Master thesis Business Administration,

“Using workarounds for better process compliance."

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Abstract

This master thesis aims to provide a better understanding of workarounds. Companies want to work more and more efficient and effective. However, a lot of companies, especially small companies, are facing so-called, workarounds. Alter (2014) describes a workaround as: "a goal-driven adaption, improvisation, or other change to one or more aspects of an existing work system to overcome, bypass, or minimize the impact of obstacles, exceptions, anomalies, mishaps, established practices, management expectations, or structural constraints that are perceived as preventing that work system or its participants from achieving the desired level of efficiency, effectiveness, or other organizational or personal goals" (p. 104). The problem in the academic field is that workarounds can be hard to detect because it is caused by typical human behaviour. Human behaviour is, most of the time identified by observation or interviews. However, process mining makes it able to detect human behaviour on a quantitative approach. This study aims to investigate how practical process mining is in the detection of workarounds in the organization. This is particularly interesting since this approach is based on quantitative research be using ERP data of an SME company to detect the "real" process. This case is tested on a company with approximately 150 employee and is a metal ware factory. This study aims to develop and test a more systematic approach to detect workarounds. The approach used in this study is to develop a De Jure model and compare this model in three different analysis; the control flow, time-perspective and resource-based analysis. Every unusual event or activity is than classified with the theory of Alter (2014). Eventually, the detected workarounds are assessed on whether they are harmless, essential or a hindrance. The result of this research is that process mining is a useful technique for the discovering or detection of workarounds. However assessing the workaround on their value or the categorization is harder, since this heavily relies on the experience and knowledge of the researcher and for that reason is biased. However this study was quiet successful in developing a new technique/method for the detection and classification of workarounds. In addition, this study is focussed on one company and one case, and is therefore less generalizable and trustful.

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1. Introduction

Here we describe the organization and the academic and practical research problem, followed by description of their relevance.

1.1 The situation and problem in practice

Company X is a production factory mainly specialized in deep drawing, finishing, composing, welding, and die-cutting. Company X aims to continuously improve its processes, products, and organization. Company X is founded in 1958 and has currently 170 employees on the payroll on three production locations. Two locations are in the Netherlands, and one is in the Czech Republic. Company X has an informal culture; everyone within the company knows each other, and processes are conducted by the intuition of involved people. The current situation is that Company X has no protocol for its administrative organization (AO) and internal control (IC). In business papers, most of the time, AO/IC is described as an internal control or auditing. Internal auditing helps an organization to improve its organizational goal by evaluating and improving the effectiveness of risk management, control, and governance (Doyle & Mcvay, 2014). Internal auditing primarily is an independent review of operations, safeguarding of assets, and fraud and errors (Ho & Hutchinson, 2010). A sound internal control is a base for high-quality financial reporting since reliable internal control can determine both procedural and estimation errors as well as earnings management (Doyle & Mcvay, 2014). Without internal control, there is no risk management, and without risk management, a company can lose potential profit.

The goal is to determine whether the processes-as-designed complies with the detected process and what the performance is of the registered process. Eventual workarounds are analyzed whether they have a positive or negative influence on the performance of the process.

1.2 The situation and the problem in the academic field

Organizations have to arrange their processes and understand the most essential processes. Different techniques have been rolled out over the past few years to design the process of an organization. The last decade especially BPMN (Business process modeller) is used to describe processes. Unfortunately, a well-designed process is not always matched with reality; every employee probably has its vision and method to reach its goal. This is especially the case in small organizations, in such organization processes are like spaghetti processes: unstructured, flexible, irregular and variable (Van der Aalst, 2011). Spaghetti processes are also conducted every time differently. For example, an order for new metal is signed every time by a different person, and no one knows who is responsible. This has mainly to do with the fact that especially in SME's (Small and medium-sized enterprises) employee/manager have a lot of responsibilities and different tasks at which the boundaries of the responsibilities are not clear.

However, it is interesting to discuss building protocols for internal control. Does this protocol deliver the best performance, or is it just an imagination of the controller. Knowing in what case the protocol deviates from reality is interesting to see but hard to detect, because this problem has to deal

with human behaviour. This deviating from the process can also be indicated as a workaround. A workaround can mean that the designed process is not effective and efficient. That consequently might indicate that employees are wasting time or even a process is broken off. According to Pollock (2005) workarounds "remain for the most part surprisingly under-investigated and (under) theorized "(p.497). This is surprising since workarounds are very common and can lead to useful insights and make processes even better and more efficient. According to Alter (2014), workarounds are unusual behaviours that create hazards, inefficiency, and illegal actions.

Despite the negative effects, researchers also report workarounds as beneficial (Ash et al., 2004). The problem in the academic field is that workarounds can be hard to detect because it is typical human behaviour. However, due to the development of process mining in the last years, it is possible to identify all the registered activities of a human being in the organization. Surprisingly, process mining is not often used to detect workarounds, but mainly to detect bottlenecks. This research is about the effectiveness of process mining in identifying and valuing workarounds. In this research, workarounds are made visible by process mining. This research provides quantitative evidence for the effectiveness of workarounds identification by process mining. This research contributes to the theory of workarounds and to a better and more systematic way of detecting and valuing workarounds. Eventually an advise and roadmap will be given, so workarounds can be detected by companies is a systematic way.

1.3 Research goal

This research takes an overview all the processes of an organization, checks their compliance with the registered process with process mining, and eventually detects whether workarounds contribute to making a process more effective and efficient. The main goal of this research is: "How effective is process mining in discovering and measuring workarounds' value?".

1.4 Relevance

Sometimes workarounds can cause damage and inefficiency (Alter, 2014; Halbesleben et al., 2010; Patterson et al., 2006). However, in some cases, the researcher confirms workarounds as beneficial and sometimes even necessary (Ash et al., 2004). Despite that, some researchers see workarounds as declaring refusal (Ferneley & Sobreperez, 2006; Choudrie & Zamani, 2016). It is relevant to investigate what workarounds could be beneficial and what workarounds are disadvantageous to organizations. This is especially interesting for SME's since they, in particular, are facing the spaghetti processes and workarounds are very common in a small organization. An organization might adopts workarounds which become part of the new organizational structure (Soh & Sia, 2004), which in turn will be more efficient and effective than the designed process and become the new protocol.

In this thesis, we will perform the following set of activities. First, the theory of workarounds is given. This will be the basis of this research and will be used in the analysis. Second, the methodology of process mining is given and discussed. Third, the De Jure model (scheduled process) is developed and described. Fourth, the actual process (De Facto) is developed and translated into business language.

Fifth, the De Jure model and the De Facto models are compared in different perspectives and the analysis is done. After the analysis a summary and advise for Company X is given. Lastly, the findings and limitations of the research are discussed. The model mentioned in figure 1.1 is a representation of the process.

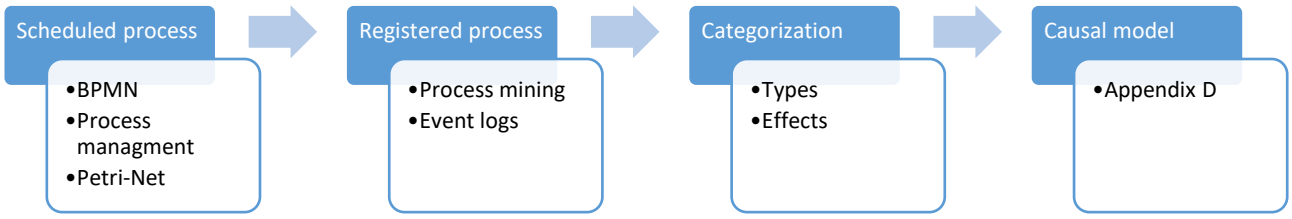

FIGURE 1.1 VISUALISATION OF RESEARCH PROCESS

2.Theoretical framework

This chapter gives a description of the used literature on (1) process management, (2) process mining, and (3) workarounds.

2.1 Theory of Process management

Porters categorization model (Porter & Advantage, 1985) describes three different processes: core processes (primarily activities), support processes (support activities) and management processes. This last process was added by (Dumas et al., 2013). This research will only focus on core processes, because of the limitations of the ERP system that only registers core processes. The core process is the primary process for value creation within a company. The core process is the production of goods and services to customers. However, to run this core process, a lot of other core processes are needed. These can include, manufacturing, marketing and sales, delivery (logistics), after-sales, and direct procurement. The following steps are essential in identifying the processes within a company.

Clarify terminology

According to Dumas et al. (2013), it is essential first to clarify terminology. Often there exists something like a short description of the process, and this can be used as a reference. This definition is crucial for everyone involved in the process to have consistent understanding.

Identify end-to-end processes

End-to-end processes involve suppliers or customers of the organization. Products and services that are sold to customers or bought from suppliers are the starting point for identifying end-to-end processes: identify product types, the kind of products that are produced in the same way; identify service type, services that are produced in the same way; identify channels through which the company is communicating with customers; and lastly, identify the customer type an organization deals with.

Identify sequential process

The sequential process is defined by its internal, intermediate outcomes. In the product lifecycle different stages can be identified with different outcomes. Customer relationship also follows different stages: leads are generated, a contract is sealed, and a service is provided. The supply chain is also a process that can be identified by its individual activities and outcomes: materials are procured, products produced and analyzed for condition assurance and delivered to customers. Transaction stages go usually from initiation to execution and acceptance. If change of business objects occur, these objects should be split up into various business processes. Finally, the different stages of a process can be explained by something temporal, spatial, logical, or something else separating it. Usually, these separations define handoffs, and major handoffs are suitable points to distinguish sequential processes (Dumas et al., 2013).

The modelling of the processes can be done by several business languages, such as BPMN, Petri-Nets, Causal net.. BPMN is the most common used in businesses and is easy to use. Petri-Nets is less common used and uses a more mathematical approach. Petri-Nets is better suited for process mining. In this research Petri-Nets is used to build a De Jure model.

2.2 Theory of Process mining

Today's enterprises are using information systems to manage their processes. An information system is a system within organisation that helps with the supporting of processes. For example a financial information system or the stock system. These information systems record events, such as incoming products or a stock sales, that can be used to analyze the process. The main goal of process mining is using the data of the event logs to gain process-related information and to automatically discover a process model, by observing events records (Van der Aalst, 2011). Van der Aalst (2011) describes two types of processes that can occur when analyzing the event logs, the lasagne process and the spaghetti process.

Lasagne processes are mostly structured and ordered processes, with a few exceptions. An empirical definition of a lasagne process is that with limited efforts, it is possible to create an agreed-upon process model that has a fitness of at least 0.8 (Van der Aalst, 2011). This means more than 80% of the cases (orders) are covered. In a structured (lasagne) model activities are rolled out repetitive and well defined and the input and output is clear.

