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Faculteit Bedrijfseconomische Wetenschappen

master handelsingenieur in de beleidsinformatica

Masterthesis

Categorizing detected process deviations by analyzing risk assesment tables

Mathias Luyten

Scriptie ingediend tot het behalen van de graad van master handelsingenieur in de beleidsinformatica

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Prof. dr. Mieke JANS

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Categorizing detected process deviations in risk assessment tables [1]

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Abstract

Financial auditing could benefit from using process mining techniques in order to examine much more financial data and make a big step towards continuous auditing. This paper investigates the applicability of conformance checking, a process mining technique, in the field of financial auditing. Conformance checking is able to detect deviations to a process model, but the amount of deviations will be too large for auditors to examine manually. A proposed solution is grouping these deviations into categories which are meaningful for auditors and connect to their domain knowledge. To link this proposed solution with control testing, a phase where conformance checking will be a valuable tool, we investigate to what extent the controls used by auditors are process oriented.

In order to do this, we examine risk assessment tables which serve as a template for Belgian auditors. In those risk assessment tables, possible risks are listed along with their suggested internal control measures. 115 of 202 internal control measures are process oriented, these are further investigated. As these control measures are written as a set of rules, they can seen as a declarative process model. The process oriented control measures can be divided into four different categories of declarative rules. When applying conformance checking on these rules, the different violations to these declarative rules can be seen as deviations from the process. Some deviations could have a more severe impact than others. By grouping these deviations into deviation categories, more information about the violated rules is provided to the auditor. By analyzing deviation groups found in literature, we found that

[1] This master thesis was written during the COVID-19 crisis in 2020. This global health crisis might have had an impact on the (writing) process, the research activities and the research results that are at the basis of this thesis.

some categories are more useful in this particular auditor case than others.

Keywords: Financial Auditing, Process Mining

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1. Introduction

This paper is situated in the context of using process mining techniques in the field of financial auditing. The existing process mining techniques are considered to be promising for auditing, like for example conformance checking (Hosseinpour and Jans, 2018). This is the process of comparing an entire set of process executions, called an event log, to a prescribed business process. This enables the discovery of process deviations with the whole data set taken in consideration. Nowadays only a sample of process executions is used to compare with the business process to check the conformity of the process. Being able to do this with the whole set of executions is a big step towards continuous auditing. Continuous auditing is an automated method for performing auditing activities on a more frequent basis. It is the most detailed form of audit which looks at all process executions and evaluates them near real time (Chan and Vasarhelyi, 2018). Conformance checking, as part of process mining, could be used to check every process execution for deviations. Such a deviation is defined as a process execution that deviates from the prescribed business process. Being able to check every process execution for deviations brings many new possibilities, but it also generates a challenge. It will reveal an enormous amount of deviations, which results in an outcome that's not feasible to investigate manually in the setting of an audit engagement. This high number of deviations is expected because of the complexity of the information systems and the dynamic flexibility that is required by process users (Alles et al., 2008).

A proposed solution for this problem is the categorisation of the detected process deviations (Hosseinpour and Jans, 2016). Grouping the detected process deviations into meaningful categories for the auditor could decrease the amount of alarms raised by applying conformance checking and thus making it a viable tool for auditors. In a literature study, possible categories for grouping these deviations have been researched (Hosseinpour and Jans, 2018). A deep dive into this research is situated in the background section of this paper. The process deviation categories suitable for financial auditing are: skip an activity, insert an extra activity, replace one activity by another,

swap two activities, repeat an activity, and execute an activity in a loop.

Besides reducing the amount of alarms, the grouping of process deviations into categories should also be presented to the auditor in a way familiar to his knowledge. As we know from cognitive fit theory, the correspondence between task and information presentation format leads to superior task performance for individual users (Vessey and Galletta, 1991). As we apply this theory to auditing, this theory can be explained as follows. The way of presenting information to the auditors effect the way they will process the information (Bierstaker et al., 1999).

