

# PERFORMANCES OF BUSINESS PROCESSES AND ORGANIZATIONAL ROUTINES: SIMILAR RESEARCH PROBLEMS, DIFFERENT RESEARCH METHODS - A LITERATURE REVIEW

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# **PERFORMANCES OF BUSINESS PROCESSES AND ORGANIZATIONAL ROUTINES: SIMILAR RESEARCH PROBLEMS, DIFFERENT RESEARCH METHODS – A LITERATURE REVIEW**

*Complete Research*

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## **Abstract**

*Management studies and organization science use the concept of organizational routines when investigating collective recurrent activity patterns. Process mining is a sub-field of business process management that analyses event log data from information systems that signifies accomplished activities for the discovery, conformance checking and enhancement of business processes. Obviously, both fields alike are concerned with analyzing event sequences. This paper studies the literature in both fields in an attempt to shed light on their relation. The main results obtained are: Scholars from both fields – while working on similar research problems – tend to employ different research methods and research tools. There also exist separated publication strands. From the set of papers that either belong to or cite papers from one of the fields, we found only three papers that cite organizational routines and process mining publications at the same time and another six papers on organizational routines that refer to process mining. The paper concludes that the adoption of methods from the counter-field may constitute a great potential for innovative research designs.*

*Keywords: Research Methods, Business Process Management, Process Mining, Organizational Routines, Literature Review.*

## 1 The Study of Performances in the Literature on Business Processes and Organizational Routines

Researchers in the areas of information systems, management, and organization science have used different concepts in order to refer to sequences of activities performed in an organization for accomplishing work. Organizational routines have been defined as “collective recurrent activity patterns” (Becker, 2004 p.645) and so they were mainly used to study behavioral regularities of the individuals in an enterprise on a collective level (Salvato and Rerup, 2011). A process has been defined as “closed, time-logical sequence of activities that is required for working on a business object” (Becker and Kahn, 2011 p.6), and a business process has been explained as a process that subscribes to the distinctive objectives of an organization and that is bound to the particular environment of the organization (Becker and Kahn, 2011). Business process management (BPM) refers to an integrated system (Hammer, 2010) of tools and methods for achieving an understanding and then for managing and improving an organization’s process portfolio (Zur Muehlen and Indulska, 2010). Therefore, BPM should plan, control, monitor, and improve operational sequences and structures in a consistent, continuous, and iterative way (Hammer, 2010). In this brief discussion, it stands out that the business process concept is often used as a “normative” construct in order to develop and prescribe “desired” performances in organizations following an engineering-like approach. The “organizational routines” concept instead is typically treated as a “unit of analysis” (Pentland and Feldman, 2005) for the empirical study of actual behavior in order to better understand it and to explain organizational and economic stability, change and survival (Pentland and Feldman, 2005).

Two more recent developments suggest discussing the two areas in connection to each other: first, the organizational routines concept has been advanced over time, and, second, process mining emerged as a sub-field of BPM. Starting with the first development, Pentland and Feldman (2005) recognized that organizational routines do not only feature a performative aspect (i.e., a view on the specific actions of individuals) but also an ostensive aspect (i.e., an “abstract pattern of how to accomplish a task” (p. 795). In addition to that, the authors acknowledge that routines can be “codified or prescribed [...] and constrained through [artifacts such as] rules and written procedures” (Pentland and Feldman, 2005 p.796) or process models. With regard to the second development, process mining emerged as a sub-discipline of BPM that taps into the plethora of rich data that can be obtained from the event logs of information systems. Process miners developed a powerful apparatus of methods and tools for studying the traces of individual performances with the intention to discover processes and to monitor and improve performance (Van der Aalst, 2011). These two trends are convergent: while BPM research recently emphasized to start process improvement projects with analyzing actual behavior as observed from single cases, management and organizational science research increasingly elaborate on the ostensive aspect of the routines, e.g. how to derive a general understanding from observed behavior.