Spaghetti processes are less formal, and for that reason only a few process mining techniques are applicable. When using a normal detection technique, the process would be barely readable due to the huge amount of diverse data. See appendix B for an example. Nevertheless, process mining techniques can still be used to improve the process by uncovering fundamental problems, such as an unstructured process. Identifying spaghetti processes involves a heuristic miner approach with default settings. This is a methodical and systematic algorithm to detect the workflow. Due to the heuristic miner approach, only low-frequency behaviour is filtered out (Van der Aalst, 2011). Activities only appear when they frequently occur together with another event. Company X's processes are expected to act as spaghetti processes, because of the lack in structure and the size of the organization. Each employee can have a lot of different tasks and responsibilities, which might be influencing the structure of the processes. The purpose of process mining is to identify the registered process by using behavioural event data. This event data consequently creates a process model that represents the "real" process. This real process is eventually compared with the designed process to detect workarounds.

Business processes can exist in different organizational aspects, such as functions, business artifacts, humans, and software systems (Dumas et al., 2013). Yasmin (2019) stated that four perspectives could be detected by process mining: control-flow perspective, organizational perspective, time perspective, and case perspective. The control flow perspective is mainly about the order of activities. This control flow perspective aims to find a good representation of all possible paths. The

organizational view shows who or what performs which activity. The perspective can also be described as the "resource" perspective. A resource is a term that reflects anyone or anything involved in the performance of processing activity (Dumas et al., 2013). The time perspective is specifically focused on the timing and frequency of events. The existence of timestamps makes it possible to discover bottlenecks and allows analysis of service levels, monitoring time of resource utilization, and the prediction of the remaining processing time of running cases (Van der Aalst, 2011). The last perspective is the case perspective; this focuses on the cases beyond the path it takes (control flow) or their originators (resource) (Yasmin, 2019). This perspective aims to focus on the behaviour, properties, and data elements that deal with individual process instances (Ferreira & Alves, 2011).

2.3 Theory of Workarounds

2.3.1 Conceptualization

Alter (2014) has conceptualized a model with five “voices” of workarounds: phenomena, types, direct effects, compensations, and organizational outcomes. Phenomena (1) describe antecedents, for example abnormalities, exceptions, accidents, and other limitations. Types (2) categorizes the workarounds, for example workarounds to "overcome inadequate IT functionality” (Alter, 2014). Direct effects (3) are consequences of the workarounds. These effects can be categorized to, for example, creation of hazards, inefficiencies, or errors". Perspectives (4) report business merit and ethical merit. The phenomena, types, direct effects, and perspectives cause organizational difficulties (5). These difficulties occur due to the translation of problems from individual to the organizational level. For example first an employee faces a challenge and uses a workaround to operate despite the obstacles than consequently, it becomes an organizational problem. Due to the scope of this research on detecting and assessing workarounds on their value or effect, only the types (detecting) and effects (consequences) are used to answer the research question. The model above will be used to label the workarounds. When the effects are clear, and a positive effect is seen, this effect can be used to improve the performance of the process and increases the critical performance indicators.

2.3.2 Phenomena on workarounds

Workarounds are of primary interest for every organization that wants to improve their processes. Alter (2014) defines workarounds as: "A goal-driven adaption, improvisation, or other change to one or more aspects of an existing work system to overcome, bypass, or minimize the impact of obstacles, exceptions, anomalies, mishaps, established practices, management expectations, or structural constraints that are perceived as preventing that work system or its participants from achieving the desired level of efficiency, effectiveness, or other organizational or personal goals” (p. 104). This definition states that a workaround is almost always a goal-driven approach that is adapted to overcome a blockade in the system to reach the desired level of efficiency, effectiveness or other goals (Li et al., 2017). Outmazgin & Soffer (2016) agree on this but applicate it more to human behaviour. They conceptualized workarounds as a type of employee behaviour. They described it as: "phenomena that

are typically determined as the behaviour of an employee to reach a certain goal (effectiveness) efficiently". Most of the employee base their decision on a risk-benefit-analysis of the situation (Röder et al., 2014). This is again a form of human behaviour: the employee is searching for the right balance between risk and the benefits. Röder et al. (2016) also state that workarounds usually develop bottom-up, which indicates that workarounds exist primarily on the employee level rather than on management level. Röder et al., (2014) partly agrees on the definition of Li et al., (2017) and Alter (2014), and states it as a discrepancy from defined processes that are rolled out in the employees' performance of routines in a working system. To summarize workarounds are deviations in the process that are developed out by employees in their routines (behaviour they do over and over) in the system. These routines probably have emerged to reach the effectivities and efficiency of a process.

2.3.3 Types of workarounds

Alter (2014) have analyzed different types of workarounds of different authors. The first type of workarounds is inadequate IT functionality. Many workarounds appear due to the weak functionalities of the available software and hardware that are needed to perform a specific step (Alter, 2014). An example by Strong & Volkoff (2010) is an enterprise software system that issues zero-dollar purchase orders resulted in a workaround of a minimum five-dollar cost whenever a vendor offered something for free. The next type is a workaround that bypasses obstacles built into existing routines. Some employees attempt to perform their work effective and execute workarounds to bypass constraints, obstacles, or anomalies that are built into routines, processes, or methods. An example of this requirement of bypassing constraints is to enter temporarily unavailable data before proceeding with any online transaction or customer interaction. Often the workarounds involve submitting "dummy data" that afterwards is corrected (Strong & Miller, 1995; Lederman et al., 2003). The third workaround is to bypass or overcome transient obstacles due to anomalies or mishaps. In paper production Supachayanont (2011) found that operators of the machines react on disturbances. An example of a study during changes in paper grade by working around the control system to achieve production. This means sometimes control steps are skipped to speed up the process so they can achieve the production targets. Another type of workaround is a workaround that responds to mishaps with quick fixes. Applying quick fixes to work around mishaps and other problems is an inherent part of many services jobs (Alter, 2014). For example the IT infrastructure (ITL) has guidelines for service management and states that creation of workarounds is the prime responsibility of IT service desks. The next type of workaround is to augment existing routines without developing new resources. Some workarounds that one is doing over and over do not require new resources (new activities registered). There are examples (Ignatiadis & Nandhakumar, 2009; Yang et al., 2012) in accounting and factory departments that employees login once and then allowing colleagues to use the same session for their transactions. This consequently makes more existing routines without developing new resources, and makes it hard to trace the process and to provide accurate information. Another type of workaround is a substitute for unavailable or inadequate resources. Workarounds often involve substitutions and sometimes occur when inadequate

staffing or unavailability of resources calls for a workaround. In some cases, the unavailability of a resource is only a perception, for example, a computer user does not know where to record the credit card information and consequently finished transactions and has entered the information elsewhere (Boudreau & Robey, 2005). Design and implement new resources is also a type of workaround. This workaround occurs when a user of the system develops and implement new software workarounds. This is called shadow system or a change in the current software. These workarounds can be an indicator of shortcomings in the current system (Brazel & Dang, 2008). An example can be a system that uses by paperwork instead of the electronic system (Fitzpatrick & Ellingsen, 2013). The next type of workaround is executed to prevent mishaps; sometimes it is possible that people are not fully trusting the system and see it as a "single version of the truth" and for that reason are willing to use another resource as double-check. This consequently decreases productivity. An example is the use of an inventory system: when people do not trust the ERP they want to check whether how much stock there is. Another type of workaround comprises of workarounds that pretend to comply with the goals of the management. For example, an employee fills in forms with “invalid data to buy time” because uncertainty declines over time. From this perspective, the continuing insistence that other units fill out these forms may only lead to more invalid data. Consequently, the tighter the control system, the more it may result in workaround activities and false data" (Alojairi, 2011). The next type of workaround is to lie, cheat or steal for personal benefit. This can damage the quality of the process and the company. For example a salesman gives the wrong date on a sales to receive his monthly bonus and afterwards corrects the false information. The last type of workarounds is colluding for mutual benefit. Sometimes lying, cheating or even stealing is accepted or even pursued by the management. Workarounds of traditional lending practices have contributed to the financial crisis in 2008-2009 (Alter, 2014).

Often it is easy to recognize a workaround when it is clear to understand a difference in the designed path from the non-designed way. However it can be hard to investigate this path (Ejnefjäll & Ågerfalk, 2019). Sometimes a block occurs. A block is something that obstructs the user from completing his work in an appropriate way (effectiveness). The block can occur for different reasons, for example, due to flaws in the system such as lack of features (Novak et al., 2012; Huuskonen & Vakkari, 2013) or design of the system that is not supporting work practices (Azad & King, 2008; Laumer et al., 2017). More often blocks appear due to a lack of resources (Ferneley & Sobreperez, 2006 ; Parks et al., 2017). Therefor a block must be checked before the effect can be determined.

2.3.4 Direct effects of workarounds

According to Ferneley & Sobreperez (2006), there are three types of effects (consequences): hindrance, harmless, and essential workarounds. Hindrance workarounds are hindering of obstructing employees in their work. When an employee is not aware of the relevance of the data he should enter, he might enter only a subset or even falls data instead of filling in all the fields. The consequence might be a loss of time and money. It might be the case that a company should change its system to make it more effective and efficient (Ferneley & Sobreperez, 2006). Harmless workarounds are workarounds that do

not affect the workflow, for example a different use of an IT system. These workarounds have such a small effect that it barely touches the structure of the process. The last type of effects is the essential workaround. Without these workarounds a prescribed procedure will not deliver its outcome. (Ferneley & Sobreperez, 2006). An essential workaround typically is a form of reaching effectiveness (a goal) and the most problematic one because the current system is not suitable enough to reach the determined goal.

Workarounds can have a negative or positive effect. Workarounds can deviate from a particular process, which may cause process violations. Other workarounds can be functionally useful or can help identifying a dysfunctional system (Ferneley & Sobreperez, 2006). The hindrance workarounds might be an indicator that employees lack knowledge or that some data might not be needed. Company X should consider actions towards employees or data. The harmless effect might be an indicator of a more efficient step in the process, or an indicator that the system is not suitable enough.. The essential workarounds can be negative and positive, since sometimes in might be an indicator that steps can be done more efficient and quickly and sometimes negative since the system is apparently not suitable enough to perform all the steps or people are skipping procedures by entering false data, for example. The hindrance workaround is a negative indicator since people are hindered by the system and for that reason the system is not efficient.

3.Methods

Quantitative research is conducted to provide an answer to the research question: "How effective is process mining in discovering workarounds and the valuation of their value?". In the first chapter the process discovery is described. Then process mining is used to check the compliance of "De Jure" model with the "De Facto" model that is conducted by mining the event logs. Lastly, the results of the analysis and the workarounds are analyzed on whether they increase the performance of the process and what the positive or negative workarounds are. This research is done in collaboration with Company X that is currently using Scherpthe ERP software., using data from 01 January 2019 to 06 May 2020. Since this includes all the months in one year this suitable enough to conduct reliable conclusions.