Research has shown that auditors have difficulty proposing possible explanations for financial statement discrepancies. One source of this difficulty is that auditors may represent analytical procedure problems incorrectly. Reason for that is that their mental image of the problem does not contain the underlying cause of the discrepancies (Bierstaker et al., 1999). This means that it is important to classify deviations into categories that connect to the auditor's mental presentation of domain knowledge. Therefore, meaningful categories of process deviations for auditors are a prerequisite for enabling conformance checking as a tool for financial auditing.

As explained earlier, an alignment between task and information presentation will lead to superior task performance. Understanding the way auditors work and think is the key for achieving this alignment. To get this understanding, we take a look at risk assessment tables, an instrument used by auditors for internal control testing, which will contribute to their expression on the fairness and correctness of the financial statements of an organisation. In this paper, we investigate whether there are process deviation categories present in current best practices of internal control testing. In order to do so, we examine risk assessment tables used in the internal control testing phase. While testing controls, auditors check to what extent risks are mitigated by using control measures. We try to answer the following research questions: "To what extent are existing control measures process-oriented?", and for those controls: "To what kind of process deviation categories can they be related?"

To address our research questions, generic risk assessment tables as part of control testing are analysed. The tables used in this study are model tools

that are provided by the Belgian information center for certified public accountants (cpa), ICCI (ICCI, 2017) [2]. They are designed as a guidance for cpa's. Coming from a national institute supporting the cpa profession, we consider these as representative tools that are being used in the accounting profession. After an analysis of the controls presented in these risk assessment tables, we check to what extent they can be related to process controls. Furthermore the used process deviation categories, if any, are analysed and categorised.

Control testing, as part of the risk assessment phase in financial audit can be linked with rule testing. A set of rules can be seen as a process written in a declarative process modeling language. In the field of process modeling, there are two types of modeling languages: procedural languages, in which a closed process model is described, and declarative languages, which is an enumeration of a set of rules. Given the nature of control testing –testing the presence and effectiveness of rules–, there is link between control testing and declarative process modeling. The control measures, listed in control testing, could be seen as a list of declarative rules, in order to find a connection between the current implementation of control testing and the techniques within process mining. Conformance checking, as part of process mining, could be a valuable tool for financial auditing. When applying conformance checking, this will result in a set of deviations to a predefined process. Given the benefit to present process information that matches auditors' knowledge, it is interesting to see which type of rules are used in control measures, to see to what extent they can be linked to certain groups of deviations.

The paper is organised as follows. Section 2 provides some background on process modeling languages, conformance checking and process deviation categories. Section 3 describes the methodology to analyse a set of standardized risk assessment tables. Section 4 and 5 present the results and a discussion of our study. Section 6 wraps it up in a conclusion.

[2] https://www.icci.be/nl/publicaties-en-tools/modeldocumenten/modeldocumenten-detail-page/tool-risicogerichte-controleaanpak-in-diverse-sectoren

2. Background

In this section, some background is provided concerning process modeling languages. It is necessary to understand the differences between the process modeling languages as we link the control measures to a set of rules in a declarative process model, rather than a procedural process model. Next, we discuss what conformance checking entails and how it can be applied in an auditing scene. At last, we give an overview on existing process deviation categories in scientific literature.

2.1. Process Modeling Languages

In the field of process modeling, there are two types of process modeling languages: procedural and declarative modeling languages (Maggi et al., 2011). Procedural process models are based upon a prescribed process, which is rather fixed. They have an "inside-to-outside" approach, meaning all process execution alternatives need to be explicitly specified in the process model. The traditional flow charts are an example of this model class. Declarative process models, on the other hand, aim to provide freedom without restricting users unnecessarily in their actions. They use an "outside-to-inside" approach, meaning anything is possible, unless explicitly forbidden in the form of business rules. A declarative process model does not start from a prescribed process. It starts from a blank canvas, with certain rules, called restrictions. This means that every process is possible, with the exception of paths that go against the declared rules (Maggi et al., 2011).