Against this backdrop, this paper is motivated by two observations we made while investigating the two fields. These observations also constitute the research question of this paper: First, we notice that the research problems and research questions addressed by scholars in both fields are often very similar and related to the study of activity sequences. Second, however, we have the feeling that researchers from the two areas employ quite different research methods and research tools to approach these problems which may be due to the different backgrounds and histories of the research communities. More precisely, we had the feeling that organizational routines research could really benefit and be inspired by the data acquisitions and analysis techniques of business process mining especially because organizational routines studies rarely tap into the meaningful data residing in the slipstream of today’s information systems. We further presume that such separation of methods and

tools also manifests in dispersed strands of publications. All the above issues result into the research question addressed by this paper: How is the relationship between research problems/ research questions and research methods/ tools in the context of the study of actual behavior in business process management and organizational routines?

This paper therefore reviews the literature on organizational routines and process mining in order to find out commonalities and differences in research problems and research questions as well as in research methods and research tools. We further want to figure out if authors in each field are aware of literature from the other. The remainder of this paper is structured as follows. Section 2 and 3 give research background. While Section 2 discusses the research problems and research questions addressed by researchers in the fields of organizational routines and process mining, Section 3 compares the research methods and research tools employed in consideration of these problems and questions. Section 4 outlines the methodology and results of a review of the literature and it provides a discussion of the findings obtained from this review. Section 5 concludes with a brief summary.

## 2 The Similarity in Research Problems and Research Questions

### 2.1 Organizational Routines

The concept of organizational routines has its origins in the field of management studies and in the literature of organization science, where it proved to be useful as a “central unit of analysis” (Becker, 2004 p.643) when researchers investigated how firms work. Routines more recently have also been described as dynamic “generative systems with internal structures and dynamics” (Pentland & Feldman, 2005, p. 793). Based on observations of individual performances as well as variation and selective retention in between different performances, researchers try to explain the dynamics of routines, which include aspects such as formation, inertia, endogenous change, and learning (Pentland et al., 2012).

Some studies focus on the relation of the performative and the ostensive aspect (Salvato and Rerup, 2011). The ostensive aspect is connected to peoples’ actual performances in different ways. It may serve as guidance or as legitimation for desired behavior (Feldman and Pentland, 2003). The performative aspect in turn informs the ostensive aspect: It creates the routine, if written procedures that codify the ostensive aspect “come to life and become meaningful“ (Feldman and Pentland, 2003 p.108). It also maintains it by exercising and modifies it if people (repeatedly) choose to diverge. Accordingly the routine can be treated in different ways. One may study a black box, isolated parts of routines (i.e., the performances, the ostensive aspect, and the artifacts), or relationships between parts and the ways in which they change (Pentland & Feldman, 2005).

In any case, two types of problems may be addressed: measurement and induction (Pentland et al., 2009). Becker (2004) gives examples of what can be measured: time of impact, decay, reaction time, etc. Inductive studies generalize the patterns (Pentland et al., 2009) based on the observation of a set of performances.

### 2.2 Process Mining

Process mining is located in the area of business process management (BPM). The central object of interest is, of course, the business process, but the central questions scholars are concerned with are how to create, manage, and analyze models representing processes as well as how to enact them in organizations (Van der Aalst, 2004). Consequently, process models are just as much important to this discipline as the processes themselves.

However, a strong emphasis on models does not imply that BPM scholars ignore that models are just an abstract, simple representation of a complex reality. Therefore, process mining deals with analyzing actual event data, gathered from information systems, in order to gain insights about processes. Tasks tackled by process miners can be classified using three categories: discovery, conformance, and enhancement (Van der Aalst, 2011).

Discovery is about constructing a process model from event data, which typically consists out of a set of sequences of events, but may be supplemented by other information. The goal is to construct a model representing the underlying process as accurate as possible while at the same time being comprehensible (De Weerd et al., 2012). Conformance, the second category, deals with comparing normative process models with actual data. The goal is to detect if a process is performed as it should be or if any deviations exist. Lastly, enhancement is about using any kind of information drawn from event data for the purpose of changing the way an organization operates for the better. Such information may but not has to originate from discovery or conformance checking. The ultimate goal of process mining research is to provide the tools and techniques to enable organizations doing the tasks described above.

