



PROCESS MINING: ADVANTAGES AND DISADVANTAGES IN THE PROCESS OF PROCUREMENT TO PAY FOR INTERNAL AUDIT AND INTERNAL CONTROLS

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Resumo/Abstract

The objective of this study is to apply process mining techniques in the fields of internal audit and internal controls. Specifically, this involved the creation of implementation flows and data analysis, as well as the assessment of advantages and challenges inherent in the purchasing and accounts payable process. To achieve these objectives, the method chosen was a case study, and the object of analysis was a Brazilian publicly-traded company in the textile industry. Some steps for this study were considered, such as process mapping, risk mapping and the classification of such risks, data extraction, insertion of these data in the process mining tool, refinement and adjustments of the false positives presented, data analysis, analysis of segregation of duties, performance indicators, and triangulation of the results through interviews with the participants of the process to assess the advantages and challenges presented in the model. The results of this study demonstrate the implementation and data analysis flows, as well as the assessment of the advantages and challenges faced to apply the model, and how its adoption can help the internal audit and internal controls departments in the execution of their activities. As these techniques can be applied to the entire population, it is possible to have a better direction of the execution of the work performed by the internal audit, as well as greater efficiency in the focus of where the improvements can be made, in addition to the activities being carried out on a timely basis, in a more proactive fashion.

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ABSTRACT: The objective of this study is to apply process mining techniques in the fields of internal audit and internal controls. Specifically, this involved the creation of implementation flows and data analysis, as well as the assessment of advantages and challenges inherent in the purchasing and accounts payable process. To achieve these objectives, the method chosen was a case study, and the object of analysis was a Brazilian publicly-traded company in the textile industry. Some steps for this study were considered, such as process mapping, risk mapping and the classification of such risks, data extraction, insertion of these data in the process mining tool, refinement and adjustments of the false positives presented, data analysis, analysis of segregation of duties, performance indicators, and triangulation of the results through interviews with the participants of the process to assess the advantages and challenges presented in the model. The results of this study demonstrate the implementation and data analysis flows, as well as the assessment of the advantages and challenges faced to apply the model, and how its adoption can help the internal audit and internal controls departments in the execution of their activities. As these techniques can be applied to the entire population, it is possible to have a better direction of the execution of the work performed by the internal audit, as well as greater efficiency in the focus of where the improvements can be made, in addition to the activities being carried out on a timely basis, in a more proactive fashion.

Keywords: Process Mining, Continuous Audit, Internal Control, Internal Audit.

1. INTRODUCTION

The growing technological evolution in companies and in our daily lives has brought changes in the ways of working. Today, automated processes perform activities that were previously carried out manually, resulting oftentimes in greater efficiency and reduced costs. The same is true in the field of auditing, where the evolution of information technology has rapidly changed the auditing scenario and profile (AICPA, 2015). This evolution in the way audits are performed has contributed to the conceptual development of new tools related to such areas as data analysis, process mining, continuous auditing, and continuous monitoring.

In the last few years, there has been great progress in the creation of new laws and regulations, spurred by the financial scandals of the past decades involving accounting fraud in financial statements. Standardization seeks to protect the control environment, which is no more than a set of standards, processes and structures that provide the basis for the application of internal control throughout the organization (COSO, 2013).

Within this context, one of the most relevant standards issued in recent decades was the Sarbanes-Oxley Act (SOx), approved in 2002, which applies to companies that trade their shares on the U.S. Stock Markets and aims to ensure compliance in the internal controls environment, in addition to bringing greater reliability in the financial statements for investors, with the assessment of the effectiveness and efficiency of their business processes (Assi, 2012). Business processes consist of a mechanism to oversee how work is performed in an organization and ensure consistent outcomes and seize opportunities for improvements in task execution (Dumas; La Rosa; Mendling & Reijers, 2013).

The increasing regulation of the activities of publicly-traded companies, in addition to the need for greater transparency in financial statements, has meant that internal auditing has an important role in this process, as it is an independent area that reports to the Board of Directors



or the Audit Committee. With the growing regulation of publicly-traded companies and the heightened demand for transparency in financial reporting, internal auditing has become a critical component of the process, as it is an independent area that reports to the Board of Directors or the Audit Committee. By definition, internal auditing is an independent and objective assessment and consulting activity, created to add value and improve the operations of an organization. (IIA, 2022). Thus, the Audit Committee acts as an advisory body to the Board of Directors and may play an advisory role, in addition to other typical internal audit activities.

Due to this scenario of rapid changes, internal audit also needs to evolve and focus on advisory activities (Deloitte, 2020), that is, to expand and modify the way companies perform audit work, constantly seeking improvements in processes in order to add value to the business. For this to materialize, it needs to seek more efficient ways of carrying out the work, identifying new methodologies and technologies.

A current technology that can help internal audit in directing activities by identifying possible weaknesses in the process with a predictive assessment of support for processes and internal controls is process mining. The main objective of this technique is to discover, monitor and improve processes, extracting knowledge from event records available in information systems, demonstrating where processes are deviating from the expected standard.

This study aims to explore how companies can use process mining for better data analysis and benefit from more timely process improvement. Furthermore, according to Jans, Alles, and Vasarhelyi (2013), process mining is a new and highly promising means for systematic analysis of data recorded by a company's Enterprise Resource Planning (ERP) system, which offers a way to explore the vast amount of data that is routinely collected and stored, leading to unique insights into how processes are performed in these companies (Jans; Alles & Vasarhelyi, 2013).

Since the creation of the SOx law in 2002, there have been few developments in the evaluation of internal control processes. However, the use of process mining techniques can facilitate a proactive evaluation of such processes, in contrast to the reactive role that auditing has played in recent years. Historically, internal auditing has relied on sampling tests that are sometimes randomly selected with a reactive role in detecting points. However, with the increasing volume of data in recent years, it has become necessary to develop techniques for more effective exploration of processes and timely identification of weaknesses in a proactive manner. In this context, process mining techniques can be used to support the timely and proactive detection of possible process deviations.

Given the need to deepen studies and assess new techniques with the use of new tools, this study aims to develop the flow of implementation and analysis of the data brought through the technique of process mining in practice, thus demonstrating the advantages and challenges of implementing process mining in internal audit work and internal controls.

2. PROCESS MINING

Data mining is a topic that has gained prominence in recent years. With the increasing volume of data and the possibility of tying it into systems, "process mining has emerged as the 'missing link' between traditional data mining and Business Process Management. Most data mining techniques are not process oriented." (IEEE, 2021).

As to the link between Data Mining and BPM, it is worth noting that the Data Mining technique aims to analyze datasets and summarize the data in new ways that are useful for the data owner (Van der Aalst, 2016). BPM aims to oversee how work is performed to ensure consistent outcomes and identify opportunities for improvement. BPM manages the entire chain and not individual activities. (Dumas, 2013).