3.1 Process discovery

In consultation with the financial controller of Company X a draft of the process is made to provide an overview of the process and protocols within Company X. This draft together with the theory of process management and the knowledge of the controller, is input for the designed process that is in line with protocol formulated by Company X. The event data together with the designed process formulated by Company X, the "De Jure" model is developed. This model is validated by the accountant to make sure all the steps within this process are not only in the process description, but in fact logged. In this case, the financial controller is hired as a participant because the controller knows the rules within the organization and protocols in accounting. The process has been conducted in Petri-Nets, since its business process language is most suitable for analysing with process mining.

3.2 Process mining and accounting compliance

The methodology used for process mining is a standard methodology founded by Van der Aalst (2011). This methodology is a general one used for different techniques in process mining: (1) the preparation of the event log, (2) inspection of the log, (3) the control flow, (4) performance analysis, (5) role analysis (Van der Aalst, 2011). The results are transferred to the client. Event logs are the essential, central part of process mining. An event log consists of activities, each with a timestamp, which are created by the system. An event log might have multiple timestamps; these timestamps need to be in time order, otherwise no process can be detected. The next step is to inspect the data for the first time. At this stage statistics are used to get a first insight in the number of cases and roles, the total number of events, number of different events present, the minimal, maximal and average number of events per case, start and end of the event and their occurrence (Bozkaya et al., 2009). The statistics assist with filtering and removing incomplete cases, for example cases that have been started before the start of the event log. After that the control flow is analysed. In this analysis the De Jure and the De Facto models are compared and the differences and commonalities analysed. The De Jure model is the model as designed together with the controller; this model includes all the activities per process. A De Facto model (the actual processes) eventually could be different from the De Jure model and shows paths that are according to the De Jure model not designed. These new paths could be indicators of workarounds and a good starting

point for in-depth analysis. Besides the comparison, it is possible to update De Facto model to a De Jure one (Van der Aalst et al., 2004). Comparing the different models might make it clear that the existing model does not provide the most effective way. This could be a motivation to improve the current (De Jure) model by using the de facto model. According to Van der Aalst et al., (2004), this might be relevant because people often found a better way to execute processes and this better way can be implemented

To perform this analysis auditors can use historical data to discover De Facto model with different perspectives (control, time and resource). De Facto means, standards in actuality so what the real standards are in the process. The De Jure model is the formal accounting standard, used when reporting on KPI's. Some mining techniques focus on the control-flow (order of activities), data/rules, and resources/organization. Auditors can use these techniques to analyze the historical data against the De Jure model. This De Jure model is, in this case, the business process model, that is designed before the process is mined. After mining the conformance-checking techniques highlight parts where conformance is low and parts with deviations. Consequently, auditors can use these techniques to assess which rules are not followed (Van der Aalst et al., 2004). The workarounds will be adopted in the new De Jure model to assess their performance in the process and whether the workarounds have a positive or negative influence on this performance.

To use process mining, an application for mining the event log is necessary. This application is called ProM and is a generic open-source process mining toolset (Van der Aalst et al., 2010). The application has a pluggable architecture and support a wide range of control-flow models including various type of Petri-nets, event-driven process chains (EPC's), business process modelling notation (BPMN), and Business process execution language (BPEL) (Van der Aalst et al., 2010). The advantage of ProM is that it supports models that represent rules, social networks, and organizational structures. There are different plug-ins to discover and check conformance of the process model. Recently a new plug-in is developed to help detect, predict, and recommend activities (Van der Aalst et al., 2010).

Process mining can give some typical errors. First time typically gives an idealized version of reality (Van der Aalst, 2011). When mining the spaghetti process, it mainly focusses on 80% of the cases that occur most often. This means that 20% per cent of the cases are left out. Therefor useful information is lost because this 20% can represent many workarounds. This consequently influences the validity and reliability of the research. For that reason eventually the causal C-Net technique is used to include all the events but this technique only notices the relations that occur mostly.

Another problem that can occur is that the model is at the wrong abstraction level (Van der Aalst, 2011). This indicates when a process involves over thousand steps, its analysis becomes too complicated and is therefore not useful anymore. For that reason, the event logs are checked and an abstraction level is chosen. A lower abstraction level than the level of the dataset decreases the validity and reliability of this research.

4. Developing the De Jure models

The De Jure models have been developed with the help of the ERP data and with the original process models provided by the accountant as guide (appendix A1, A2, A3). The ERP data consist not only of workflow data but also of merged data from three separate modules. Those modules are purchase tables (PO, purchase data), sales tables (SO, sales data) and production tables (JB, production data). Those different modules have been filtered out in three different tables. What should be kept in mind is that Company X works with a simple system that does not log a lot of data, so mainly only the beginning and the end of the process is logged.

After having configured the data into three different logs, all the events have been renamed. When summarizing the three event logs (SO, PO, JB), the sales process data contains 1330 orders and 51268 events, the purchase process data 2992 orders and 41338 events, and the production process 4122 orders and 112078 events. All the event categories have been summed up, and together with COMPANY X the events have been labelled with business terms, to understand what step in the process it concerns. This has been quite a harsh job since there are very many activities identified in their ERP system. The method used here is, that the data is compared with the process models (Appendix A) the accountant provided. When comparing the data to the model, it is easier to categorize the data and rename events under the right activity. Once all the events are renamed, they have been filtered in Promlight (the application for process mining). This filtering is required because this 80% should be representative for De Jure model, since it would be logical that this 80% represents the designed model. The filter used in Prom is a heuristic filter since it was almost impossible to discover any process due to the spaghetti as discussed above. The spaghetti models are shown in appendix B. However to conduct an excellent, readable model filtering was required. Another problem faced is that a lot of activities have the same timestamp. For example, when an employee clicks on the save button, all the details of the order are kept (and changed) with the same timestamp. However, the heuristic filter filters the most important 80% of activities for all the three modules.

This 80% of events should be representative of the process and how the different modules act in the ERP system. For that reason, these filtered logs are used to make a De Jure model in Petri-nets. Those Petri-Nets are eventually validated with the accountant to make sure the processed model is a good representation of the De Jure Model. The discovered models are validated with the accountant and displayed in the next section . In table 4.1 the steps taken to develop the De Jure model are summarized.

TABLE 4.1 DEVELOPING DE JURE MODELS

Step 1	Make BPMN of the process (Appendix B)
Step 2	Received event log with different terminology
Step 3	Filter event log on 80%
Step 4	Discover process with event log and use the BPMN process as guidance
Step 5	Validate process with the accountant
Step 6	Improve and deliver end process
Step 7	De Jure models final

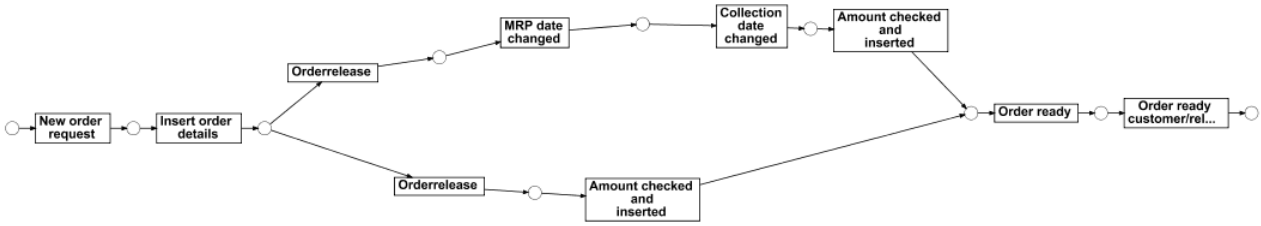

FIGURE 4.1.1 SALES PROCESS IN PETRI-NET

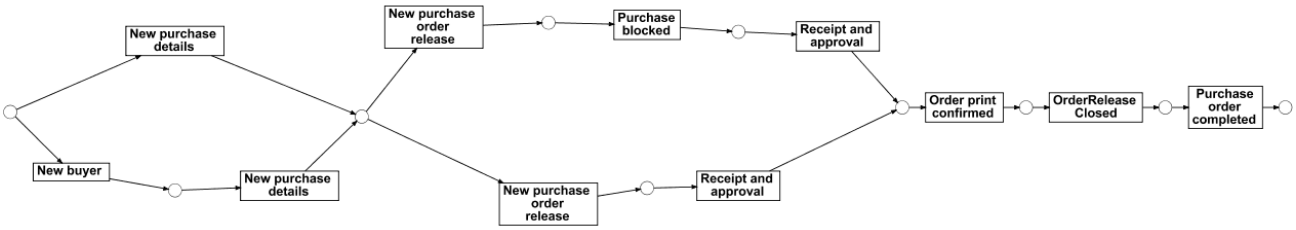

FIGURE 4.1.2 SALES PROCESS IN PETRI-NET

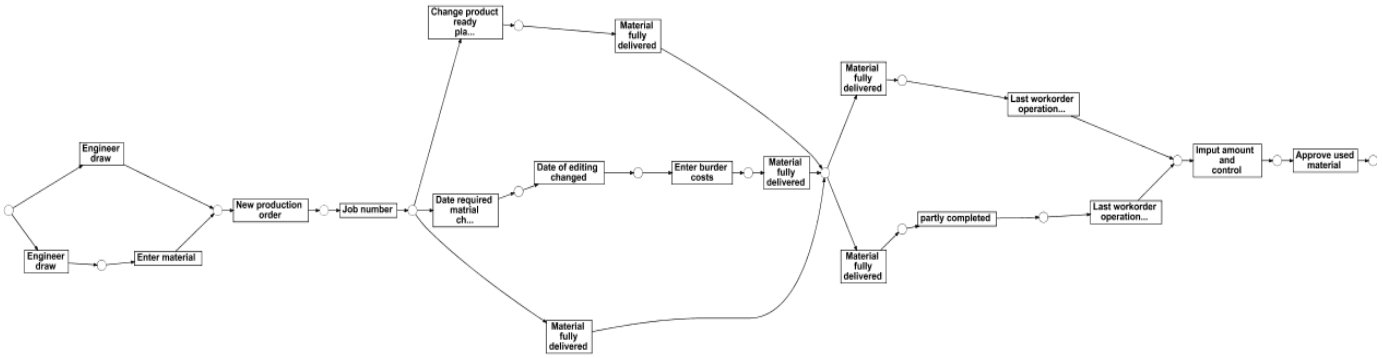

FIGURE 4.1.3 PRODUCTION PROCESS PETRI-NET

4.2 Summary of event logs (Heuristic filtered)

4.2.1 SO process steps in ERP system

The most significant events in the sales process are displayed in the Petri-nets above; those are the 80% events that happen the most and filtered with Prom. However, those activities are displayed in ERP language and need a translation into a business language to make it more understandable. First, the process steps are displayed in table 4.2.1.1, and the translation is given in table 4.2.1.2. The start event is Nw. Record (OrderHed) and the End event is status Open -> Closed (OrderRel). Those events in the ERP system are summarized to business context and processes.