## **2.3 Discussion**

Researchers from both fields assemble and then describe abstract, underlying patterns from the observations of individual performances/instances. Also researchers from both fields are interested in dynamic aspects as they compare instances with process models or single performances with the ostensive aspect with the intention to identify deviations from prescribed or established behavior. Such deviations help studying stability and change of routines and those effects that cause changes, and they allow process miners identifying differences between normative and actual processes. Both fields maintain a set of approaches to calculate measures of processes or of organizational routines respectively based on data about single performances (durations, frequencies, etc.) and these measures are intended to help managers improving organizational effectiveness and efficiency in both fields alike.

# **3 The Diversity in Research Methods and Research Tools**

## **3.1 Organizational Routines**

With organizational routines being a field concerned with studying reoccurring patterns of activities performed by individuals, a natural approach is going into the field and observing the objects under study. Using organizational routines as an analytical lens, data can be gathered by doing case studies. Typical methods such as interviews, document analysis, or action research are then used (Becker and Zirpoli, 2008). The analysis steps required typically comprise of the identification of repeated sequences of activities, the calculation of certain measures of similarity and the identification of the actors involved in performing the activity (Becker, 2004).

However, apart from these traditional, informal ways of analyzing organizational routines, scholars of this field are increasingly interested in more formal approaches. Already in the 1990s, Pentland and Rueter (1994) used the metaphor of interpreting a routine as a language, and consequently they used a formal, grammatical representation to describe it. Other approaches include using so called narrative networks to represent routines (Pentland and Feldman, 2007).

As gathering data about actual performances of routines can be laborious, it seems reasonable to collect data signifying the performances from information systems. This is what (Pentland et al., 2009) suggest to facilitate large scale empirical research. To accomplish their analysis, they use simple

summary statistics, but also methods borrowed from the social science literature on sequence analysis (Abbott, 1995). Other ideas include fitting markov chains to event data (Pentland et al., 2011).

### **3.2 Process Mining**

In the early day of process mining, authors experimented with different methods from the field of artificial intelligence such as markov chains, neural networks, but also algorithmic heuristics (Cook and Wolf, 1998). The algorithms of these days produced state-machine-like process models (Agrawal et al., 1998). However, one problem with these approaches is that if the underlying processes exhibit concurrent behavior, the combinatorial nature of state machines produces unreadable (and thus unusable) results.

As a consequence, the  $\alpha$ -Algorithm has been developed (Van der Aalst et al., 2004). This algorithm directly constructs a petri net representation making independence between events explicit. This improves readability of concurrent processes. However, the  $\alpha$ -Algorithm relies on a number of assumptions that may not be realistic. It can only discover processes which can be represented as so called structured workflow nets, i.e., models with a very particular structure. Modifications have been proposed to overcome this constraint (Alves de Medeiros et al., 2004; Wen et al., 2007). Another assumption is that data is not noisy, which motivated researchers to develop the HeuristicsMiner (Weijters et al., 2006). The Fuzzy Miner (Günther and Van der Aalst, 2007) is even more geared towards highly unstructured and noisy data. Another approach applies heuristics to balance over- and underfitting to data (Van der Aalst et al., 2009). Yet another very recent approach is doing sequence analysis (Bose and Van der Aalst, 2012).

Since there are too many techniques to give a comprehensive list here, we kindly refer to Tiwari et al. (2008) or de Weerd et al. (2012) for a more detailed overview on the different process mining algorithms.