2.2. Conformance checking

Conformance checking is a process mining technique that enables the discovery of process executions that are not conform the expected process. The expected process is often described in the form of a procedural process model (Van der Aalst et al., 2012). However, comparing process executions against a declarative process model, i.e. a set of business rules, is another form of conformance checking. This is done by collecting the entire set of process activities as happened in reality, called an event log. Next, all process executions, or traces, within this event log are identified by linking connecting process activities to each other. Consequently, a trace is a unique sequence of activities in the log (Jans et al., 2014). At last, all the discovered traces are compared to the prescribed process model or business rules to reveal deviations (Hosseinpour and Jans, 2018).

2.3. Process deviation categories

In business process mining literature, there are three different papers that propose deviation categories. Each of the identified studies has a list of different process deviation categories. Often these categories detect the same kind of deviation, but under a different terminology. Examination of this literature reveals that there are six process deviations categories that fit in the field of financial auditing (Hosseinpour and Jans, 2016).

The process deviation categories of relevance to auditing are: skip an activity, insert an extra activity, replace one activity by another, swap two activities, repeat an activity, execute an activity in a loop (Hosseinpour and Jans, 2016).These deviation categories could be useful categories for grouping deviations detected by using conformance checking. Process executions can also deviate from the expected model by other values, for example values of certain documents could vary. However, this is not the scope of this research. We focus our study on the sequence of events, only to turn to other deviations in a follow-up study.

3. Methodology

To further discover the applicability of conformance checking in financial auditing, we investigate whether existing controls that are used by auditors are process-oriented. Afterwards, if process-oriented controls are identified, we investigate whether deviations of those controls can be grouped in meaningful process deviation categories that relate to the auditor's knowledge.

3.1. Research approach and method

To answer our research questions, we have chosen for a qualitative research approach, because qualitative research is an approach that involves discovery and is the typical respond to research questions requiring textual data. (Williams, 2007). We use a content analysis study, which is defined as a detailed and systematic examination of a particular body of materials, in our case control measures. A content analysis study reviews forms of human communication such as books and has the purpose of identifying patterns, themes, or biases (Williams, 2007). More precisely, we analyze control measures used in control testing, situated in risk assessment tables that serve as model templates for auditing firms in Belgium.

3.2. Research instrument

The control measures that are described in risk assessment tables and are used as input for our research are collected from the website of ICCI, the Belgian information center for company auditing. It is established in 2001 as a helpdesk for cpa's who need support when confronted with problems of technical or juridical nature. One of the tools that ICCI provides are model documents. These models serve as practical working tools for cpa's. Among these tools are templates of risk assessment tables. We use these tables as research instrument to investigate the process deviation categories that are typically investigated during the risk assessment phase of an audit engagement. We used five different risk assessment templates, each linked to their own process: sales, purchases, payroll, inventories and treasury & investments.

Each of the risk assessment templates consists of recognized business risks, accompanied by desired internal control measures. An internal control measure, as defined in auditing, are the mechanisms, rules or procedures implemented by a company for assuring the integrity of their financial statements. In order to check whether existing control mechanisms are process-oriented controls, we analyse the desired internal control measures.

3.3. Coding scheme

In the following section, the coding of our data set will be discussed step by step

3.3.1. Generalization of control measures

The five templates consist of risks and desired control measures applicable to all sectors, as well as certain control measures specifically for certain sectors like for example the car industry, construction industry or retail. In the further analysis of these templates, we will only focus on the control measures applicable to all sectors, to obtain generic results. A dive into certain sectors could be insightful for further research. In order to filter the control measures from specific sectors, we code every control measure from the general sector with 1 and a 0 to controls from a specific sector. The control measures with a 0 will be filtered out in further steps

3.3.2. Filtering process-oriented control measures

The goal is to investigate whether there is a link between the control measures and the six process deviation categories, listed above (skip an activity, insert an extra activity, replace one activity by another, swap two activities, repeat an activity, execute an activity in a loop). To reach that goal, we start with a check whether the internal control measure has a process notion. A business process is a structured set of activities, designed to produce a specific output (Davenport, 1993). We define a control measure to have a process notion when it involves one or more activities of a business process. The same procedure as the previous step is applied for selecting the control measures with a process notion. For each control measure, the question will be asked 'Has this control measure a process notion?". When yes, it is coded as 1, if no coded as 0. Control measures with a 0 will be filtered out in the next steps.