TABLE 4.2.1.1 SO PROCESS STEPS

Event	**Module**	**Event subprocess**	**Module**
Nw. Record	OrderHed		
Nw.Record	OrderDtl		
Nw.Record	OrdelRel	Need by: 26/03 < 01/05	OrderRel
Status: Open -> Closed	OrderDtl	Ship By: 25/03	OrderDtl
Status: Open -> Closed	OrderHed		
Status: Open -> Closed	OrderRel		

TABLE 4.2.1.2 SO ERP EVENT TRANSLATION

Event	Translation
Nw.Record (OrderHed)	New order request
Nw.Record (OrderDtl)	Insert order details
Nw.Record (OrderRel)	OrderRelease
Status: Open -> Closed (OrderDtl)	Amount checked and inserted
Status: Open -> Closed (OrderHed)	Order Ready
Status: Open -> Closed (OrderRel)	Order ready customer/release
Need by: 26/03 > 01/05 (OrderRel)	MRP date changed
Ship by: 25/03	Collection date changed

4.2.2 PO process steps in ERP system

The most significant events in the purchase process are displayed in the Petri-nets above; those are the 80% events that happen the most and filtered with Prom. However, those activities are presented in ERP language and need a translation into a business language to make it more understandable. First, the process steps are displayed in table 4.2.2.1, and the translation is given in table 4.2.2.2. The start event is Buyer ID (POHed), and the End event is status OpenOrder: Yes -> No (PoHed). Those events in the ERP system are summarized to business context and processes, outlined below.

TABLE 4.2.2.1 PO PROCESS STEPS

Event	Module	Event subprocess	Module
Buyer ID	PO Header		
Nw. Record	PoDetail		
Nw. Record	PoRel	Approvalstatus: A -> U	PoHeader
Print as: N -> C	Po Header		
Status: -> Closed	PoDetail		
Status: -> Closed	PoRel		
OpenOrder: Yes -> No	PoHeader		

TABLE 4.2.2.2 PO ERP EVENT TRANSLATION

ERP event	Translation
Buyer ID (PoHed)	New buyer
Nw.Record (PoDtl)	New Purchase
Nw. Record(PoRel)	New Purchase order Release
Nw.Record (PoHed)	New Purchase Order
Prints as: N -> C (PoHed)	Order Print confirmed
Status: -> Closed (PoDtl)	Receipt and Approval
Status: -> Closed (PoRel)	OrderRelease Closed
OpenOrder: Yes -> No (PoHed)	Purchase order Completed
Approvalstatus: A -> U (PoHed)	Approval undefined

4.2.3 JB process steps in ERP system

The most significant events in the production process are displayed in the Petri-nets above; those are the 80% events that happen the most and filtered with Prom. However, those activities are presented in ERP language and need a translation into the business language to make it more understandable. First, the process steps are displayed in table 4.2.3.1, and the translation is given in table 4.2.3.2. The most significant events in the JB process are summarized above; those are the 80% events that happen the most, filtered with Prom. The start event is Engineer Draw (JobHead) and the End event is Job Complete: No -> Yes. Those events in the ERP system are summarized to business context and processes, outlined below.

TABLE 4.2.3.1 JB PROCESS STEPS

Event	**Module**	**Event subprocess**	**Module**	**Event subprocess**	**Module**
Engineer draw	JobHead				
Nw.Record	JobHead	Nw. Record	JobMtl	Required date:	JobMtl
Job Numer	JobMtl	Req by: 15/02	JobHead	Due date:	JobOper
Issued complete: no -> Yes	JobMtl	Completed quantity	Jobhead	Burder Costs	JobHead
Candidate: no -> Yes	JobHead				
Job complete: -> Complete	JobMtl				
Job Complete: No -> Yes	JobOper				

TABLE 4.2.3.2 JB ERP EVENT TRANSLATION

ERP event	**Translation**
Engineer draw (JobHead)	Insert draw of product
Nw.Record (JobHead)	New production Order
Job Number (JobMtl)	Enter job number
Issued complete: No -> Yes (JobMtl)	Material fully delivered
Candidate: No -> Yes (JobHead)	Last work order operations complete
Job Complete: -> Complete (JobMtl)	Approve used material
Job Complete: No -> Yes (JobOper)	Product ready
Nw. Record (JobMtl)	Enter material
Req by: 15/02 (JobHead)	Change product ready planning
Completed quantity (JobHead)	Partly completed
Required date (JobMtl)	Date required material changed
Due Date (JobOper)	Date of editing changed
Burder Costs (JobHead)	New burder costs

4.3 Function tables and competences

The function table (4.3) describes who performs which function. Most employees have a lot of competences in the ERP system. However, it might still be an indicator of a workaround when, for example, the planner sometimes confirms in the warehouse. The function INK stands for purchase. ADM is administration, KWAL is quality management, MAG is warehouse, PLANN is planning, VERK is sales, WVB work preparation, PROD is production, UREN is changing hours, and MRP is manufacturing resource planning. This function table with competence is used for the resource-based analysis in section 6.3.

TABLE 4.3 USER ROLE

Username	**Function**	**JB**	**PO**	**SO**	**Competence ERP system**
Admin					ADM~LEZEN~APPL~INK~INKMNGT~KWAL~MAG~MRP~PLANN~PROD~~UREN~VERK~WVB
AVE	Group controller	x	x	x	ADM~APPL~INK~INKMNGT~UREN
BHN	Toolmaker	x	x		INK~MAG
BSM	Administrative employee	x		x	ADM~UREN~VERK
CWE	Logistic employee	x	x	x	INK~MAG~PROD~PRODMNGT~UREN~VERK
DDO	Logistic leader	x		x	MAG~UREN
HKA	Logistic employee	x		x	MAG~UREN
HOL			x		LEZEN~INK~KWAL~MAG~PLANN~PROD~UREN~VERK~WVB
HVB	Quality employee	x			KWAL
JHI	Engineering	x	x		LEZEN~INK~PLANN~PROD~WVB
JVB	Production leader	x	x	x	INK~KWAL~MAG~PLANN~PROD~UREN~VERK~WVB
JKL	Production leader	x			PLANN~PROD~PRODMNGT~UREN
KBO	Planner	x	x	x	ADM~INK~MAG~PLANN~UREN~VERK~WVB
LBL	Purchaser	x	x	x	ADM~INK~MAG~PLANN~UREN~VERK~WVB
RMA	Quality manager	x			KWAL

5. Detected process events

In the previous chapter is described how the De Jure models have been developed with reliable filtered data and the help of the business process. However, to detect workarounds it is essential to configure all the data instead of 80% of the cases. Workarounds are mainly abnormal behaviour that do not happen all the time, and for that reason, are harder to detect with only using 80% of the cases. This chapter identifies the real process based on the ERP system data. It is clear that there are a lot more events than described in the 80% most important cases. In the next sub-sections a translation of the ERP data to business context is given for the three processes. This translation is used in the analysis in chapter 6. The discovered (De Facto) models will be shown in the analysis chapter 6, since this makes it easier to compare the models.

5.1 Sales process

In table 5.1, all the events and translations of the sales process are mentioned. These are all the events that happen in the event log without filtering. Those event logs are eventually used for the discovery of the "real" process.

TABLE 5.1 SALES PROCESS TRANSLATION

ERP event	**Translation**
Nw.Record (OrderHed)	New order request
Nw.Record (OrderDtl)	Insert order details
Nw.Record (OrderRel)	OrderRelease
Status: Open -> Closed (OrderDtl)	Amount checked and inserted
Status: Open -> Closed (OrderHed)	Order Ready
Status: Open -> Closed (OrderRel)	Order ready customer/release
Need by: 26/03 > 01/05 (OrderRel)	MRP date changed
Ship by: 25/03	Collection date changed
Status: Closed -> Open (orderHead)	Reopen order head
Status: Closed -> Open (OrderDtl)	Changing order details
OrderQty: 217.000 -> 244.0000 (OrderDtl)	Changing order quantity
Ship to: 1OV -> 5 OV	Ship to change
Our requested quantity: 15.000 -> 16.000 (OrderRel)	Changing quantity automatically
Status: Closed -> Open (OrderDtl)	Open order details
Our stock shipped Qty: 4.800 -> 11.200 (OrderRel)	From stock supplied
Rev: 00/00 -> 00/01	Rev Change
Doc List Price: 4,4 -> 4,19 (OrderDtl)	Change doc list price
Character01: -> D (OrderRel, OrderHed)	Character change
Our Job Qty: 0,00 -> 660 (OrderRel)	Change job quantity
	Credit hold
Status: Closed -> Open (OrderRel)	Reopen order release
Credit Hold override (OrderHed)	Credit hold override

5.2 Purchase process

In table 5.2, all the events and translations of the purchase process are mentioned These are all the events that happen in the event log without filtering. Those event logs are eventually used for the discovery of the "real" process.

TABLE 5.2 PURCHASE PROCESS TRANSLATION

ERP event	Translation
Buyer ID (PoHed)	New buyer
Nw.Record (PoDtl)	New Purchase
Nw. Record(PoRel)	New Purchase order Release
Nw.Record (PoHed)	New Purchase Order
Prints as: N -> C (PoHed)	Order Print confirmed
Status: -> Closed (PoDtl)	Receipt and Approval
Status: -> Closed (PoRel)	OrderRelease Closed
OpenOrder: Yes -> No (PoHed)	Purchase order Completed
Approvalstatus: A -> U (PoHed)	Approval undefined
Print as: N -> C (PoHeader)	Order print confirmed
Approvalstatus: A -> U (PoHeader)	Change purchase to undefined
Received qty: 0,00 -> 8.000 (PoRel)	Purchase partly received
Vendor Qty: 3.500 -> 3592 (PoRel PoDetail)	Vendor Qty change
Due date: 30/04/19 -> 07/05/19 (PoRel)	Changing due date
Promise date: -> 05/04/19 (PoRel)	Setting promise date
OpenOrder: no -> Yes (PoHeader)	Order reopened
Unit price: 0,380 -> 0,390 (PoDetail)	Changing unit price
Qty. Change req.: no -> yes (PoDetail)	Requires quantity change
Invoiced amt: 0,00 -> 1,93 (PoMisc)	Amt remaining claim
Ready to print: yes -> No (PoHeader)	Change purchase to blocked
Status: Closed -> (PoDetail)	Order Detail closed
Approvalstatus: U -> A (PoHeader)	Order approved
Cost Per: C -> E (PoDetail)	Cost per: C -> E
Status: Closed -> (PoRel)	Delivery order closed

5.3 Production process

In table 5.3, all the events and translations of the production process are mentioned. These are all the events that happen in the event log without filtering. Those event logs are eventually used for the discovery of the "real" process.

