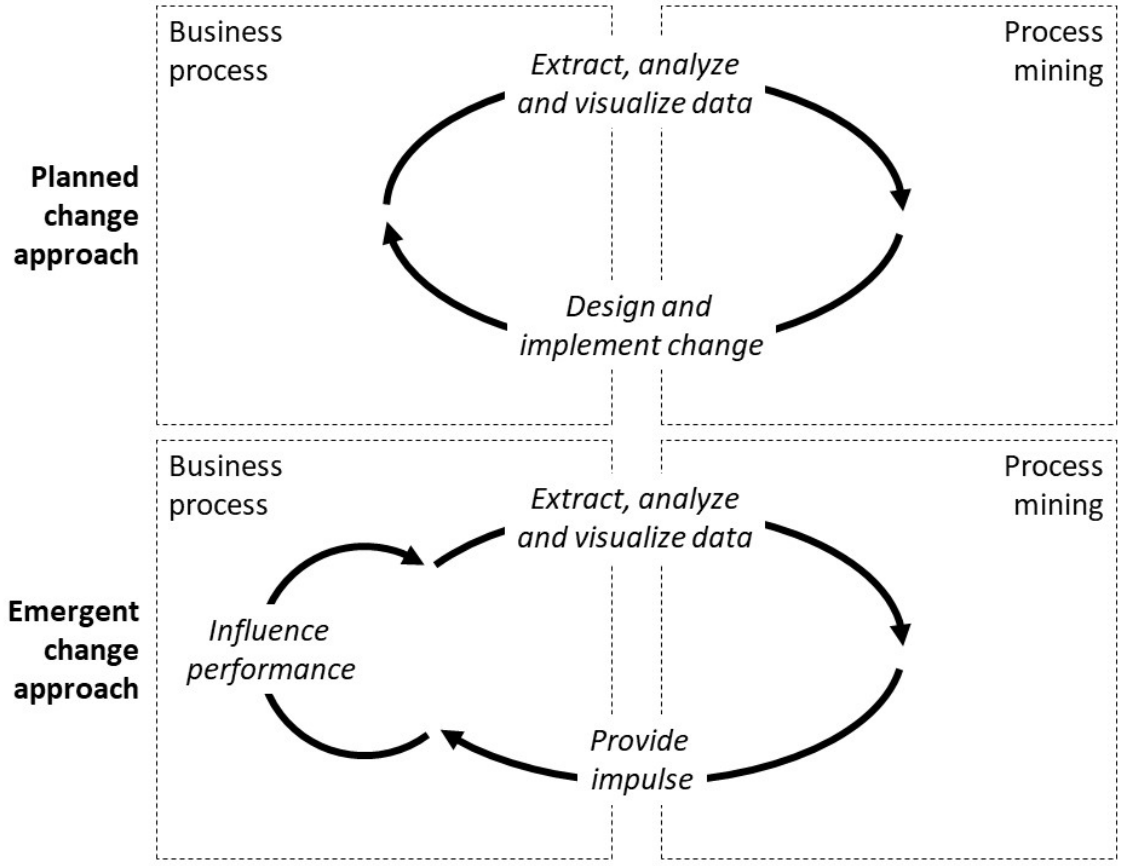

Figure 2. Planned change versus emergent change.

The central implication of our argument for process mining is a shift in ontology. Rather than assuming that process participants simply carry out a business process as designed, our arguments shift towards assuming that these participants have agency as they carry out a business process. When changes intended by process analysts and owners do not materialize, for instance, this is not only a matter of lacking information and accuracy of the process model, but it is also a matter of process participants' intentions and understandings (Beverungen, 2014). This implies that successful process mining does not only require technical experts that design algorithms, but it also requires change agents (Reinkemeyer, 2020). Moreover, the role of process mining in organizations may shift from a 'steering instance' towards a facilitator and enabler that provides a context (e.g., in the form of a process model) for organizational change.

5.2 Process Models as Drivers of Organizational Change

A sub-stream of business process management deals with its social dimension (Ariouat et al., 2017; Batista et al., 2017; Benevento et al., 2022; Stein Dani et al., 2022; Suša Vugec et al., 2018; Zerbato et al., 2022). It has been recognized that process performances often deviate from the designed process models. Possible solutions for this are outlined, such as better integration of participants in process modeling. However, in this context, it is not yet explained how process participants change the business processes that they perform. We contribute to this discussion because we examine the social effect of process models. More specifically, we suggest that process models can expose how business processes are patterned, which can lead participants to focus on fewer paths or explore new paths.

While this article is conceptual in nature, future research could use empirical studies to better understand the relationship of process models and business process change. One way to conduct such studies is through experiments (Aysolmaz et al., 2022). For instance, people could be provided with different process models (e.g., varying degrees of complexity, modularity, or omissions), asking them how the process model may change the performance of a specific business process. Moreover, case studies may be suitable. Scholars could use focused, ethnographic observations of process participants that use process models, and examine how business processes change over time and which role process models plays for such changes.

Relatedly, we believe that more research is needed to better understand the social dimension of process models: how does the enhancement of a process model influence business process change? Does more information in the process model make change more or less likely? Do different kinds of process models influence change differently? Do actors iterate between focusing and exploring over time? What are the conditions under which process participants use exploring and focusing? These questions provide possible avenues for the future of social business process management.

5.3 Implications for Business Process Mining in Practice

Finally, we believe that our arguments can guide practitioners of process mining in organizations in managing business process change. We devise principles that may help practitioners to better manage change:

- Implications of an emergent change approach:
  - Do not assume that planned changes will be implemented as expected; consider that people have agency when they perform business processes.
  - Consider the values, motives, emotions, and aims of people performing a business process.
  - Be open to iterating—changes need time.
  - Trust in the ability of people to find a good solution.
- Implications of exposing, exploring, and focusing:
  - Support people by exposing the patterns of business processes.
  - Help them decide which paths to explore or how to focus on certain paths.

We hope that these scientific and practical suggestions open new avenues for process mining—avenues that take the socio-material context in organizations into consideration so as to design better interventions into real-world business processes.

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