3.3.3. Restriction categories in declarative language

We investigate the process deviation categories that might be present in control testing tools. Since these tools refer primarily to rules that need to be adhered to, we link control testing to declarative process modeling. As described in the background section, declarative languages consist of a set of rules or restrictions that must be respected. In the Declare language, the most developed declarative language, the possible restrictions can be grouped in four different templates: existence, relation, negation and choice (Maggi et al., 2011).

An existence restriction applies to only one event (this means one step in the process) and defines the cardinality of that event in the process instance. For example one event should exist at least once in the process instance. Where existence describes the cardinality of one activity, a relation restriction defines the dependency between multiple activities (Pesic, 2008). An example of such relation is 'response' which means that if activity A is executed, activity B has to be executed after it. Negation restrictions are negated versions of a relation, for example a not response restriction between A and B means that if A happens, B cannot happen afterwards. At last, a choice restriction specifies the necessity to chose between several activities that are mutually exclusive. Each of these four different types has many formulas for further defining the specific restriction rule. In this study, however, we only use the high-level restriction rules.

As next step, we investigate which control measures with a process notion relates to which of the four restriction categories. All control measures are checked and coded along these categories. The coding will be done as followed: each control measure with a process notion will be matched with one of the four types of restriction rules. As these four categories include all the possible restriction rules, the coding of the control measures will be mutually exclusive. When the control measure matches with a type of restriction rule, it gets coded as 1, when not matched it gets coded as a 0. An existence rule in this case will be a rule that involves only one activity. A relation rule is defined as a rule that consists of at least two activities and involves the relation between them. A negation rule is a rule that forbids a certain activity to happen. A choice rule is a rule that enforces a choice between two or more activities.

3.3.4. Linking with process deviation categories

After the list of desired internal control measures is coded along the four categories of declarative restrictions, we investigate whether it is possible to link this with process deviation categories, as found in literature. We will use the six process deviation categories, as earlier described in this paper. We will investigate which of the process deviation categories are able to detect violations to the different types of restriction rules, if any. This is a valuable step because it gives more insights in which process deviation categories relate to the auditors way of thinking when applying control testing. The coding will be done by creating a table that matches the four types of restriction rules on one side, and the six process deviation categories on the other side.

4. Analysis

The input of our analysis are five risk assessment templates, provided by ICCI. We focus on the desired internal control measures, listed in those templates. In this section we will provide an overview of the outcomes of applying the code scheme, as described in section 3.3, to the list of desired internal control measures.

4.1. Applying generalization

As first step, the control measures not applicable to the general sector are filtered out. When taking all five templates into consideration, this sums up

to a total of 307 internal control measures. Of those 307 control measures, 208 are applicable to all sectors. The remaining 99 control measures are specifically designed for a certain sector and are not included for further analysis. The analysed data is thus narrowed down to 208 internal control mechanisms.

4.2. Applying process notion filter

As second step, the 208 measures were coded on their process notion. As previously discussed, we define a process notion as a rule that involves one or more activities. When applying this rule to the list of remaining control measures, this results in a total of 115 internal control measures with a process notion. For further analysis we are focusing our research on the control measures which are applicable to all sectors and have a process notion. The following analysis will thus be executed on the remaining 115 control measures.

4.3. Applying restriction categories

In a third step, we assign each of the remaining control measures to one of the restriction categories. The results are presented in Table 1. Of the 115 control measures, 79 are related to the existence category. These are all rules concerning one specific activity like for example 'The system automatically generates sales invoices for all imported sales orders.' This can be transferred to the rule 'the activity 'generate sales invoice' has to happen at every instance of a sales order'.

Of the remaining control measures, 26 are rules related to the relation between two ore more activities. An example of such a control measure is the following: 'New customers are screened and approved before being included in the system.' This specifies the tasks 'screening' and 'approval' to be necessary before the task 'include customer in system'. This rule involves the relationship between these activities and is thus classified as a control measure that relates to a relation restriction.