TABLE 5.3 PRODUCTION PROCESS TRANSLATION

ERP event	Translation
Engineer draw (JobHead)	Insert draw of product
Nw.Record (JobHead)	New production Order
Job Number (JobMtl)	Enter job number
Issued complete: No -> Yes (JobMtl)	Material fully delivered
Candidate: No -> Yes (JobHead)	Last work order operations complete
Job Complete: -> Complete (JobMtl)	Approve used material
Job Complete: No -> Yes (JobOper)	Product ready
Nw. Record (JobMtl)	Enter material
Req by: 15/02 (JobHead)	Change product ready planning
Completed quantity (JobHead)	Partly completed

Required date (JobMtl)	Date required material changed
Due Date (JobOper)	Date of editing changed
Burder Costs (JobHead)	New burder costs
WIPCleared no -> yes (JobHead)	Wipcleared
Allocated qty: 300,-- -> 0,00 (JobHead)	Allocated quantity change
Nw.Record (JobOper)	Operations
Run Qty: 10.000 -> 29.500 (JobOper)	Change run quantity
Completed: no -> yes (JobOper)	Order completed
JobReleased: no -> yes (JobHead)	Work order released
Required qty: 1.600.000 -> 2.000.000 (JobMtl)	Change required material
Issued qty: 1.280 -> 2.000 (JobMtl)	Issuing quantity
Lastlabordate: -> 02-01/19 (JobOper)	Last labour date
Closed: -> 20/02/19 (JobHead)	Close jobhead
Hours: 5,27 -> 10,00 (JobOper)	Changing hours
Act. Labor cost (56 -> 70). (JobOper)	Enter/change labor cost
Last printed: -> 22/01/19 (JobHead)	Last printed
Issued complete: yes -> no (JobMtl)	Issued not complete
Sched. Start: 04/02/19 -> 30/01/19 (JobHead)	Change scheduled start
Schedlocked: no -> yes (JobHead)	Schedlocked
Sched. Due 19/03/19 -> 20/03/19 (JobHead)	Scheduled time change
Received to stk: 0,00 -> 330,0 (JobHead)	Received to stock change
Closed: 20/06/19 -> …	Order closed, date undefined
FixedQty: no -> yes (JobMtl)	Fixed quantity
Wipcleared: yes -> no (JobHead)	Not wipcleared
U/M -> ST (JobHead)	Change unit measure
Ready to print: yes -> No (JobHead)	Not ready to print
Burden rate: 23.3 -> 35 (JobOper)	Change burden rate
Act Prod Hrs: 0,00 -> 0,50 (JobOper)	Change production hours
StartHour: 3,50 -> 7,96 (JobHead)	Start hour change
DueHour: 0,97 -> 1,00 (JobOper or Head)	Due hour change
JobEngineered: yes -> No (JobOper)	Job not engineered
Ready to print: no -> yes (JobHead)	Order ready to print
Ready to print: no -> yes (JobHead)	Not engineered
Prod. Quantity: 2.400 -> 2.500 (JobHead)	Produced quantity change
Candidate: yes -> no (JobHead)	Last workorder not released
Qty/Parent: 0,16 -> 0,200 (JobMtl)	Qty parent
Completed: yes -> no (JobOper)	Not completed

6. Analysis

When using a heuristic inductive miner and trying to develop a Petri-net, it becomes clear that the process is a spaghetti process. One of the causes is that a lot of activities have the same timestamp, which makes it harder to detect a control flow. In appendix B the spaghetti processes can be found for the three processes. These spaghetti processes do not bring any useful insights since they are difficult to read. Therefor causal net c is used. Causal net c identifies the control flow by using all events but only displays the most important relations. The control flow is compared to the De Jure model, to detect workarounds. This is done manually since it is impossible to automatically compare a causal net with a Petri-net. Before comparing all the incomplete cases are filtered out, since some cases have started before the start of the data set. The analyses are done with a heuristic miner with the default setting. The heuristic miner is applicable for event logs that are noisy and is used to express the main behaviour.

After configuring the control perspective, the time perspective and resource perspective are analysed. This is done by discovering a Petri-net model based on 80% per cent of the data and comparing this model with the data. Filtered data is used since Promlight is unable to compare an large spaghetti model in time perspective. The time perspective is expressed in maximum and median time. The maximum time is chosen to see whether there are substantial delays in the system and the median time is preferred because it is less sensitive for peaks and for that reason is the most suitable to display the reality.

Lastly, in the role (resource) analysis, every step within the ERP system is analyzed and compared on role and authorization a person has in the process. This role analysis is based on the tasks every employee has, as shown in appendix C.

6.1. Control flow analysis

The control flow analysis has been conducted by using the causal net, with a frequency 0. Petri-nets would give unreadable output when used on all events. Causal net is better equipped for this. The causal-nets have been analyzed with the De Jure model to discover differences. First the sales process is analysed, then the purchase process, and last the production process.

6.1.1 Control flow analysis sales

The Sales process is mined with the interactive Data-Aware Heuristic miner. All the events are calculated.

(1)(1.1.1) The first finding is that some cases start with order ready customer/release, although the event "order ready" should be the end event. In these cases the order details are changed after the order-ready event, probably correcting data. This is a workaround to bypasses obstacles built into existing routines.

(2)(1.1.2) The second finding is that the order dates are replaced frequently. This can be part of the procedure as seen in De Jure model. The order date events occur single events. This is explained by the fact that Company X uses with a second system for production planning (excel) to prevent mishaps. In

this excel sheet, the production is planned and afterwards the order date is changed. This means that only the order date is logged and displayed in the ERP system.

(3)(1.1.3) An other finding is that after delivery from stock the order is never marked as "order ready". This is due to Inadequate IT functionalities , because the system is built for production, not for delivering from stock.

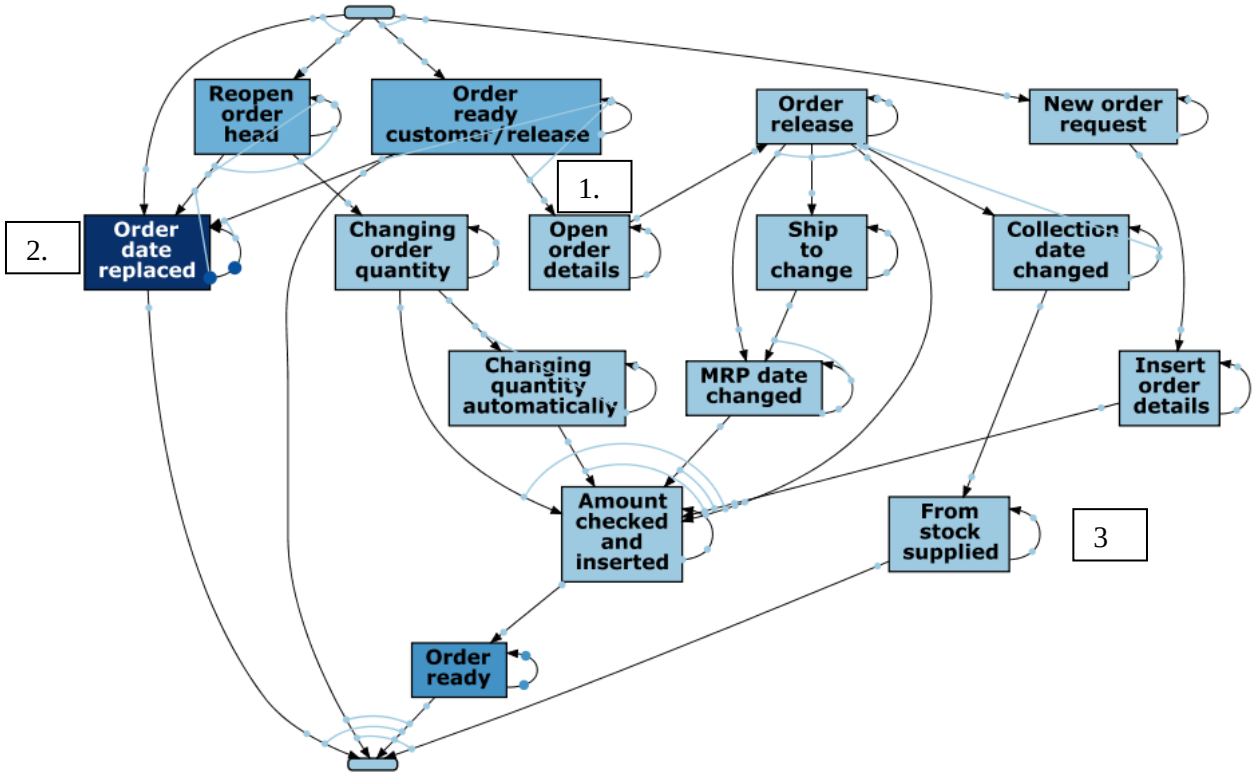

FIGURE 6.1 SO PROCESS CAUSAL-NET

6.1.2 Control flow analysis purchase

A lot more events happen than described in the De Jure model. In the causal-net can irregularities be seen. See figure 6.2.

(1)(1.2.1)The first divergent event is the change in unit price. This change in unit price happens quite often after the purchase order release, for instance from zero to a price of 30. Setting the unit price initially to zero is probably done, so the order can proceed without delay. This workaround can be seen as pretend to comply (buying time), and as bypassing obstacles built into existing routines.

(2) (1.2.2) Another finding is the frequent change of the buyer ID. The system automatically uses the buyer-id of the logged in user, however when a new buyer ID is implemented before an order this indicates that the someone else is working in the account of the logged in user. This is a form of Augmenting existing routines without developing new resources. Someone is entering the order with the account of another person.

(3) (1.2.3) Undefined orders are registered orders without quantity. Sometimes an order is undefined, and afterwards the quantity is changed. However, some undefined orders are not changed. It might be that the purchase has never arrived and the order stays in the system. These orders might be an indicator of inadequate IT functionality because the system should give a warning or should delete these orders.

(4) (1.2.4) Some purchase orders are completed without any other events happening. This can indicate that some steps of an order are not conducted. These steps are taken at the end of the year, probably done by the accountant before the annual report to get the system up-to-date. This is a form of pretend to comply or an inadequate its system because the system should give notification or it is just easy to confirm instead of checking whether an order has arrived.