### **3.3 Discussion**

General speaking, organizational routines research lends itself to the set of empirical research methods and research tools of the social sciences. Process mining instead is affected by its roots in computer science and favors research methods and research tools that originate from inductive inference theory, but also from the field of artificial intelligence. Some overlaps can be seen such as markov models, which have been experimented with in process mining a long time ago, and which are now also recognized in the organizational routines field. Another example is sequence analysis, which is currently popular in both of the fields; although in process mining it is just one method among many. Surprisingly, none of the papers that discuss tools and methods in one of the two fields makes a reference to similar approaches in the other area; even though they are addressing similar problems as we elaborated in the previous section.

## **4 Literature Research on the Connection of the Fields**

### **4.1 Methodology**

Motivated by the before described observations from our frequent use of the literatures from both fields, we wanted to get a more comprehensive picture of the intersection of process mining and organizational routines. We decided to do a literature review in order to systematically carve out evidence for our hypothesis that publication strands in organizational routines and process mining are separated. Such separation could state a reason why the researchers in the two fields address similar

research questions with different research methods and research tools. Therefore, the goal was to identify articles that establish a connection between process mining and organizational routines, and to quantify their number.

Because of this particular focus on the links between the fields, we developed and implemented a specific search process that operationalizes our strategy. Notably, we searched for the following two types of articles:

- (1) Articles being either from the field of organizational routines or process mining which discuss and/or reference articles from the other field.
- (2) Articles being from a field other than organizational routines and process mining which reference both of these fields.

Unless stated otherwise, we will consider any article as belonging to the fields of process mining or organizational routines if the corresponding phrase is found in title, abstract, or keyword. Notably, we did not bind our search to any specific academic journals.

We initially considered three data sources for the analysis: Web of Science, Scopus, and Google Scholar – each of which has its own advantages and drawbacks. Google Scholar is praised mainly for its good coverage as well as full-text indexing, but it is also criticized for bad data quality and occasional unexpected behavior in the search functionalities (Jacso, 2008). In particular, Google Scholar outperformed the Web of Science when it comes to conference proceedings (Franceschet, 2009), and those are an important source for the process mining literature. Scopus also provides much better coverage of conference proceedings, but Google Scholar is best (Bar-Ilan, 2008). The Web of Science, and Scopus in particular, provide much better data quality and reliable search functionality though, and have similar but not identical coverage (Bar-Ilan, 2010; Gavel and Iselid, 2008; Vieira and Gomes, 2009). For our study, we therefore decided to use those two of the three databases which offered a value added. Google Scholar was chosen to maximize coverage and because a manual analysis was manageable given the small number of results (i.e., data quality issues are not that important). Scopus was chosen because of its sophisticated search functionalities (forward and backward search) while still covering conference proceedings.

Retrieval from Google Scholar was accomplished using keyword search. We searched for the combination of “process mining” and “organizational routines”. The latter was used in American and British English form, resulting in two different searches. All results underwent a manual analysis to identify articles of types (1) and (2). As for searching Scopus, we made use of the possibility of moving forwards and backwards through the citation graph. We retrieved two sets of process mining and organizational routines articles independently using the respective search phrases, while configuring Scopus to search in title, abstract, and keywords<sup>1</sup>. For each of these sets, we retrieved all articles citing one of the set’s members and then subtracted all articles of the original set. This delivered two sets of articles not from but citing the corresponding field. We then calculated intersections between these sets to identify articles from both types (1) and (2). All data was retrieved on February 15, 2013.

## 4.2 Results

Searching Google Scholar delivered a total of 16 results, which have been filtered to remove any false positives or unpublished material. In particular, we removed a master thesis, a proposal for a research

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<sup>1</sup> In Scopus syntax, the query was ‘TITLE-ABS-KEY("process mining")’ for process mining, and we used an analogous query for organizational routines. Scopus automatically handles British and American English.

project, a complete issue of an E-Government Journal that contained two separate papers, one from each field, two false positives concerned with the process of mining metals from the Peruvian grounds, and two other false positives mentioning the phrase “organizational routines” but not in the sense of the corresponding research field. This leaves a total of nine articles related to both fields that we could identify from Google Scholar.