Thus, the goal of process mining is to transform event data into insights and actions, with data mining being an integral part of data science (Van der Aalst, 2016). According to Van der Aalst (2012) it is worth noting that the objective of process mining is also to discover, monitor, and improve processes. Process mining techniques are a means of compliance verification, allowing organizations to identify problems and possible solutions. This technique can identify potential process deviations, enabling the evaluation of its application from an internal audit and internal controls standpoint, since, by identifying process risks and the design of controls, it will be possible to evaluate process mining from this perspective.

3. INTERNAL AUDIT AND CONTINUOUS AUDIT

Internal auditing is defined as an independent and objective assessment and consulting activity designed to add value and improve the operations of an organization. The audit helps the organization achieve its objectives with the assessment of risk management, control, and governance processes (IIA, 2022). One possible methodology to add value to the organization is continuous audit, where the first approaches were in 1991, with Vasarhelyi and Halper, who reported that the evolution of IT, the emergence of big data, and the increasing use of data analytics rapidly changed the landscape and profile of continuous assurance and auditing (AICPA, 2015).

Continuous auditing emerged to make audits more timely, i.e., closer to the date of the event, and to cover a larger population, since traditional audits are usually annual audits, whose population selection is restricted, and records are extracted long after the event has occurred. To address these issues, the AICPA (2015) introduced the definition of continuous auditing in their "Red Book":

A continuous audit is a methodology that enables independent auditors to provide written assurance on a subject matter, for which an entity's management is responsible, using a series of auditor's reports issued virtually simultaneously with, or a short period of time after, the occurrence of events underlying the subject matter. (AICPA, 2015).

The adoption of continuous auditing focuses on using the benefits of automation to perform more frequent and in-depth audits (AICPA, 2015). According to some studies, continuous auditing reduces the costs of ongoing audits, as it allows for a shift from detective auditing to preventive auditing, that is, that deviations can be detected before they occur (Li; Rydl & Hughes, 2007).

Continuous auditing emerges with a bias towards automation of internal controls, in which control and risk assessments are automatically and continuously performed, encompassing all transactions. This change impacts the nature of the evidence, as well as the time, procedures, and levels of effort required by internal auditors (Li; Rydl & Hughes, 2007). The possibility of auditing processes "closer to the event" reflected the evolution of technology toward online systems in real time (AICPA, 2015).

Continuous Audit emerged in 1991 (AICPA, 2015), while Process Mining emerged in 2012. The major difference is that Continuous Audit extracts reports and crosses information (AICPA, 2015) in order to reach the results, while process mining uses logs events directly from the system to discover, monitor, and improve processes (Van der Aalst, 2021). The process is mapped within the tool, and any interaction with the flow is recorded. Process mining can be performed in real time through the direct link between the mining tool and the ERP. Both techniques aim to shorten presentation deadlines and event diagnosis by creating process monitoring.



4. METHOD

The research is characterized as a case study in a publicly-traded company in Brazil subject to Brazilian Securities and Exchange Commission (CVM) rules, whose purpose is to oversee, standardize, discipline, and develop the securities market in Brazil (CVM, 2022). The case study allows investigators to focus on a “case” and retain a holistic, real-world perspective, and to understanding a comprehensive method that covers design rationale, data collection techniques, and specific approaches to data analysis (Yin, 2015).

The research aims to conduct a descriptive case study, as it seeks to identify the advantages and challenges in implementing the process mining technique for continuous auditing and internal controls by analyzing its practical application.

For this study, the purchasing and accounts payable cycle was chosen due to its greater similarity with other industries, in addition to being a routine process that occurs in all companies, because in this way a larger number of companies may benefit from this study. The period comprised in the analysis for the application of process mining in the flow of purchasing and accounts payable is one month of data extraction, more specifically the month of July 2019, with filters applied for processes that started and ended within the same period to avoid false interpretations. In addition to the flow data analyzed, this study also includes interviews with process participants, to capture perceptions regarding the application of the model and to identify the advantages and challenges of process mining.

The interviews were semi-structured and conducted online. In total, three people were interviewed, and the duration of each interview was between one hour and one hour and thirty minutes. The interviews were recorded and then transcribed, and the transcripts were sent to the interviewees for verification.

The Business Process Management technique (BPM) technique was used for process mapping. BPM is the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and take advantage of improvement opportunities (Dumas, 2013).

For the purchasing cycle, according to BPM definitions, the cycle begins when a product or service needs to be acquired and ends when the product or service has been delivered and paid for. This acquisition process includes activities such as obtaining quotes, approving the purchase, selecting the supplier, issuing the purchase order, receiving the goods or consuming the service, and verifying and paying the invoice (Dumas, 2013).

Therefore, for the development of this study, evidence was collected from the following sources: system logs, analytical and detailed transaction research, and interviews with those involved in the process. Furthermore, for the implementation of the model, it was necessary to use a market tool, and one was chosen that allows for use in free versions for academic purposes. This tool can be acquired by the studied company should it choose to implement the studied process. There are several tools available in the market where transactional data can be imported from files or updated through interfaces, which is the connection between two systems. In this study, the version available for academic studies is the one for data import.

The chosen tool for this study was Celonis, which provides companies with a modern way of understanding their business processes through data analysis and intelligence, providing an x-ray view of the processes and identifying inefficiencies (Celonis, 2022).

The steps of this study were as follows: i) process mapping, ii) process risk mapping and classification, iii) data extraction from the studied company, iv) data insertion into the tool, v) refinement and adjustment of false positives in the tool, vi) data analysis, vii) analysis of segregation of duties, viii) performance indicators, ix) interviews with process participants, and



x) conclusion. According to Yin (2005), a protocol should contain four sections: (a) an overview of the study, (b) data collection procedures, (c) data collection questions, and (d) a guide for the case study report.