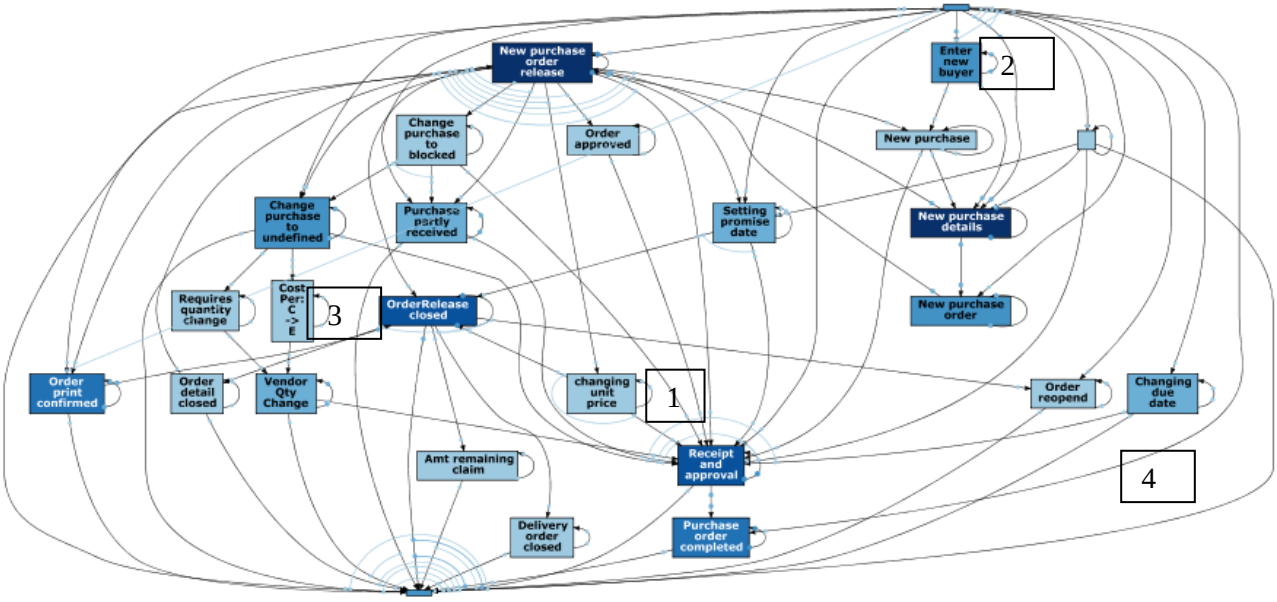

FIGURE 6.2 PO PROCESS CAUSAL-NET

6.1.3 Control flow analysis production

(1)(1.3.1) Issuing quantity is a strange event that happens after the job number and production order. Someone changes the required material after the order is released. This is probably done to let the process continue, despite the lack in stock. The amount of stock is later corrected. This is a form of bypassing obstacles or pretend to comply. This is done so the order can already be produced and the next process step can be started. However, this next step has been "achieved by filling in invalid data".

(2)(1.3.2) Some orders are wipcleared after their last work date. The material for this order is fully delivered and production was ready to start. However the production has not ended and no product was produced. This event is hard to categorize. It might be due to weak IT functionality that this order is after the last labour date wipcleared in the system and not proceeded.

(3)(1.3.3) Sometimes the required material for an order is changed, as if less is required. This is probably done, because no more material was available for producing. Company X wanted to start producing, to be able to deliver their first amount without having to wait for the other material. This is a workaround to win time and to avoid waiting for the material. This workaround can be classified as a substitute for unavailable or inadequate resources. They still want to produce; however, the material (resource) is not fully delivered.

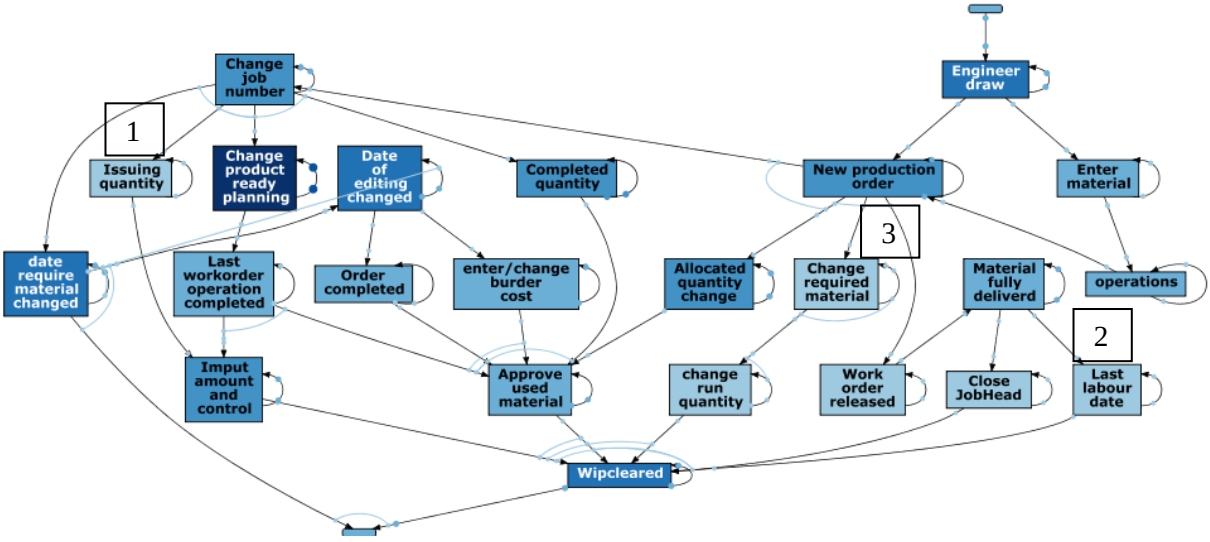

FIGURE 6.3 JB CAUSAL-NET

6.2 Time perspective and log alignment

In this analysis the log is filtered to about 80% of the activities to discover a new Petri net (model). This model is analyzed with the filtered log data to discover the median and maximum lead times. The highest maximum time might indicate workarounds, because employees will find more efficient alternatives (Outmagazin, 2014).

6.2.1 Time perspective analysis sales

(1)(2.1.1) The figure shows the time perspective, with the median time within brackets and the maximum time without brackets. According to the median time it takes 21 days to deliver an order after it is released. The maximum time of delivery is 1,1 year. This unusual long delivery time might be caused by systemic error. The administration checks those open orders each year and confirms the system, or the order was never executed and is closed. Because the system should warn for open orders, this type of workaround is due to inadequate IT functionality. Another reason for a long event might be the use of another system (a shadow system). This workaround is called a design and implement new resources.

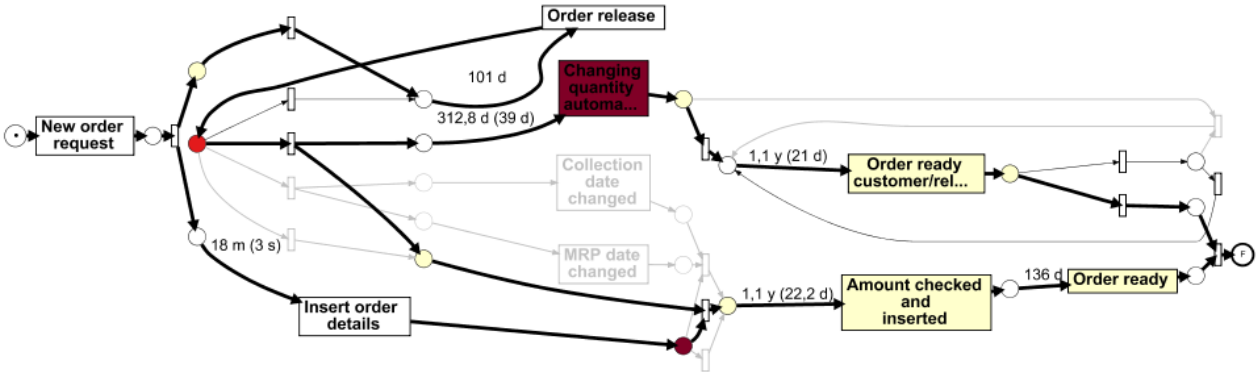

FIGURE 6.4 SO PROCESS TIME PERSPECTIVE

6.2.2 Time perspective analysis purchase

(2.2.1) In the purchase process the median time for setting a promise date is seven days. This is remarkable since the promise date should have been added when the order was released and not seven days after release. It might be possible that the promise date was not known at the time the order was released. So the fields are left open or filled with invalid data.. This workaround can be qualified as bypassing obstacles built into existing routines or pretend to comply to speed up the process.

(2.2.2) As in the sales process there appear some peaks. Some orders stay for 200 days in the system without delivering or deleting this case. This is a situation where the IT function is not adequate because it should give a notification that an order is still open. Another reason might be the use of a different system (a shadow system). It might be that the order is delivered and noted in an excel sheet without changing this order in the system. This workaround is called a design and implement new resources.

Figure 6.5 is bigger displayed in Appendix E.

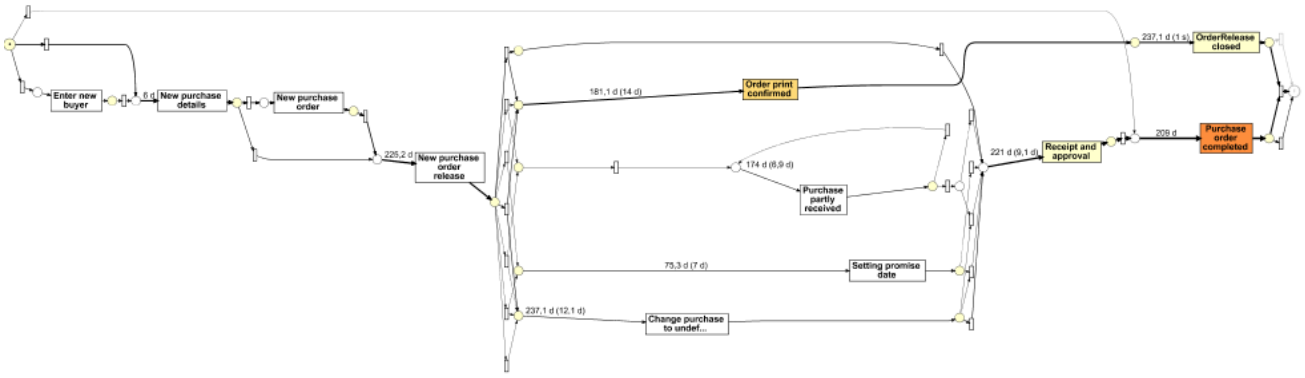

FIGURE 6.5 PO PROCESS TIME PERSPECTIVE

6.2.3 Time perspective analysis production

The overall fitness of this model is 78,5% and is reasonable. This model is configured with a filtered dataset that contains 80% of the most important events. Figure 6.6 is bigger displayed in appendix E.