None of the control measures are rules related to a negation restriction. This can be clarified by the fact that all rules are written in the format of certain activities that need to happen, instead of forbidding activities.

Existence	79
Relation	26
Negation	0
Choice	10
Total process controls	115

Table 1: Applying restriction categories

The 10 remaining control mechanisms can be related to the choice category. As described earlier, the choice relationship specifies the necessity to chose between activities. When a person performs one activity, he cannot perform the other. This relates to segregation of duties. Segregation of duties is the concept of requiring multiple people to perform a series of tasks (Robin-Jan et al., 2011). This is done to prevent fraud and error, by not giving too much power to one person. An example of two tasks that require a segregation of duty, from the list of control mechanisms: billing of an order and the registration of it. Both of these tasks cannot be executed by the same person. We can relate these segregation of duty rules to the 'choice' category in declare. By dividing all 115 control mechanisms with a process notion to the 4 categories we have described, this results in the following table.

Note that the restriction type negation is not present in the analyzed control measures. This indicates that existence of an activity, relation or choice between activities is checked, rather than specifying forbidden activities. An exception is the choice restriction rule, but this is not a true negation rule.

4.3.1. Periodic existence category

Most of the rules, 79 of the 115 control mechanisms, are positioned in the existence categories. To gain more insights in this larger category, we added an extra classification by extracting the control mechanisms that have a periodic existence. These are rules of activities who need to happen periodically, like for example the rule 'Basic files are periodically checked by management.' By splitting this category existence into periodic existence and pure existence rules, we get 24 control mechanisms belonging to periodic existence. Adding this split to our table gets the following result.

Existence	55
Periodic existence	24
Relation	26
Negation	0
Choice	10
Total process controls	115

Table 2: Restriction categories with extra split on periodic existence

4.4. Applying process deviation categories

So far we haven't linked the internal control measures to process deviation categories. We used an intermediate step by linking the control measures to categories of declarative process modeling. This step was necessary because the control measures are written as rules that need to be followed, not as possible deviations. In order to link the six process deviation categories, identified in the literature review, to the categories of declarative process modeling, we will check which of the process deviation categories are able to detect violations to declarative rules, in each of declare categories.

An existence constraint can be violated by skipping the activity or by replacing it with another activity. Other deviation categories like for example 'inserting an activity' will not violate this constraint. A relation constraint could be violated by skipping and replacing one of the activities, as well as swapping the two activities. Besides, in some cases relation constraint can also be violated by inserting an extra activity, if the activities involved in the relation constraint have to happen in quick succession. Negation constraints could be violated by inserting the activity, replacing an activity with the activity described in the negation constraint, and by repeating or looping the activity. A choice constraint, where a choice between two or more activities is needed, can be violated by skipping both activities when a choice is required, inserting a forbidden activity, replacing an activity with one, and by repeating or looping a forbidden activity. Table 3 shows which process deviation categories are able to detect violations to the different declarative rules.

4.5. Useful deviation categories for auditors

We will take a closer look at some of the process deviation categories as shown in Table 3 and discuss their applicability in a declarative modelling

		Process deviation categories					
		Skip	Insert	Replace	Swap	Repeat	Loop
Restriction rules	Existence	X		X			
	Periodic existence	X		X			
	Relation	X	X	X	X		
	Negation		X	X		X	X
	Choice	X	X	X		X	X

Table 3: Process deviation categories able to detect deviations to the four types of declarative rules

setting. Table 4 shows a narrowed down version of table 3. The restriction rule Negation is left out, as it did not occur in the investigated control measures. Besides, the deviation categories Repeat and Loop are left out.