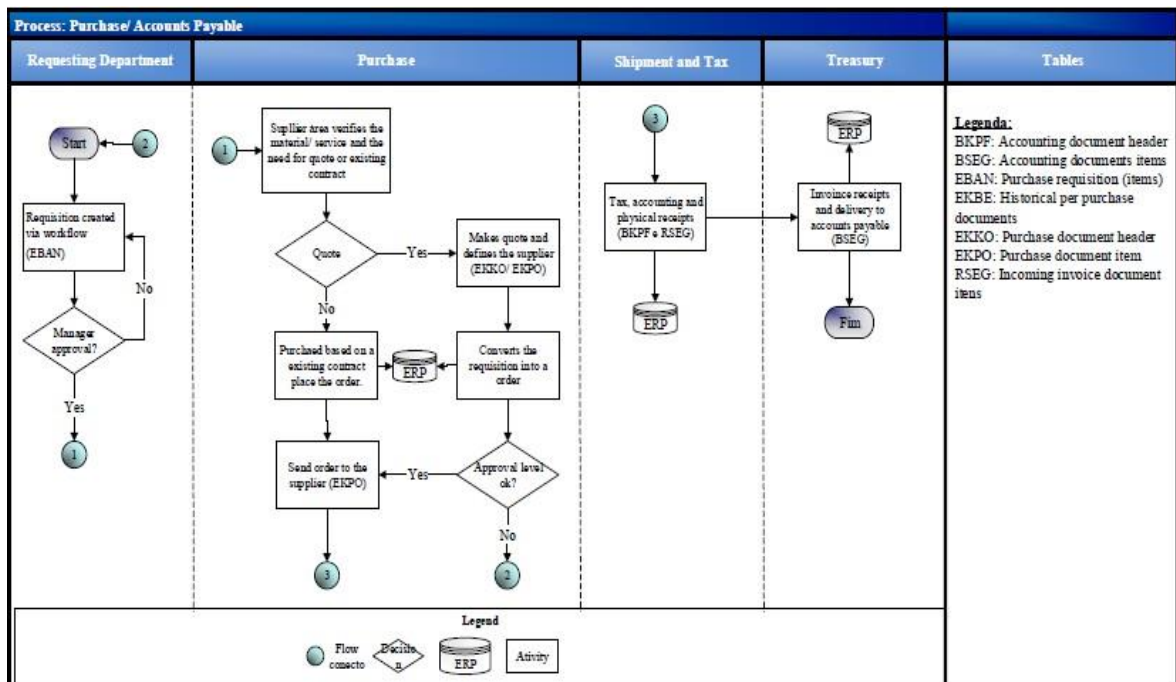
5. IMPLEMENTATION OF PROCESS MINING

5.1 UNDERSTANDING THE PROCESS

The PCAOB audit procedure numbers 2100 and 2300 require the auditor to first plan the audit, considering materiality, identifying risks of material misstatement in the financial information. After this initial assessment, the auditor is to define audit procedures with the purpose of responding to the identified risks, defining the nature, timing, and extent of audit tests (PCAOB, 2021).

The use of process mining indicates that it can be used for process discovery, compliance, and improvement, where discovery is through logs presented without prior process mapping. In the case of compliance, it compares an existing model with the logs to obtain a diagnosis, and improvement means verifying a mapped process with what occurs through logs and identifying a new model (Van der Aalst, 2012).

FIGURE 1. PURCHASE PROCESS AND ACCOUNTS PAYABLE FLOWCHART



Source: Prepared by the internal audit of the company studied

Based on the models shown above, the study was as follows: understanding the process (process mapping), identification of risks, data extraction, insertion of data into the tool, and interpretation/analysis of results. Therefore, we will apply the work planning steps suggested by PCAOB (2021) with compliance assessment by Van der Aalst (2012).

The first step was to understand the process, where the internal audit of the studied company mapped the flow with the business areas to understand the process using the BPM methodology, detailing the flow of transactions and existing tables. Figure 1 represents the mapped flow.



As showed in Figure 1, the process can initiate in 3 ways, by the requesting department, by production planning, or by the storeroom. The departments create the purchase requisition, which follows the approval flow (a). When there are requests made by the storeroom department, it is not necessary to go through this approval phase, as it is understood that a pre-approval has occurred (b).

Purchases requested by other departments or by the production planning department are sent to the purchasing department, which quotes from suppliers. Most purchases from the storeroom department already have contracts, and the purchasing department places an order with the supplier (c). With quotations made, suppliers are chosen and the purchasing department transforms the requisition into a purchase order, which is sent for approval in accordance with established authority levels (d).

After creating the purchase order, the order is forwarded to the supplier (e) who, upon sending the goods or providing the service to the company, the process proceeds to receiving the goods or services and receiving the invoice (f) and then to the accounts payable department (g).

The flow mapping becomes relevant for understanding the sequence in which the tables are presented in the system and supports the correct application of the data in the tool. In this flow, the tables used and the moment of the flow that transact in each table are all detailed.

5.2 MAPPING OF PROCESSES RISKS

Continuing with the methodology of process mining implementation and after mapping the flow, the study will proceed to risk mapping in the process and classification of it's criticality, in addition to identifying filters (controls) to be applied in the system.

In this work, some references were used for process mapping and risk identification, starting with the definition of risk, which, according to COSO, is the possibility that an event will occur and adversely affect the achievement of objectives (COSO, 2013). For each risk identified by the Company, control activities are associated, which consist of actions established by policies and procedures that help ensure that management guidelines are being followed (COSO, 2013).

For the definition and guidance of risks, the Public Company Accounting Oversight Board (PCAOB), a body that oversees the quality of work and documentation of external audit firms for publicly-traded companies in the U.S., issues some documents in order to set audit standards. One of the standards issued is number 15, Audit Standard 15 (audit procedure 15), which deals with audit evidence.

This document brings up the concept of assertions, or potential errors in the processes for issuing financial reports. The assertions are: existence and occurrence (assets and liabilities exist at the date and the recorded transactions have occurred), completeness (all transactions and accounts that should be presented in the financial statements have been included), accuracy and valuation (assets, liabilities, equity, revenues and expenses have been recorded in the financial statements at the correct value), rights and obligations (the company controls the rights to assets and liabilities are obligations), and presentation and disclosure (the financial statements are properly classified, described and disclosed) (PCAOB, 2022).

In addition to these references, the "Internal Control Toolkit," a book that details the risks and controls that large processes have (Doxey, 2019), outlines the steps of the process and the risks discovered if the company does not have controls to mitigate them. Please see Table 1 for a detailed and possible coverage of this study, evaluating the purchasing and accounts payable process.



TABLE 1. DETAILS OF THE PURCHASING AND ACCOUNTS PAYABLE PROCESS AND RISKS

Purchasing and Accounts Payable Process Controls according to Doxey (2019)	Present in this study?	Observation regarding the application in this study:	Risks discovered if they do not have the controls in the 1 st column
Supplier selection and management – Supplier selection, compliance of supplier, supplier documentation, purchasing from approved suppliers, business interruption contingency plans, supplier performance.	No	This step cannot be captured in this study, since the supplier selection and evaluation process were carried out in another tool that was not part of this study.	Purchase made from an unapproved supplier, related-party transactions, conflict-of-interest situations, goods purchase may not meet the quality standards, unauthorized prices.
Purchasing/ Ordering – Its gets segregation of duties from accounts payable/payment, receiving and accounting activities, writer purchase policies, purchase price negotiation, oral or written contracts, advance payments, purchase order distribution, evaluation of purchasing process, blanket purchase order, independence within the purchase process, requisitioning process.	Yes	This step can be evaluated with the application of process mining.	Unauthorized or improperly authorized, made for an unauthorized supplier, violations of conflict-of-interest controls, goods purchased may not meet the quality standards, materials may be received early or late, duplicate payments may occur.
Import – documented procedures, custos brokers, timely response inquiries, origin declarations and certifications.	No	The import process and documentation are recorded outside the analyzed system. In addition, the volume of imports was very low compared to domestic purchases.	Regulations can be violated, import privileges may be lost, and incorrect documentation can impact financial exposure.
Receiving – the receiving department should be physically segregated from production, the receiving function must be separated from the buying function, receiving location will accept only those goods with approved purchase order, receipt documentation, receipt recording, receiving procedures.	Yes	In this process, it is possible, through the analysis of system logs, to verify the receipt of goods and storage, registration of the invoice, with values and amounts received, and the user who recorded the receipt in the system.	Unauthorized purchase, receipts violations of conflict-of-interest controls, related-party transactions, records lost or destroyed, records misused by unauthorized person, unrecorded liabilities, good purchase does not meet quality standards, purchases and/or payments recorded in the incorrect amount, to the wrong account, or in the wrong period.