(2.3.1) When analyzing this model, it still looks like spaghetti. The De Jure model as predefined becomes more visible. The strange thing is that sometimes if an order takes too long, after 19,3 days an allocated quantity change can be seen, this can be an indicator of workarounds. In 18,8% of the cases, an allocated quantity change takes place. At half of the time before the material is fully delivered, first the date of material changed and the editing time changed are changed. This indicates material is not directly deliverable. This is probably also a reason to sometimes change the allocated quantity so they can overcome a high delivery time and a later editing time. This is probably done for a few reasons. First, to set back the inventory, so the product is in the system back to stock and can be used. This can be done by several planners in the system, so they set back one order, the product goes back in stock and can be used by other planners, so the planner does not have to wait for the product to arrive. After a while, the order gets wipcleared from the system. This is an example of a substitute for unavailable or inadequate resources. If there is not enough stock to enrol an order, the planner conducts an allocated quantity change.

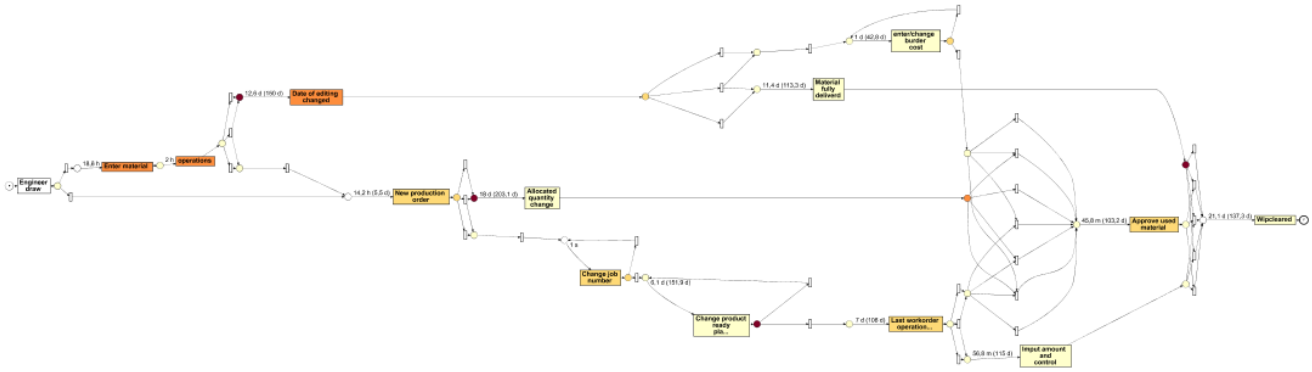

FIGURE 6.6 JB PROCESS TIME PERSPECTIVE

6.3 Resource-based analysis

In this section, every process and every event is analyzed with the roles of the employees. In appendix C, the role definition can be found. The colour green indicates that an event is conducted by the right person and is not suspicious; the colour orange might be an irregular event and is worth further investigation. See table 6.1, 6.2, 6.3.

6.3.1 Resource-based analysis sales

(3.1.1) The order date replaced event is done automatically by the system and is renewed over and over. There are no other events relating to this event, because those are registered in another system. This is designing and implemented new resources due to the leak of the ERP system. So this seems like a strange event that suddenly appears, but the rest of the event takes place in the excel sheet.

(3.1.2) Events as order ready customer/release, amount checked and inserted, and order ready are sometimes conducted by the buyer or planner. This can mean that the steps are forgotten by logistics or that the planner/buyer has the last decision. Or those steps are taken by the administration department indicating that the steps are indeed forgotten and "repaired". This workaround can be categorized as mishaps with quick fixes, the planner, buyer or administration conducting the quick fix.

TABLE 6.1 SALES RESOURCE-BASED ANALYSIS

	Admin			Logistic				Produc	Planne	Buyer	system	
Event	Admin	AVE	BSM	CWE	DDO	HKA	EGR	JVB	KBO	LBL		totaal
Order date replaced											18686	18686
Order Ready	10	6		5096	4268	142	68		22			9612
Order release									1670	252	2238	4160
Reopen order head		12		2			2	36	230	96	3770	4148
Order ready customer/release	10			1956	1748	46	62		52	2		3876
Amount checked and inserted	10	6		1156	1052	42	62		48	2		2378
New order request									1432	118		1550
Insert order details									1432	116		1548
Chang order quantity									566	168	702	1436
Collection date changed									720	210		930
ship to change									796	8		804
MRP date changed									514	30	2	546
Changing quantity automatically									428	36		464
Open order details		10		2			2		88	68	244	414
From stock supplied				202	160	18	6		2			388
Rev change									124			124
Change doc list price									78	8		86
character change											46	46
Change job quantity									32			32
Credit hold override		18	6									24
Reopen order release		4		2			2		8			16

6.3.2. Resource-based analysis purchase

(3.2.1) Some events of receipt and approval of purchase are confirmed by the administration or the planner/buyer, instead of logistics employees. However, a the planner and buyer might decide to close the order themselves, since they are responsible for the whole process. It is not usual that the administration signs for the receipt and approval. Administration checks the orders each year and closes them. This is a form of pretending to comply because according to the procedure, the order should be closed in the end.

(3.2.2) Another unusual event is the vendor quantity change done by logistics employees. The planner or buyer should change the order quantity . But when a vendor does not deliver the agreed upon quantity, logistics change the quantity instead of waiting for another delivery. This is workarounds because actually, the vendor should deliver more of the specific product, instead of adapting the quantity the vendor has provided. This is a workaround in the form of mishaps with quick fixes because actually, the order quantity was not as confirmed in the order confirmation. They simply fix this by changing the amount the vendor has delivered instead of waiting for an after delivering..

(3.2.3) Logistics or the toolmaker sometimes change the purchase details, which should be done by the buyer or planner. This is probably done for the same reason as described above. workaround as above; the details are changed by someone who has not the right to do so. This is a form of adapting changes in the order after it is delivered. This it can be categorized as a mishap with quick fixes.

TABLE 6.2 PURCHASE RESOURCE-BASED ANALYSIS

event	administration			logistics				tool maker		Productio	Planner	Buyer	Totaal
	admin	AVE	BSM	CWE	DDO	EGR	HKA	KBU	BHN	JHI	KBO	LBL	
Receipt and approval	36	84		2738	1296	20	180	46	132		50	240	4822
New purchase order release				258					274	32	1954	2256	4774
orderelease closed	30			2752	1314	22	198	46	222		32	140	4756
New purchase details				258					274	32	1912	2084	4560
purchase order completed	38	342		1702	906		268		68		32	280	3636
order print confirmed			10	1606	746	12	86		60		430	226	3176
Change purchase to undefined	34	76		104				46	196		900	1298	2654
New purchase order				14							1666	818	2498
Enter new buyer				244					254	32	252	1272	2054
purchase partly received				1068	504		38						1610
Vendor qty change				38					16		522	868	1444
Change due date									10		654	560	1224
Setting promise date											1158	56	1214
order reopend				36							28	718	782
Changing unit price				58					150		64	244	516
requires quantity change												284	284
New purchase				18					40	24	12	150	244
Amt remaining claim			212										212
Change purchase to blocked		10		12								168	190
order details closed				24							22	84	130
Order approved				14							36	58	108
Cost per: c -> e											32		32
Delivery order closed				20							10		30

6.3.3 Resource-based analysis production

(3.3.1) Sometimes the production changes the product ready planning instead of the planner. This can indicate that production starts earlier and later adapts this in the system. However, the product ready planning should be a prediction made beforehand and not after the product is prepared. This is a form of filling in data to comply with the rules.

(3.3.2) The engineer draw is sometimes implemented by the production employee or the buyer instead of the planner. It might be a correction that the planner mist a step. The system should not accept this because the draw should be available once the order is released. Probably invalid data has been entered, so this workaround is qualified as bypasses obstacles built into existing routines.

(3.3.3)The date of the required material is sometimes adapted by the production leader instead of the planner or buyer. It might be that the production leader starts the production earlier or later and adapts the system. The date of editing might also be changed by the production leader instead of the planner. This workaround pretends to comply by filling in the data afterwards.

(3.3.4) The allocated quantity change is sometimes changed by the planner instead of logistics. However, this type of workarounds is already described in 6.2.3 and is defined as a substitute for unavailable or inadequate resources.

(3.3.5). The planner sometimes confirms that the material is fully delivered. This might indicate that procedures are not always followed because this confirmation has to be done by logistics or the production leader. This again is a form of pretending to comply

TABLE 6.3 PRODUCTION RESOURCE-BASED ANALYSIS

Events	Administration		Logistics			Fabhoe			Production		Data	Planner	buyer	engineer	Controller	tool maker	
	Adm	BSM	CWE	DDO	HKA	Fabhoe	Fabhoe	Fabhoe	JVB	JKL	DATA	KBO	LBL	JHI	AVE	BHN	Totaal
Change product ready planning									370			11386					11756
Engineer draw									110			7088	84				7282
Date require material changed									222			6674	222				7118
Date of editing changed									202			6620					6822
Allocated quantity change			2202	928	1282				1284		50	778		20			6544
Completed quanitity			2828	630	30	582	154	1870	192		118						6404
Material fully delivered			1674	134	4206	20		22	34		68	210					6368
Imput amount and control	36								104			5160					5300
Approve used material									108			5052					5160
New production order									310			4760		44			5114
Change job numer									474			4268		60			4802
Last workorder operation completed		12	1892	396	26	662	140	442	404			12				14	4000
Enter/Change burder cost						630	1370	1374	274		148						3796
Operations									52			3382	28	12			3474
Enter Material									50			3380	26				3456
Order completed									2944								2944
Change required material									884			1292		20			2196
Work order released									68			2058					2126
Change production hours				16					670		16	1282					1984
Wipcleared															1770		1770
Issuing quantity			122		890	74		310	16		24	114					1550
Last labour date			848	58				14			58						978
Close JobHead	36								44			858					938
Changing hours									218			268	224				710
Enter/Change labor cost			162	34		54	30	332	18		12					14	656
Last printed									116			522					638
Issued not complete					36				326			94					456
Change scheduled start									92			84	206				382
Schedlocked												240					240
Scheduled time change												218					218
Received to stock change			32	24	70												126
Order closed, date undefined									32			40					72
Fixed quantity												50					50
Change unit measure												38					38

6.4 Summarizing results

See table 6.4 for an overview. The organizational perspective and the resource perspective are most useful in detecting workarounds. A possible explanation is that some events have the same timestamp, which makes it hard to analyze the time perspective.

The most detected workarounds the inadequate IT functionality, probably explained by the fact that Company X is a relatively small company with a less advanced system. The second most detected workaround is pretend to comply. This type of workaround appears when people change data afterwards or log a step that was forgotten. The third most detected are, bypasses obstacles built into existing routines. Employees want to do work as quick as possible even if that means filling in invalid data.

6.5 Assessing of workarounds on their effect

As mentioned in theory different impacts of workarounds can be classified. Ferneley & Sobreperez (2006) have stated three categories: hindrance, essential and harmless workarounds. The workarounds discovered and organized in the previous section are categorized into one of these categories.