The sets of articles retrieved from Scopus are depicted in Figure 1. On the left and right side respectively, one can find the sets of articles representing each research field. We found 900 process mining and 333 organizational routines articles (after removing duplicates). We then retrieved all articles citing those in these sets. This delivered 2,016 results for process mining and 5,693 for organizational routines. Subtracting all articles belonging to the corresponding research fields, we end up with 1,540 articles citing but not being process mining articles and 5,545 articles citing but not being organizational routines articles. Intersecting these sets reveals that there are no articles being in both fields. Also, there are no process mining articles citing those belonging to the set of organizational routines. However, we found three organizational routines articles citing process mining as well as four independent articles that cite both research fields. One of the latter is a false positive and therefore was removed from the set. This amounts to a total of six articles found via Scopus.

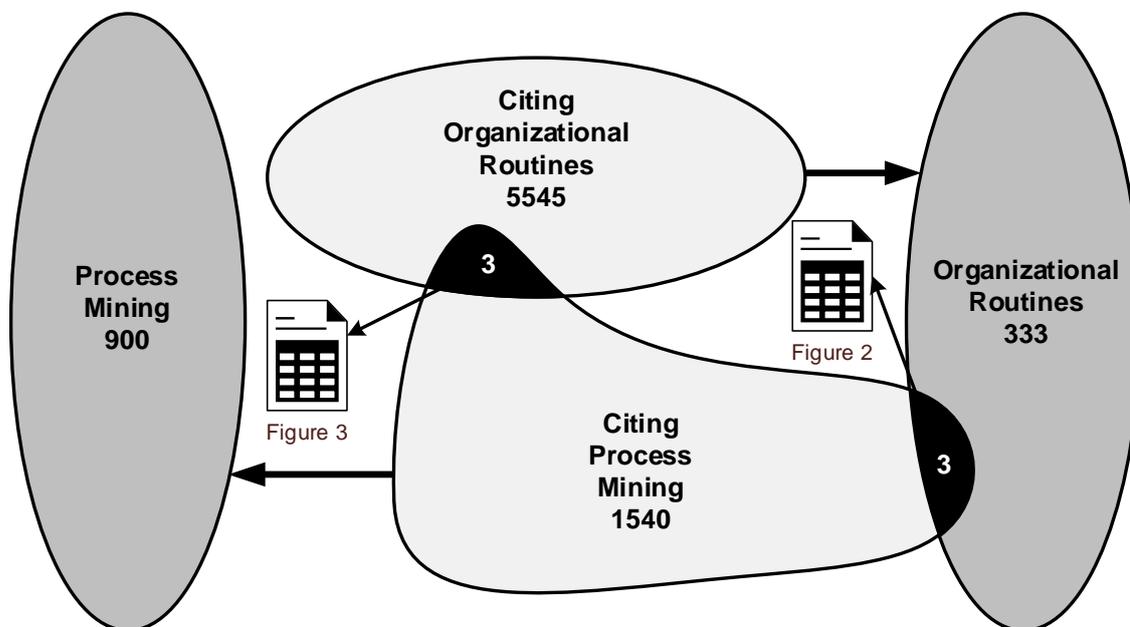


Figure 1. Bibliographic analysis of process mining and organizational routines publications in Scopus

All articles from Scopus have also been identified with Google Scholar. Thus, the total number of articles representing the interconnection between process mining and organizational routines, as measured by this literature search, is nine. These articles have been further analyzed manually in order to identify their relationships to either of the research fields. Consistent with the results from Scopus, we found only two types of articles. The first six are those belonging to organizational routines but citing process mining, the other three are those citing both but not belonging to any of the fields.

The description of the details regarding the articles’ topics and especially their relation to either field is summarized by the two subsequent figures. Figure 2 exhibits a timeline of those articles from the field of organizational routines that cite process mining. Figure 3 visualizes a timeline of those articles

citing both organizational routines and process mining while the article itself could not be classified as belonging to any of the two fields.