<p>Accounts Payable – segregation of duties, invoice accuracy, duplicate payments, invoice approval, goods receipt.</p>	<p>Yes</p>	<p>In this process, it is possible, through the analysis of system logs, to verify the registration of accounts payable with the approval steps.</p>	<p>Purchase may be stolen, destroyed, or lost, purchase podem ser recebidas but never reported, or reported inaccurately. Purchases or services may be ordered and received by an unauthorized individual, payments may be made for goods or services not received and/or in advance of receipt, duplicated payments, records may be lost or destroyed.</p>
<p>Payment – segregation of duties, payment reconciliation, supporting documentation, payment approval with corporate policy, supplier discounts, and signatures.</p>	<p>No</p>	<p>The database extractions were carried out up to the registration for payment, therefore the payment and reconciliation phases were not part of this study.</p>	<p>Controls may be bypassed allowing the potential for theft or error, purchases or services may be ordered and received by unauthorized individual, items received may be received but not reported or reported inaccurately, duplicate payments, or payments with wrong amounts or a nonexistent suppliers, financial statements may be misstated; unauthorized purchases, recorded with the wrong amount, payments made for goods or services not received.</p>

Source: Adapted (Doxey, 2019)

The risk assessment of the process was carried out considering potential errors and using the reference in Table 2 (Doxey, 2019) with the criticality assessment of the materialization of the risk, termed risk level. The classification of the risk level was based on the standard market methodology of COSO ERM (2017), and the evaluation was conducted in a qualitative manner between impact and probability, through inquiries to the internal audit department of the studied Company, where the classifications presented in Table 3 were reached.

TABLE 2. MAPPING OF RISKS, AFFIRMATIONS, PROCESS STEPS AND FILTERS

Risk factor category	Subcategory	Potential Errors	Internal controls process	Filter	Risk Level
Missing activities	Absence of record of goods receipt	Integrity	Receipt	Any process without Goods Receipt	High
	Absence of invoice record	Integrity	Receipt	Any process without the record of invoices	High
	Absence of approval in the process	Validity	Purchase Order/ Receipt/ Accounts Payable	Any process without approval	High
Missing values	Missing Purchase Order Value	Valuation	Purchase Order	Any process without Purchase Order value or equal to BRL 0	High
	Missing Purchase Order Quantity	Valuation	Purchase Order	Any process missing quantity in the Purchase Order	High



	Absence of Invoice	Record	Receipt	Any process without an Invoice number	High
Segregation of Duties	Violation of Segregation of Duties	Integrity	Purchase Order/ Receipt/ Accounts Payable	The employee who created the order also released the order	High
Weekends	Unauthorized weekend activity	Integrity	Purchase Order/ Receipt/ Accounts Payable	Process instances with activities taking place on weekends	High
Crossing of information (2-way match)	Differing amounts between the Purchase Order and Goods Receipt	Valuation Validity	Purchase Order e Receipt	Processes with Purchase Order and Goods Receipt values that do not match	High
	Differing quantities between the Purchase Order and Goods Receipt	Valuation Validity	Purchase Order e Receipt	Processes with Purchase Order and Goods Receipt quantities that do not match	High
	Differing amounts between the Purchase Order, Invoice, and bills	Valuation		Processes with Purchase Order and Invoice/Invoice Receipt values that do not match	High
Change in the process flow segregation of duties	Payments before goods received without accounting and tax record.	Validity Authority	Purchase Order/ Receipt/ Accounts Payable	Payment before Goods Receipt	High
	Creation of requisition after Purchase Order	Authority	Purchase Order	Requisition created after Purchase Order	Medium
	Unusual start with invoice receipt	Authority	Receipt	The process starts with receipt of invoice	Medium
	Ending process with the creation of the Purchase Order	Authority Validity	Purchase Order/ Receipt/ Accounts Payable	The process ends with the creation of the Purchase Order	High
	Unusual start in the process	Integrity	Purchase Order/ Receipt	Accounting or tax release is followed by the creation of a purchase order; the physical or accounting receipt is followed by a purchase requisition.	High
	Starting the process with the receipt of goods	Validity Authority	Purchase Order/ Receipt	The process starts with Goods Receipt and then the purchase requisition is created.	High

Source: Adapted from Duan, Vasarhelyi and Codesso (2022).

After mapping the process, identifying and classifying the risks, and determining the filters to be applied, a new stage of data extraction then began.

5.3 BASE EXTRACTION (DATA INTEGRITY ANALYSIS)

Once the process was mapped and the risks and filters to be applied in the tool were identified, the next step defined in the process was the database extraction. The Institute of Electric and Electronics Engineers (IEEE, 2021) details six guidance items in order to avoid application errors. In Table 4, the first column shows the manifest items and the column next to it presents their practical application in this case study.



TABLE 3. DATA EXTRACTION

Manifest IEEE (2021)	Application in practice:
Event data should be treated as first class passengers as the quality of the results depends on the quality of the event records;	Ensuring the quality and integrity of the extraction was an important and crucial part of the process since, without the data, it would not be possible to continue the study; validations of the number of items were verified to guarantee the integrity of the information;
Extraction of records must be driven by questions, so it is important to choose the type of case that you want to be analyzed;	A specific process was chosen for a determined period, where the understanding of the existing processes and tables was obtained, as well as the identification of the risks of this process.
Competition, choice, and other basic flow control constructs must be supported;	Risk identification and evaluation, as well as process design, were carried out considering existing methodologies.
The events must be related to the elements of the process model, where there are techniques to diagnose and quantify discrepancies in the model;	Risks and controls of the processes were mapped, identified and presented in chapter 6.2
Models must be treated as intentional abstractions of reality, and therefore the model must emphasize facts relevant to a particular type of user, adjusting the model to the target audience,	Following the initial input of data into the tool, samples were analyzed to identify false positives and adjustments were made to the model in order to identify material facts for the internal audit departments and internal controls.
Process mining must be a continuous process, and it is not advisable to use PM as a one-time process	Once the tool is adjusted, the continuous process becomes part of the internal audit routine. In this study, however, a population was selected, but there is a clear need for continuity and continuous evaluation of the process.

