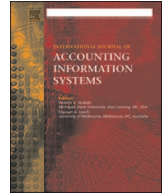


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## Financial process mining - Accounting data structure dependent control flow inference



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### ABSTRACT

The increasing integration of computer technology for the processing of business transactions and the growing amount of financially relevant data in organizations create new challenges for external auditors. The availability of digital data opens up new opportunities for innovative audit procedures. Process mining can be used as a novel data analysis technique to support auditors in this context. Process mining algorithms produce process models by analyzing recorded event logs. Contemporary general purpose mining algorithms commonly use the temporal order of recorded events for determining the control flow in mined process models. The presented research shows how data dependencies related to the accounting structure of recorded events can be used as an alternative to the temporal order of events for discovering the control flow. The generated models provide accurate information on the control flow from an accounting perspective and show a lower complexity compared to those generated using timestamp dependencies. The presented research follows a design science research approach and uses three different real world data sets for evaluation purposes.

### 1. Introduction

Data explosion (Krcmar, 2010) and information overflow (van der Aalst, 2011a) are well known phenomena that accompany the increasing integration of information technology into society and business. The availability of large amounts of digital data provides extensive opportunities for novel data analyses. This study focuses on the analysis of large data sets in the context of financial audits.

Financial audits are carried out by external auditors. They are an important control mechanism in order to enable stakeholders - such as investors or financial analysts - to make decisions based on information that provides a true and fair view of the financial position and performance of the reporting entity. The availability of abundant digital data opens up new ways for improving financial audits. However, it also introduces new challenges to the audit profession as it requires additional skills to deal with data that exhibits characteristics which are commonly discussed under the term Big Data (Chen et al., 2012) in academia and society.

Financial year-end audits encompass different audit activities. An important aspect in contemporary risk-based audits is the testing of internal controls over financial reporting (Rittenberg et al., 2008). In order to be able to assess the effectiveness of internal controls the auditor has to gain an understanding of how the internal controls affect the business processes in an organization. The activities carried out in order to process business transactions create the entries in the financial accounts. An auditor requires an understanding of how the audited entity's internal controls, business processes and financial accounts relate to each other in order to be able to carry out a financial audit effectively. The International Standard on Auditing 315 (Revised) requires that

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“the auditor shall obtain an understanding of the information system, including the related business processes, relevant to financial reporting (...)” (IFAC, 2012, sec. 18)<sup>1</sup>.

The rationale to audit business processes, related internal controls and information systems is the assumption that well-controlled processes lead to complete, accurate, valid and authorized postings on the financial accounts.

The audit of internal controls becomes more complex with the increase of computer technology that is used for transaction processing. Processes become more complex, are automated and generate amounts of data which can hardly be handled with traditional audit procedures. The results are large data sets that form the basis for the preparation of financial statements which the auditor has to issue an opinion upon.

Data analytics can be used to deal with large data sets. Yet, they are rarely used in the context of financial audits. Scientific publications related to the analysis of large journal entry data sets are almost absent.<sup>2</sup> The study at hand focuses on process mining as a novel data analysis technique to improve process audits as part of financial statement audits.

Process mining is a specific data analysis technique that uses recorded event log data to provide information about business processes. Process mining algorithms produce models by analyzing the available source event logs. They can potentially be used in the context of financial audits to create reliable process models for audit purposes effectively and efficiently. During the testing of internal controls auditors assess if the business processes that lead to the entries in the financial accounts are well controlled in order to ensure that only complete, accurate, valid and authorized transactions are recorded. Auditors, for example, assess if a procurement process is properly controlled to ensure that material postings to the relevant financial accounts, such as raw materials or trade payables, are correct.

The type of information needed for process audits is contemporarily collected manually in a time-consuming and error-prone way. External auditors traditionally employ manual audit procedures like interviews and the inspection of source documents during process audits. The application of process mining techniques would enable the auditor to generate reliable process models as a source of information automatically. It would make manual data collection procedures for this purpose obsolete. Instead of collecting relevant information via interviews during walkthroughs and the inspection of a very limited number of sampled source documents, process mining can potentially be used to produce reliable process models automatically by considering the entirety of recorded transactions. Related to the aforementioned example of a procurement process, auditors would not need to carry out time-consuming and error-prone interviews. Instead, they could use process mining techniques to create models of the procurement process based on the actually recorded event data. Automating the model generation would set free resources that could then be spent on the actual testing of internal controls and detected deviations from standard procedures.

Process mining projects are commonly carried out in different stages (van der Aalst et al., 2012): planning and justification (stage 0), data extraction (stage 1), connecting the event log and creating the control flow (stage 2), the creation of integrated process models (stage 3) and operational support (stage 4). This study focuses on the determination of the control flow (stage 2).

In order to be useful for process audits the mined models have to represent the underlying data correctly and they must be readable to the auditors. The control flow provides information about the structure of a process. It describes the sequence of activities that are carried out within a process. Contemporary general purpose process mining algorithms use the temporal order of events to infer the control flow in mined process models. They require a specific structure of the event log (van der Aalst, 2011a, chap. 4.2) in order to operate correctly. Data from common source systems like Enterprise Resource Planning (ERP) systems usually do not store financially relevant event data to serve as input for general purpose process mining algorithms. Gehrke and Müller-Wickop (2010) introduce a technique that allows to create an event log from ERP source data by exploring specific data relationships between journal entries. Their approach is promising because it uses the universal structure of accounting data which is in principle independent of the ERP system used for transaction processing.

The algorithm introduced by Gehrke and Müller-Wickop (2010) maintains the original data structure, but at the cost that the generated event log is not suitable for traditional general purpose mining algorithms. A main difference compared to traditional event logs is the characteristic that traces<sup>3</sup> in these types of event logs are not linear. In traditional event logs all events are strictly chronologically ordered. This means that each event has exactly one or no predecessor and one or no successor. This is not the case for financially relevant data that served as input for this study. The purchase of two different goods, for example, is often paid by a single payment. If an event log containing non-linear traces is used as input for traditional general purpose process mining these create overly complex models that, from an audit perspective, do not provide the necessary information required by the auditor<sup>4</sup>. The questions arise of how an event log, created on source data from ERP systems by exploiting the general structure of journal entries, can be used in order to infer the control flow of mined models? And how can this be done by simultaneously maintaining information on the relationship between business processes and the financial accounts?

This study answers these questions by introducing an alternative approach to infer the control flow. The creation and linkage of the event log itself is demonstrated by Gehrke and Müller-Wickop (2010). The main contribution of the study at hand is the

<sup>1</sup> Similar requirements can be found in national audit standards such as the Auditing Standard No. 12 (PCAOB, 2010) or the IDW-PS 261 (IDW, 2009).

<sup>2</sup> Debreceny and Gray (2010) conclude that a large body of literature regarding data mining does exist in various application domains, but their study reveals that there is no literature related to data mining on recorded journal entries.

<sup>3</sup> A single execution of a business process is called process instance. They are reflected in the event log as a set of events that are mapped to the same case. The sequence of recorded events in a case is called trace.

<sup>4</sup> The event log can be transferred into a strictly linear event log as shown by Müller-Wickop and Schultz (2013) but this approach introduces the duplication of events and neglects the implication for data values that represent the entries on financial accounts.

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