	Article	Content	Relation to process mining
2007	Singh (2007)	The author discusses process modeling in the service industry and provides suggestions for improvement. The recommendations are derived from perceiving processes as organizational routines.	One of the suggestions is to frequently update process models, and process mining may provide the means to do this. His references are van der Aalst et al. (2003) and van der Aalst and Weijters (2004).
2008			
2009	Pentland et al. (2009)	The authors advocate the use of workflow management systems as a rich data source for empirical research in the field of organizational routines and give an example.	They emphasize that process mining scholars have used workflow data for a long time to analyze workflows, and that organizational scholars should do so too. They reference van der Aalst and Weijters (2004) and van der Aalst et al. (2003).  Referencing van Dongen and van der Aalst (2005), they deem standards for representing workflow data as well as freely available tool support to analyze it to be interesting.
2010			
2011	Pentland et al. (2011a)	The authors analyze invoice processing routines in four Norwegian organizations using event data. They reflect their findings against the backdrop of organizational routines as an empirical science.	Referencing van der Aalst and Weijters (2004) and van der Aalst et al. (2003), they recognize process mining as a discipline that is concerned with creating formal models from workflow data. However, they consider their techniques inapplicable as they believe organizational routines to be too noisy and unstructured to be analyzed using formalisms such as petri nets.
	Pentland, Haerem, and Hillison (2011b)	The authors use event data of four invoice processes to test and compare two theories. One predicts routines to be stable over time, with atypical data being the result of atypical inputs; the other predicts the opposite. Their data suggest the latter is true.	They reference van der Aalst and Weijters (2004) while discussing implications of their work. Process mining might help to better deal with variability as it provides more sophisticated techniques for checking process conformance.
2012	Pentland et al. (2012)	The authors develop a theoretical, formal model of how organizational routines emerge. It is based on markov chains and explains mechanisms such as variation, retention, or selection, which are meant to describe how routines evolve over time.	In this article, process mining is briefly mentioned as a field concerned with analysis of business processes. The authors cite van der Aalst et al. (2007).
	Gaskin, (2012)	This dissertation is concerned with analyzing design routines in organizations, for instance in product design. The goal is to describe a routine's structure and its evolution.	Process Mining is mentioned as a related field, but is not discussed any further. The author references van der Aalst (2011).

Figure 2. Timeline of articles from the field of organizational routines citing process mining.