Source: Adapted from IEE (2021)

As mentioned earlier and explained in the introduction of this study, data is one of the main items of a good process mining application, as it is the key point to have a good result, Van der Aalst (2012) mentions that process mining aims to discover, oversee, and improve processes.

TABLE 4. DATA FEATURES

Characteristics that the data must have:	Application in practice:
The activity that took place during the event (e.g., signing, authorizing, paying),	Extraction of log information, including date and user who approved purchase orders, requisitions, and payments
The process instance of the event (for example, an invoice, a receipt, an order,	Extraction of purchase order number, invoice number, order and invoice amounts, number of items received
The originator, or party responsible for the event,	Extraction of requesting user information and approving users
The date and time of the event.	Extraction of the date, time, and user of each processing routine performed

Source: Adapted from Jans, Alles, and Vasarhelyi (2014)

In addition, Jans, Alles and Vasarhelyi (2014), define “in order to allow data mining analysis, four features must be extracted from the information system about each event”. In Table 5, the first column shows the features of the data according to Jans, Alles and Vasarhelyi (2014), while the adjacent column presents the application in practice in this case study.



In this study, great care was taken to ensure the accuracy and integrity of the information. The IT teams along with the internal audit team of the studied Company participated in the extraction and carried out data integrity tests. The extracted data considered 1 month of the 7 tables indicated in Figure 1. It was verified that the number of items from the start of the flow mapped in the tool is the same presented at the end. It was not possible to extract more months or transactions of continuous data due to a limitation of the adopted tool, as the version of the tool being used is for academic purposes and has a limitation on the volume of data it can handle; it is also not able to use the direct connector with the online system.

5.4 INSERTING DATA INTO THE SOFTWARE

After the data extraction step described in Table 4, the data was inserted into the Celonis software using academic user profile, with the possibility of importing the file that was previously made available by the studied company. Celonis allows usage with some restrictions on data volume and direct connection with the company's system through an interface. In addition to Celonis, there are other tools in the market, such as Disco, ProM, and Datriick.

The great difficulty in this stage was the lack of pre-existing documentation of tables and system data of the studied company, so the mapping of the process and identification had to be mapped by the internal audit department and not by the business area exclusively for this study.

Initially, an attempt was made to extract the direct tables with the extension, in order to use the tables according to the official design of the software company. However, the documentation received did not match the standard tables of the manufacturer, which made it difficult to insert the data.

Another challenge was to understand the flow in chronological order to reflect the process in the data mining tool. Furthermore, as the version of the tool used had limitations, it was not possible to integrate it with the Enterprise Risk Process (ERP) system, which made it difficult and took more time to implement the model.

In this model, manual adjustments were made more than once in order for it to reflect the process. For example, it was necessary to adjust the date format, as the version of the tool used the American format, while the data sent were in the Brazilian format. Other adjusted items are also the numbers; the U.S. format uses dots for decimal places, while the Brazilian format uses commas. After inserting the data into the tool, the data analysis process then began, whose objective is to identify weaknesses in the processes. This step will be detailed in the next chapter.

5.5 DATA ANALYSIS

The data was imputed into the tool according to Figure 2. After the initial input of the data, some items that needed to be analyzed by the internal audit of the Company studied were identified. For each nature identified by the tool, one item was selected to evaluate and understand the process, in order to make adjustments to the model if necessary.

Based on this analysis, it was possible to identify behaviors that are part of the process and that should be disregarded from the non-permitted behaviors, and adjustments were made, leading to the final outcome. Items that had not been completed were disregarded from the anomalies, since, as previously explained, the population of the model was of 1 month and some processes could not be completed from start to finish.

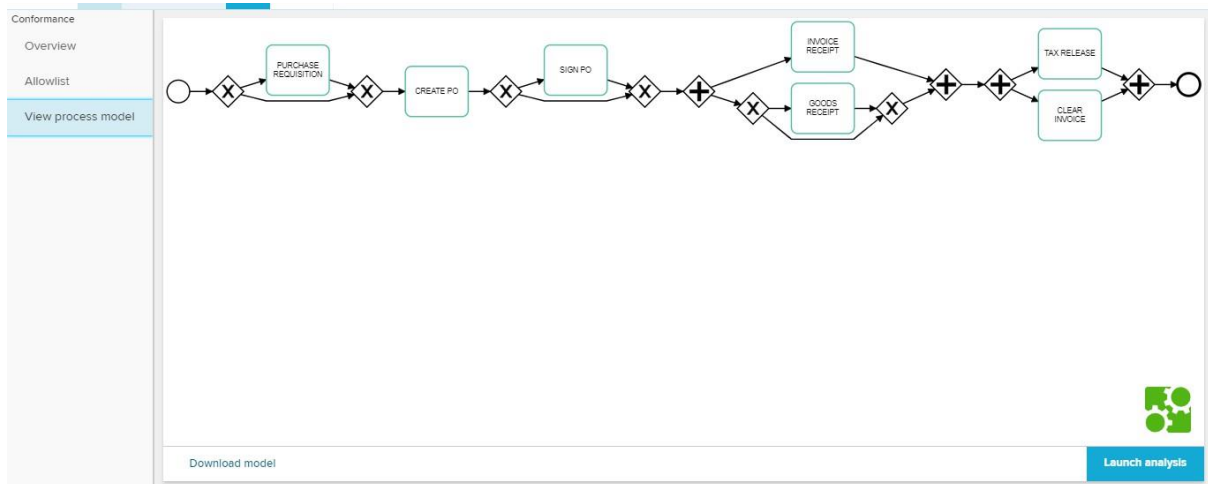
In addition to the incomplete items, 34 different behaviors were identified and, with the analysis of the company's internal audit, it was concluded that 20 behaviors were relevant to



the operation and 14 were classified as violations of the processes. These adjustments were made to the tool, leaving one violation, which represented 0.45% of the total studied population.

With this adjustment in the model, it can be noticed that this evaluation of behaviors is a relevant process in the implementation of process mining, since, once it is classified incorrectly, many situations that should be investigated as an expected behavior may go unnoticed. For this reason, this process should be reviewed from time to time, with the selection of random items considering behaviors in the population classified as expected and unexpected, as there may be situations to be analyzed that were classified as expected behavior. Details of the flow designed and implemented in the tool can be seen in Figure 2.

FIGURE 2. FLOW INSERTED IN THE SOFTWARE



This flow describes as an initial step the purchase requisition, thereafter the creation of the purchase order (create purchase order), approval of the purchase order (Signpo), invoice receipt together with the receipt of the goods or the provision of services (invoice receipt and goods receipt), after that there is the fiscal receipt (tax release) and the closing of the invoice (clear invoice).