4.5.1. Replace

In a procedural process modeling setting, where a prescribed process model holds, there will be a clear difference between the deviation categories replace, skip and insert. In a declarative process model however, where all traces are possible as long as a set of certain rules hold, the category replace in which one activity is replaced by another, is not that useful. For an existence rule, there will be no difference between skipping the activity or replacing the activity by another, because the model does not specify which activity should happen after it. Remember that when a specification of which activity should happen after it is given, the rule would be classified as a relation rule. The same idea holds for the difference between inserting an activity and replacing in the case of an negation rule. We could thus argue that the process deviation category replace would only be useful in case the rule specifies a relation between multiple activities.

4.5.2. Repeat and Loop

It is noticeable in Table 3, that the process deviation categories 'Repeat' and 'Loop' have the same pattern for detecting violations to the different types of restriction rules. This confirms the finding that auditors make no difference between the process deviation categories 'Repeat an activity' or 'Loop an activity' (Hosseinpour and Jans, 2018). Auditors rather use the term 'Duplicating' for referring to an event like repeating or looping an activity (Hosseinpour and Jans, 2018). This indicates that the fact that an

activity such as 'checking invoice' happens is important to an auditor, but the fact that the activity happens once or multiple times is not important for the auditor.

		Process deviation categories				
		Skip	Insert	Replace	Swap	Duplicating
Restriction rules	Existence	X				
	Periodic existence	X				
	Relation	X	X	X	X	
	Choice		X			X

Table 4: Useful process deviation categories for detecting violations to rules in control testing

5. Discussion

In this section, our findings and considerations are discussed, as well a proposed way of working.

5.1. Findings of our study

One of the things learned throughout the research of risk assessment tables is the fact that the internal control measurements check for certain rules. This indicates that auditors search for violations of these rules, rather than deviations of a procedural model. This supports the idea of an external auditor whose concerns are more high level (DeFond and Subramanyam, 1998). The exact process model doesn't have to be followed, everything is possible as long as a certain set of rules are held. Most conformance checking techniques are defined for procedural models and are not directly applicable to declarative models since they are based on playing the "token game" while counting missing and remaining tokens. However, when confronted with a declarative process model, conformance checking is still possible to detect process deviations (De Leoni et al., 2015). When adapting alignment based approaches to deal with the large search spaces induced by the flexibility of declarative modeling, you get a powerful tool for relating observed behavior with modeled behavior (De Leoni et al., 2015). By aligning event logs and predefined declarative process models, in our case the desired internal control mechanisms, discrepancies between log and model are mediated such that observed

log traces are related to paths in the model. The resulting alignments provide diagnostics that pinpoint where deviations occur (De Leoni et al., 2015). This alignment based approach for conformance checking using declarative process models has been implemented in ProM, a powerful process mining tool (De Leoni et al., 2015).

5.2. Deviations and weights

With the aid of an alignment based framework violations of declarative process rules could by discovered with conformance checking (De Leoni et al., 2015). These violations could be looked at as being deviations from these rules. We could argue that some deviations of certain rules are more harmful than others. As an example we use a rule from the sales template: 'Credit notes are checked and approved before they are finally processed in the system.' This rule can be transferred to the rule 'the activity 'check and approve credit note' has to take place before the activity 'process credit note' can take place'. We could argue that a 'swap' deviation of these activities is less harmful than a complete 'skip' deviation of the 'check and approve credit note' activity. By assigning weights to those different deviations on the rules, big steps towards continuous auditing could be taken. As seen in this paper, different deviation categories are applicable for the different types of rules. Further research on determining weights to those deviation categories is necessary to further investigate the applicability of this proposed approach.

6. Conclusion

By analyzing generic risk assessment tables, made by ICCI as a template for Belgian films, we have studied whether existing controls are process-oriented. The key take away from our research is that control measurements are used to check if certain rules hold, rather than checking if a prescribed process model is followed. Using conformance checking on an event log to detect deviations to rules, could be a step towards continuous auditing. The categorization of these deviations could be a great tool to handle the amount of deviations that would be found. For each type of restriction rule, in this case the control measure, different categories of deviations are possible. By assigning weights to each of the different deviations, more information about the deviations and how severe they are, will be provided to the auditor. Further research in this field could be situated around the topic of the determination of weights to these deviations.

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