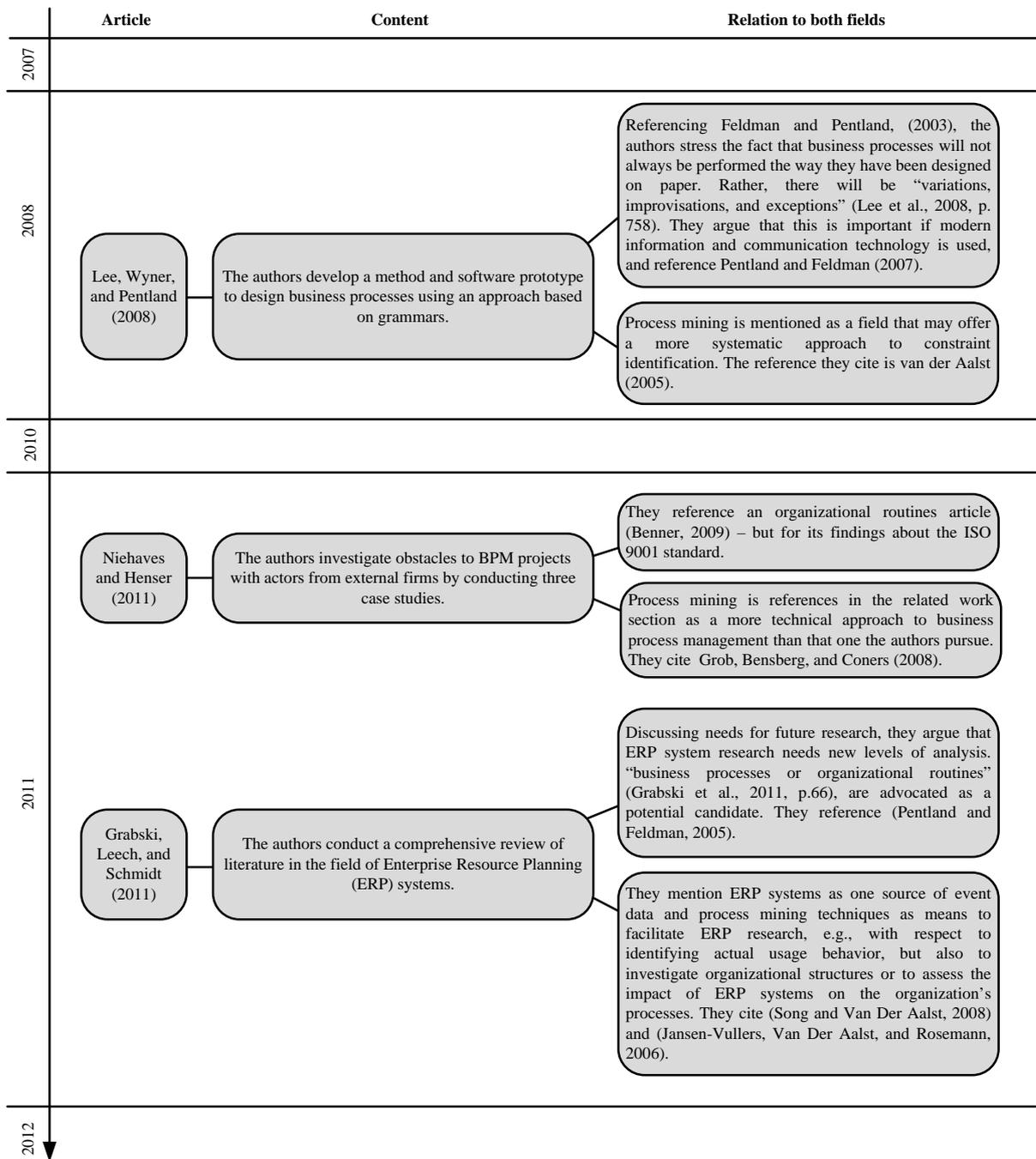


Figure 3. Timeline of articles citing organizational routines and process mining, but not belonging to any of these fields.

### 4.3 Discussion

The analysis reveals that of the six organizational routines articles citing process mining, four are authored by Pentland and another (Singh, 2007) by one of his PhD students. Moreover, Pentland coauthored one of the other three articles. Although he is also the most important author of this field, as measured by number of articles found in Scopus (he (co)authored 12 articles, the second author is Feldman with 10 articles), this can be considered an indicator that process mining is far from widely known among organizational routines scholars. The connection appears to be established via a single author only. Apart from this apparent however yet important observation, we conclude three implications from the study of the identified literature at the intersection of organizational routines and process mining.

*Event log data from information systems constitutes a valuable additional data source for the study of organizational routines.*

The common way of data collection for studying organizational routines comprises methods such as interviews, document analysis, or action research (Becker and Zirpoli, 2008). All these are time-consuming and thus expensive because they require for the participation of the performers of the activities under study. Additionally, all these methods come with the risk that the performers' description of how the routines' performances may differ from how the routines are performed in fact and that the description may be incomplete. Accordingly, organizational routines researchers yet acknowledged that event log data constitutes a promising additional data source (Pentland et al. 2009). However, our review indicates that these recommendations were not yet accepted.

*Process mining approaches can help dealing with variability of organizational routines.*

Recent organizational routines studies show a great interest in the ostensive aspect of the routines, e.g. when trying to derive a general understanding from the observed behavior including the analysis of the dynamics of the routines (Pentland et al. 2012). Here, process mining techniques could make helpful contributions. This includes the availability of frequently updated models of the processes (Singh 2007) as well as approaches for checking process conformance with actually observed behavior (Pentland et al., 2011b).