Providing further details on the analysis, the main items that were classified as false positives, in other words, the tool identified them as conflicts, after selection and analysis by the internal audit team, it was determined that they were expected and accepted behaviors. The main situations found were the following: (1) Invoice received followed by its closing; (2) Closing of received invoice followed by the tax release; (3) Tax release followed by invoice receipt.

The three situations above are the main identified items that represent 76% of the total items. These cases occur because, within the same purchase order, several receipts of materials may occur, which can lead to some distortions by the tool, making this step of the process of analyzing in detail very important.

Other items presented by the tool, but which were considered false positives after evaluation by the studied company, were these: (1) invoice received followed by invoice; (2) invoice receipt followed by invoice receipt; (3) goods receipt followed by goods receipt; (4) tax release followed by tax release; (5) approval of the purchase order followed by approval of the purchase order; (6) purchase requisition followed by purchase requisition. These situations occur because, as there are recurring purchases of merchandise, a purchase order is generated for a high value and, as the material planning requests, it consumes from this order. That is why the situations above occur, as these orders have more than one request.



The items classified as violations and that must be monitored by the department of internal controls and internal audit are as follows:

TABLE 5. VIOLATIONS TO BE MONITORED

Process violations	Risk Classification	Detailed description of the violation
Tax Release is followed by Sign Purchase Order	High	In this situation, it is clear that the process did not occur as it should, with the purchase requisition, quotes, purchase order, and subsequent physical receipt and tax release. This type of situation requires attention, as the process was carried out completely out of the flow. It is an opportunity to improve the process and also the possibility of fraud, since the negotiation may not have been carried out by an independent department of the requester, that is, the segregation of duties did not occur.
Invoice Receipt executed as started activity	High	The receipt of the invoice is the beginning of the process, it shows that the process took place outside the system and that the purchasing department did not participate, that is, a note was made of some improvement opportunities, such as segregation of duties, improvement in the process flow, in addition to fraud risk notes.
Goods Receipts is followed by Sign Purchase Order	High	Receiving the goods before sign purchase order shows that the purchase had already been made and that the order approval process was pro forma. This type of situation also demonstrates weakness in the process with risks of fraud and opportunities for improvement.
Create Purchase Order is followed by purchase requisition	High	The creation of the order occurring before the purchase requisition shows that the flow did not follow the correct process, in which the commitment with the supplier was assumed and there may not have been the necessary approvals for the process. There are opportunities for improvement and the possibility of monitoring this indicator in order to bring greater reliability to the process.
Clear Invoice is followed by Sign Purchase Order	High	Invoice clearance should never occur before the purchase order, it demonstrates that the flow did not occur as it should and that the approvals due before the purchase were skipped, there may be a risk of fraud in this process that should be assessed, indicating a good population for audit testing, as well as detection of improvement in the process and awareness of the people involved. An indicator may be created to monitor these transactions.
Tax Release is followed by Create Purchase Order	High	When carrying out the tax receipt and the subsequent purchase order, it demonstrates once again that the flow did not go according to plan. Therefore, some actions can be taken, such as monitoring and data analysis to understand the situations.

The six situations highlighted above are the main items identified from the 14 violations and account for 91% of the total number of violated items. With the examples above, it is possible to notice the improvements detected in the process that this tool can explore, as well as identify samples for carrying out audit tests and controls.

Other items considered as violations were: invoice clearance followed by sign purchase order, purchase requisition followed by invoice receipt, merchandise receipt or sign purchase order, tax receipt followed by purchase requisition, invoice receipt followed by create purchase order. These other situations also show that there are points of improvement in the process, in addition to indicators that can be monitored and samples selected for the purposes of internal audit work tests.

If the interface of the process mining tool is placed between the systems, the work of the internal audit and internal controls teams can be performed in a more timely manner, thus avoiding the materialization of mapped risks.



5.6 SEGREGATION OF DUTIES ANALYSIS IN THE PROCESS

Another important item that can be analyzed is the segregation of duties in the process. The SEC describes that controls must have certain features, namely: automated or manual, reconciliations, segregation of duties, review authorizations and approvals; safeguarding and accountability of assets; prevention or detection of errors or fraud (ISACA, 2021).

The analysis of segregation of duties is an important item of data analysis, as it can detect fraud or improvements in the process, for example, when evaluating that the user can create the order and insert the invoice for payment, this can expose the company to risks. Therefore, we can verify that the tool can support the crossing of information and the materialization or not of conflicts in the segregation of duties. Other items such as approval, revision, prevention or detection of errors, or fraud were addressed in item 4.5.

Upon analyzing the process of creating purchase orders and inserting invoices, a total of 45 users with access to two transactions for creating an order and inserting a payment invoice were identified, two of these users executing both transactions for the same number of purchase orders, with a total of 51% of the total volume. And upon analyzing in detail, apparently the user uses that transaction to settle payments, since the values that users enter are small when compared with the total value of the order.

This identification of vulnerabilities can bring process improvement, with the creation of purchase orders by the relevant areas, mapping of a matrix for segregation of duties in processes, adjustments in the access profile to tools, redesign of the process flow to avoid regularization of processes that bring rework and inefficiencies, as well as a reduction in the risk of fraud.

5.7 PERFORMANCE INDICATORS

The studied tool brings some performance indicators. The first indicator presented is the time it takes a process that has been classified as within the expected to occur. In this model, it takes an average of 10 and a half days, but when it comes to an item that is classified as violated, the number of days increases to 48 and a half days.

Besides the number of days, the tool also points out the number of times the process undergoes interactions, with an average of 5.7 changes for items that are within the flow, and when compared to cases that deviate from the standard flow, there are 33,5 interactions. Figure 3 demonstrates the mentioned indicators.

FIGURE 3. PERFORMANCE INDICATORS



Source: Celonis tool, 2021.

These two performance indicators demonstrate that not following the process flow leads to rework for internal teams, in addition to commitment to deadlines, which can impact production



processes in the manufacturing units. Monitoring with the use of process mining brings some opportunities for improvement, as well as bottlenecks in processes, leading to greater efficiency to the company's processes and operation.

In Table 7, a detailed inspection was carried out for the main violations described in Table 6, where we have virtually the same scenario of greater need for interactions and days for regularization of the process, making it clear that failing to follow the process generates inefficiencies and a greater volume of work for the teams.

Considering that the number of violations in this sample was 533 items, through a simple calculation where 533 multiplied by 33.5 (number of interactions with violations) generates a value of 17,856 interactions, and that each interaction takes an average of 1 minute, we would have a volume of 298 hours in this process, while those same 533 violations multiplied by 5.7 (average number of interactions without violations) would have 51 hours in the process without violations. In other words, for 1 month of sample of this company, we would have more than one person assigned full time to regularize the process. This analysis therefore demonstrates how companies can seek efficiency in their processes.