*Process mining approaches require adjustments for the study of organizational routines.*

Apart from merely mentioning the existence of process mining, Pentland criticizes it for its inability to be applied in a very unstructured setting with noisy data and frequent variations from rules (Pentland et al., 2011). And indeed, these are challenges not properly addressed by the early process mining techniques he references (Van der Aalst and Weijters, 2004; van der Aalst et al., 2003). Even in recent articles, noise and incompleteness are considered to be challenges (Van der Aalst, 2011). Process miners ask how outliers and atypical behavior can be removed from data or dealt with in algorithms, and how business processes with an exponential number of traces (performances) can be mined when only a tiny fraction is observed.

But these questions are not only asked but also worked on, and process miners have made good progress (Breuker and Matzner, 2013). For instance, the HeuristicsMiner (Weijters et al., 2006) or Fuzzy Miner (Günther and Van der Aalst, 2007) have been put forth to deal with noisy data. On the one hand, these results could be interesting for organizational routines to enrich the toolbox available in empirical studies. On the other hand, techniques such as the markov chain models (Pentland et al., 2012) Pentland uses instead might be worth a second try in the field of process mining. Optimal matching, a sequence analysis technique that originated from computational biology, has already been

rediscovered independently by organizational routines (Salvato, 2009) as well as process mining scholars (Bose and Van der Aalst, 2012).

The goal must be to learn from each other instead of reinventing the same techniques separately. We could only speculate if the observed separation is due to the different academic disciplines the involved researchers subscribe to and the different publication outlets they address. However, as IS researchers we consider the transfer of methods and tools between the fields to be a highly promising and innovative inter-disciplinary research topic to work on. It must be subject to future work to further elaborate on the particular premises of such transfer.

## 5 Conclusion

This paper analyzed the literature on organizational routines and process mining with the intention to gain first insights on common ground and differences in research questions, tools and method, as well as to investigate the relations between publications in the two fields. A first result of our literature review is that both fields are well established: Google Scholar delivers 5,990 hits on “process mining”, 18,200 hits on “organizational routines”, and 4,240 hits on “organizational routines”. Despite of many false positives this indicates an enormous body of literature, which is confirmed by the Scopus numbers (900 for “process mining”, 333 for “organizational routines” due to smaller coverage).

A second result was achieved from a discussion of the prevalent research problems and research questions in process mining and organizational routines research, because research in both fields exhibits quite some similarities: Both look into sequences of activities from individual performances/instances with the intention to discover underlying patterns. Again in both fields alike, researchers investigate the dynamics and compare single performances with processes/routines with the intention to identify deviations from prescribed or established behavior. Therefore the same kind of data (event sequences) is tapped into.

On the contrary, the research in the two investigated fields differs as regards data collection and data analysis. To our observation, organizational routine research often does not exploit the plethora of data logged by information systems which denotes actual performances of a routine while “conventional” data collection techniques such as questionnaires and observations are favored instead. The same holds true for the data analysis: we illustrated that the algorithmic mining procedures differ substantially from optimal matching or markov chains as preferred by researchers in the field of organizational routines research – although in most cases techniques from either fields would also be well applicable to study the research question.

We hypothesized that one root cause of this separation could be a separation of the research communities which then would also manifest in separated strands of publications. Accordingly, the structured literature analysis finally revealed a very weak connection of the two fields. We found only three articles citing organizational routines and process mining publications at the same time and six on organizational routines that refer to process mining. These results suggest that the interrelations of the fields should be examined more thoroughly; researchers may learn a lot if considering the work from the counterpart. And therefore this paper will be the opener for subsequent research that will focus on the adoption, modification, and evaluation of process mining approaches for the study of organizational routines. Challenges to be met in that process such as handling of noisy and incomplete data could be briefly touched upon in this paper only.

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