TABLE 6. ANALYSIS OF INDICATORS OF PROCESS VIOLATIONS

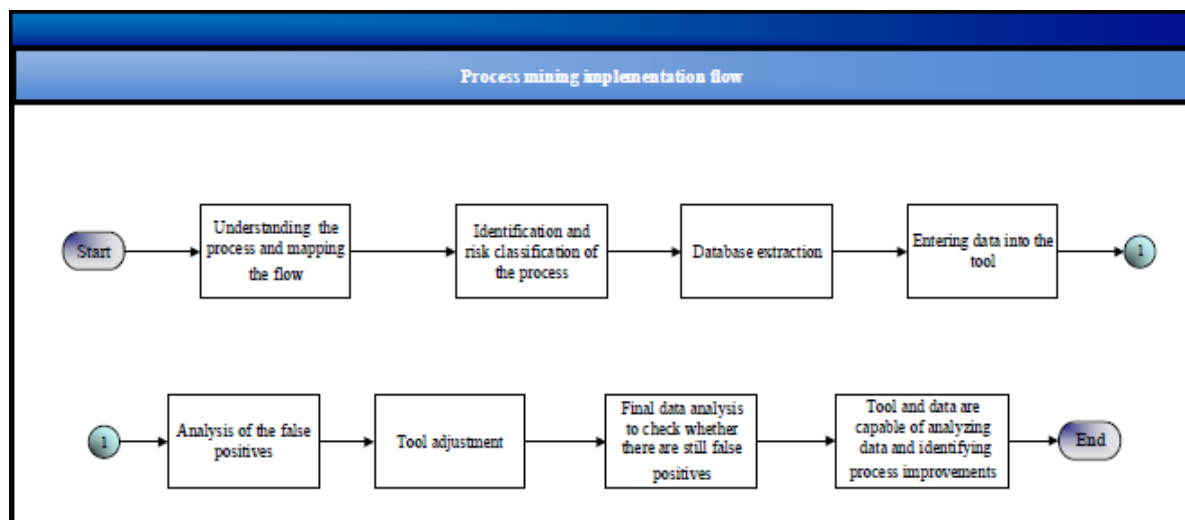
Process Violation	Time (days)		Number of Interactions		Notes
	Violated cases	No violation	Violated cases	No violation	
Tax Release is followed by Sign Purchase Order	61.7	10.5	54.8	5.7	The time to regularize the process for cases with violations is longer than the company's standard in terms of time and interactions in the process.
Invoice Receipt executed as started activity	0.1	10.5	4.2	5.7	When the invoice is received and there is no purchase order, an option is to regularize the process with payment, which means that the time and number of interactions for regularization are few. It would be interesting to evaluate and indicate these situations for monitoring, as well as select samples for testing.
Goods Receipts is followed by Sign Purchase Order	51	10.5	51.4	5.7	The time to regularize the process for cases with violations is longer than the company's standard in terms of time and interactions in the process.
Create Purchase Order is followed by Purchase Requisition	36.5	10.5	21.1	5.7	The time to regularize the process for cases with violations is longer than the company's standard in terms of time and interactions in the process.
Clear Invoice is followed by Sign Purchase Order	88.3	10.5	75.2	5.7	The time to regularize the process for cases with violations is longer than the company's standard in terms of time and interactions in the process.
Tax Release is followed by Sign Purchase Order	120.3	10.5	11.2	5.7	The time to regularize the process for cases with violations is longer than the company's standard in terms of time and interactions in the process.



5.8 PROCESS MINING IMPLEMENTATION AND DATA ANALYSIS SCHEME FOR INTERNAL AUDIT AND INTERNAL CONTROLS

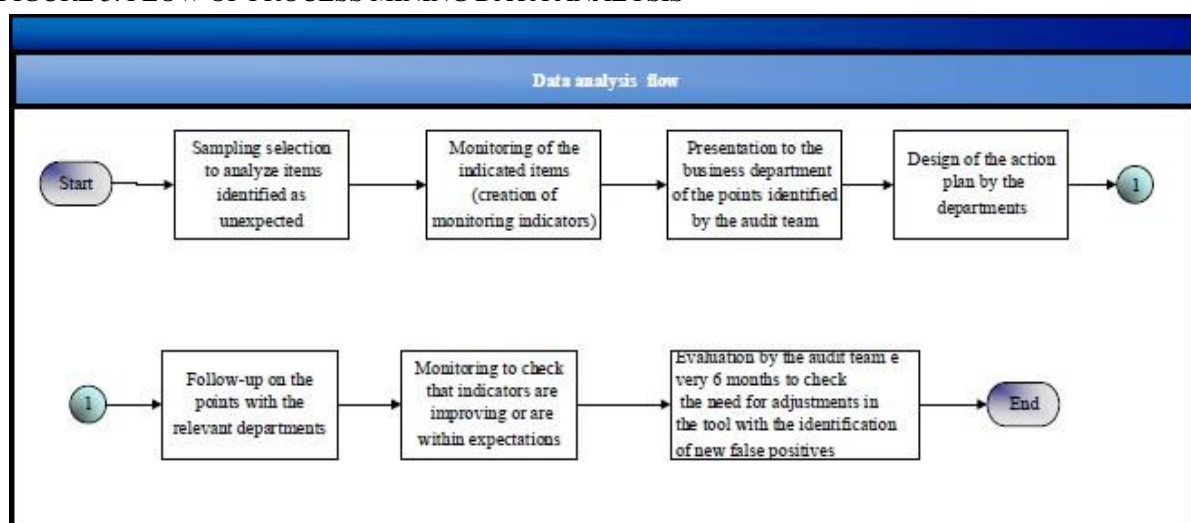
After verifying the details of and analyzing this study, it was possible to develop a process mining implementation flow for the internal audit, considering the continuous audit model, and also for internal controls with the purpose of evaluating the efficiency and possible improvements in the processes. Figure 4 demonstrates the implementation flow.

FIGURE 4. PROCESS MINING IMPLEMENTATION FLOW



The flow begins with the understanding of the process and mapping. Without this initial understanding, any other step that follows becomes difficult. The higher the level of detail in this mapping and flow of tables, the better it will be for inserting the flow into the tool, thus reducing rework and identification of false positives.

FIGURE 5. FLOW OF PROCESS MINING DATA ANALYSIS



After understanding the process, it is important to extract the base with all the precautions described above. The next step is the identification of risks, classification, and filters to be applied in the tool, a step that is also very important in the process, as insertions will be made in the tool based on the identification of risks and filters. The next step is to insert the data into



the tool. After that, it is necessary to evaluate and adjust the false positives, which leads to the final step in order to start analyzing the data to identify and improve the process, and, lastly, the establishment of continuous monitoring and ongoing review of false positives to be adjusted in the model whenever necessary.

Once verified the details of and analyzing this study, it was possible to develop a data analysis flow from process mining to internal audit and internal controls, as shown in Figure 5. Upon the insertion of data into the tool and adjustments of false positives, the data analysis stage then begins, and it is important to make a sample selection of some items to validate that they are items that do not conform to the pattern and identify the root cause to trace an action plan. By doing so, it is possible to create performance indicators or risk indicators, which, according to COSO, performance indicators (KPI) are aimed at the performance of the operation, while risk indicators (KRI) are metrics used by the organization to warn about the increased exposure to risks in various departments of the organization (COSO, 2010).

Subsequently, the points identified by the internal audit must be presented to the business areas. This report must go through the entire organization, from the analyst to the executive board, as well as to the control body, such as the audit committee or the board of directors.

The business areas must define the action plan with the terms stipulated in accordance with the internal audit policy. After the action plan is defined, the follow-up phase then begins, which is the follow-up on the implementation of the action plans by the internal audit and/or internal controls departments, where the outcomes can be monitored and, in this way, evaluate whether the indicators are within an acceptable risk limit. It is important for the company to establish a reassessment routine from time to time with a random selection of items to revalidate whether there are new ways of mining processes that are being followed and that require adjustments in the tool or survey of points of attention and monitoring and, therefore, keep the model always updated with its processes

5.9 ADVANTAGES AND CHALLENGES PRESENTED IN THE STUDY

As part of the study, three interviews were conducted with the direct participants of this project, seeking to detail the advantages and challenges presented. The interviews were semi-structured, guided by questions, but the conversations would be open to other additional questions according to how they evolved.

The questions were intended to assess, in the view of those who participated in the project in all stages, what are the points of attention, if they would do something different, the advantages and challenges of the model, the characteristics of the data, and the relevance of the integrity of the information, evaluating each stage of the process.

One of the questions asked related to the classification of 4 items that they consider the greatest advantage of applying process mining, namely: (i) it considers 100% of the population; (ii) the data entered is independent of the actions of the auditees; (iii) it allows the auditor to have a more effective way of implementing the risk model, and (iv) the possibility of conducting analyzes that are impossible with the existing audit tools such as finding out the way in which the processes are actually being carried out in practice.

Two responded in 1st place and one person responded in 2nd place, about the possibility of conducting analyzes that are impossible with existing audit tools, how to discover the way in which processes are actually being carried out in practice, in addition to identifying social relationships between individuals. In 2nd place was the possibility of this model covering 100% of the population

About the possibility of conducting analyzes that are impossible with existing audit tools, how to discover the way in which processes are actually being carried out in practice, in addition



to identifying social relationships between individuals, two responded in 1st place and one person responded in 2nd place, the latter being the possibility of this model covering 100% of the population.

The additional SWOT analysis (suppressed because of pages limitation) from the answers brought some positive points, such as the possibility of analyzing 100% of the population, which differs a little from the work carried out by external audits, which analyzed a sample. According to one of the interviewees, one of the advantages of the study was “its originality for application in internal audits” (interviewee 1), and to another interviewee “the possibility of discovering how the process actually works through the marks that remain in the system, and not from what was mapped” (interviewee 3). The weaknesses presented sum up the need to have a very detailed mapping of the process and the identification of the sequence of work, so that all its nuances are included in the tool and in order to avoid several analyzes and identification of false positives.

In the interviews, the advances of this model were clear. With the implementation of the tool along with the automatic link to the ERP, without the need to extract and insert data, the market tools allow you to have a direct link between the two systems and information is updated in a timely manner. Some threats were also pointed out, mainly with regard to the integrity of the data and the detailed mapping of the process, as these well-executed steps avoid analysis distortions. According to one of the interviewees “people cannot stop and analyze more deeply, they want more deterministic models. The outcomes are not as clear as the deterministic models, because something is likely to happen” (interviewee 1), that is, it needs additional analysis that can be complemented with probabilistic, statistical and analytical models, in other words, process mining directs to something that may be wrong, but needs further analysis of the items pointed out.

These interviews made it possible to assess that process mining application still has many advantages and challenges, and that when applied it can offer many benefits, aimed at improving processes and monitoring items that are outside the normal processes.

6. CONCLUSIONS

This work sought to develop a process mining implementation flow and a data analysis flow, as well as evaluate the advantages and challenges of applying the model for the internal audit and internal controls departments. When applying process mining in other companies, one should always evaluate their process individually, as there may be specificities that must be adjusted in the model. The developed flows are a suggestion that can be adopted taking into consideration the specificities of the processes of each company.

Process mining is a relatively new trend with few companies using it, due to the fact that the tools have a representative cost and there is a general lack of knowledge of the scope and opportunities that companies can have when using them. Process mining can offer a relevant technological evolution for companies and keep up to date with the best and most efficient market practices, in addition to the possibility of continuously monitoring processes and identifying failures in a more timely fashion than with traditional audit work.

The need to ensure the integrity of the data was very clear, as well as the need for mapping and understanding the detailed process for a more effective application. Another evident factor is the continuous application of the model with the existing links in the tool directly with the ERP and not with the extraction of data from a period, as carried out in the model.

Another item identified during implementation is that quality depends on the effort and dedication of the teams involved, since the better the understanding of the flow and the process,



the better the reflection of this flow in the tool, and along with that the possibility of better identifying points for improvement and weaknesses of the process.

It is worth pointing out that just like the business area, the internal audit and the internal controls department can benefit from process mining, as it offers greater a range in test samples, more timely reporting, more structured and visual indication of irregularities, notes of possible problems with the segregation of duties in the processes and, therefore, the audit work and internal controls can be better directed.

There are some key points in the application of the model, namely the evaluation and classification of the false positives that the tool can bring – once classified incorrectly, many situations that should be investigated as an expected behavior can go unnoticed. For this reason, from time to time, it is advisable to review this process, with the selection of random items considering behaviors classified as expected and unexpected in the population, as some situations may be classified incorrectly.

For future studies, it would be useful to look for a process that has more automated steps or that the studied sample be larger, in addition to using the automatic link with the tool so that the data can be constantly updated. Another study possibility is to carry out an initial diagnosis with a preliminary evaluation of the outcomes, followed by implementation of action plans with subsequent reading, in order to evaluate the before and after and quantify the benefits and return of the model.

Currently, it is difficult to find many companies applying this process in practice, either because of the high cost of the tool, which often makes the project unfeasible, or due to the need to know the techniques and to have a multitasking project that requires the participation of several departments, such as the business area, IT, and internal audit or internal controls departments.

This study made it possible to verify that process mining is an apparently new topic, compliant to the departments of internal audit and internal controls, as in chapter 4 it was possible to demonstrate some forms of analysis that can be carried out, bring improvements and monitoring of processes and of internal controls in order to support management and governance bodies in achieving their strategic objectives.

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