Pretend to comply is a typically essential workaround because an order should be out of the system. This workaround is enrolled, especially when the administration confirms the order after a while. This confirmation is essential because otherwise, the order will stay in the system and will be scheduled over and over, which can lead to efficiency damage.

Inadequate IT functionality is a hindrance workaround. This is especially the case since some orders stay for longer than one year in the system, without any notification from the system. Another problem is that the system is not built for some specific tasks. For example, a delivery from stock no one has to confirm.

Bypasses obstacles built into existing routines is a typical essential workaround. Sometimes a field is filled with "dummy data" to establish the order in the system ready production scheduling without a collection date or price. This is often done to speed up the process. However, an employee should be careful not to forget to fill in the data afterwards. The challenge in this workarounds is to not escalated necessary workarounds to a hindrance workaround.

Substitute for unavailable or inadequate resources is a form of an essential workaround, but might lead to efficiency losses. For instance, when the planner changes the allocated quantity at the expense of another order.

Design and implement new resources is a type of workaround that is harmless. Sometimes the system lacks functionalities which makes it necessary to call for a shadow system. It looks like that Company X logs a lot of activities without vantage. This is not a problem if this occurs in the right way. However,

sometimes steps are taken in an excel sheet, which do not happen in vantage; this makes it sometimes hard to detect whether how steps are performed.

Mishaps with quick fixes are essential, but can also be harmful. Missed steps can be corrected afterwards. When this correction takes too much time the system is not correct and other orders will be affected, or the information to the client might be wrong.

Prevent mishaps is a harmless workaround, since this workaround aims to prevent possible failures. Company X is planning the production with an excel sheet. So the steps are taken just not within the ERP-system.

Augment existing routines without developing new resources is a type of workaround that is harmless but can be essential. Sometimes someone is working on somebody else account within the system. This type of workarounds is often harmless, but can be essential when that someone has not the authorization in the system.

In table 6.4 an overview of all the detected workarounds is provided. This overview shows what type of workarounds is detected by what type of perspective (Organizational, Time, Resource). The effect of the workarounds and the frequency is shown. Table 6.4 is the source for the advice to Company X because this provides us with an overview which types of workarounds are essential and hindrance and which ones should be further researched.

TABLE 6.4 SUMMARIZING RESULTS

	Perspective				
Type Workaround	**Organizational** *(perspective, process, event number)*	**Time** *(perspective, process, event number)*	**Resource** *(perspective, process, event number)*	**Count**	**Effect**
Inadequate it functionality	1.1.3* - 1.2.3* 1.1.3 **- 1.2.4** 1.3.3	**2.1.1 - 2.2.2**		7	Hindrance
Bypasses obstacles built into existing routines	1.1.1- **1.3.1** **1.2.1**	**2.2.1**	3.3.2	5	Essential
Mishaps with quick fixes			3.2.2 - 3.2.3	2	Essential
Augment existing routines without developing new resources	1.2.2			1	Essential Harmless
Substitute for unavailable or inadequate resources	1.3.3	2.3.1	3.3.4	3	Essential Hindrance
Design and implement new resources		**2.1.1 - 2.2.2**	3.1.1	3	Harmless
Prevent mishaps			3.1.2	1	Harmless
Pretend to comply	1.1.2 **- 1.2.1 - 1.2.4- 1.3.1**	**2.2.1**	3.3.1 – 3.3.3 – 3.3.5 – 3.2.1	9	Essential
Total	14	7	10		
1 = Sales, 2 = Purchase , 3 = Production * 1.1.3 (Example) Organizational perspective, Sales process, Event number (3) *1.2.3 (Example) Organizational perspective, Purchase process, Event number (3) ***1.2.1** Indicating an workarounds is classified in two categories					

6.6 Advise for Company X

After having detected and analysed all the workarounds in table 6.4., we can see what workarounds are harmless, essential or hindrance. The essential and hindrance workarounds are the workarounds Company X should consider to change in its system.

The essential workarounds are the workarounds employees conduct because without them the processes will lead to a decrease in efficiency. So the workaround “pretend to comply” and “bypasses obstacles built into existing routines” are the ones that definitely should be adapted in the system. Sometimes employees fill in invalid data to proceed the process, however when they fill in invalid data they should be aware of the fact that these data can cause damage, if they do not correct this data into the valid data. The advice for Company X is to analyse and see in how many cases an order is not changed afterwards when an employee had filled in invalid data. Priema should consider if this influences the company or other orders and see whether they will allow this. If they will not allow this it would be advised to change the setting of the system that if an order is released there is no possibility to change the data afterwards. This is a simple solution and employees can no longer enter false data. Secondly, the workarounds of the allocated quantity change, such as “substitute for unavailable or inadequate resources” are also essential workarounds, that should be changed in the system. There should be a possibility that the material that will be reserved in the system can be “temporary” so the material can be used by another order.

The harmless workarounds such as “prevent mishaps” and “augmenting existing routines without developing new resources” should be considered to whether they make the process more efficient or reliable. In most cases these workarounds do not cause any damage and will not cause damage in the future.

The hindrance workarounds are probably the most problematic and should be evaluated. Especially the one of the inadequate IT system. This means some activities are still done without using the system, in for example, excel files, meaning not all the information is stored within one system, indicating that it might be sometimes hard for everyone to get all the information needed for their order.

It would be advised to evaluate whether the system is still suitable enough for this organisation. The organisation might have grown and the system might not be suitable enough anymore to handle the huge amount of information. Maybe a more advanced system can help with changing these workarounds. The advice is to uses this research when reflecting on the problems of the current system.

7. Discussion and conclusion

In this chapter, the conclusion, limitations, theoretical-, and practical implication are discussed.

7.1 Conclusion

This research aims to explore the question if process mining is an excellent technique to detect workarounds and consequently asses them on their value. For that reason, the following research question was formulated: "How effective is process mining in discovering and measuring workarounds on their value?" After having analyzed the three processes of Sales, Purchase and Production based on the theory of Alter (2014), the conclusion is that some workarounds are more easy to detect than others. The overview states that "pretend to comply", "inadequate it functionality", "bypasses obstacles built into existing routines", "substitute for unavailable resources" and "design and implement new resources" were the main workarounds detected by process mining.

In table 6.4 the workarounds are categorized in harmless, essential and hindrance. The categorization strongly relies on the background of the researcher. Also, the effects can be vague. Some workarounds indeed are necessary to conduct the process and overcome long delivery time. However, in risk-management terms, the workarounds are not accepted since the system is not equipped to do so.

Concluded can be that process mining is an effective way of discovering workarounds. But is this a better way than simply interviewing or observing people? In my opinion the interviewing of people is faster but probably not more effective. This is mainly because the data of an event is a reflection of reality instead of someone opinion. In general, process mining is effective in detecting workarounds, but more time consuming than interviewing employees.

7.2 Limitations

The limitations of this research are very high, because every process is different and every ERP system is used in a different way. It might be that an other company has a more advanced system with more options. Especially the terminology of translating the ERP system steps to business language is a difficult step and is a combination of interpretation and validation.

Another limitation might be the size of the a company. In this company, with 150 employees, the processes are less structured and more like spaghetti, which probably helps in detecting workarounds. Also, the system is perhaps less strict since it concerns a small organisation.

However, the company and the system are not the only limitations in this research. Also the interpretation of the workarounds forms a limitation. The detecting of workarounds is clear. The categorization of the workarounds in the categories of Alter (2014) and their value heavily depends on the interpretation of the researcher. To conclude, this research brings a lot of insights on how to detect workarounds. However, the interpretation of this workarounds heavily depends on the researcher, company and the data.

7.3 Theoretical implications and future research

The advantage of quantitative analysis is that the discovery of workarounds is based on quantitative data that is a reflection of reality. However, the classification of the workarounds in categories is still done by the researcher, and relies on his interpretation. This study also contributes to the literature in aiming to assess the workarounds on their value and analyze whether they should be ignored or can cause significant problems in the future. In some cases, a workaround can be an indicator for an insufficient process that needs to be updated. If, for example, an employee fills in invalid data, this might be an indicator that the process should be changed and the data should be entered later in the process. For the contribution of the literature three causal models have been developed for every perspective. These models provide a simple overview of this research and can be helpful for a future researcher to detect workarounds. A researcher can simply view every perspective and look in the model for an indicator. After having configured the indicator the researcher can see the cause and eventually the effect and assess whether a workaround can cause any damage or trouble for an organisation. This overview makes it more easy to see in glance what the workarounds are and what type and effect occur. The causal models developed can be found in Appendix D.

Due to the limitations of this study in a specific industry and a particular company, further research should be done to qualify how useful process mining is in detecting workarounds. In other branches or companies different types of workarounds can be identified. For that reason, the scope of this research is too limited to a specific company and department. Future research should be done in different branches and different companies. In addition, better methods for the categorization of workarounds should be investigated In general: a better understanding of workarounds and more accessible detecting methods based on quantitative data rather than qualitative methods should be researched.

7.4 Practical implications and recommendations

From a practical side businesses can benefit from this research about workarounds. It should be considered is that a lot of workarounds are not a problem for most companies, especially for small businesses with a lot of workarounds.

Some workarounds might cause problems in the future, for example, when someone does not fill in valid data and later forgets to change this data order is released for zero euro, for example. In general, it would be advised to analyze all the workarounds and see whether these workarounds can cause any danger within the organization. Surely process mining can be a tool to detect workarounds that risk management would not expect to happen. However, a lot of organization are on forehand aware of workarounds but do not see any danger. However it would be recommended for every organization to check whether their processes comply with the designed process. As shown in this research companies are often not aware of the fact employee are “working around” the system and what the possible threats of these workarounds are.

The advice would be for every organisation to first, clarify its processes in a readable business

language, such as Petri-net. Than compare this process with the ERP system and see what steps in the business process are logged and noticed in the system. Third, provide an employee list with the tasks and responsibilities of employee in the system. After conducting these three steps a De Jure model can be developed in Petri-Net.

After receiving the event data, this data should be cleaned an prepared before any process mining technique can be applied. The renaming of the event data should be done with the terminology used in the De Jure model otherwise it is impossible to compare activities. Once every activity is renamed and the processes are separated the analysis can start.

First, the control flow analysis is conducted, to see whether the ordering of activities is the same in the De Jure model as in the De Facto model. This analysis provides an overview to see whether if there are activities that happen in an unusual sequence and eventually these activities can be analysed on whether these are workarounds. Second, the time perspective is analysed. The time perspective should be checked on whether there are unusual high lead times in the process. For example, when an activity normally takes 21 days and in the De Facto model 30 days this might be an indicator of an workarounds because it is unusual behaviour. Third, the resource-based analysis is conducted, this can be done manually, since it is easy to who performs which activity in Prom. For example, the controller of a small company can see in one eyelash if an employee performs an activity in the system he or she is not intended to do so. Eventually all the results and notification can be analysed with Appendix D to see whether the workarounds can cause any damage and should be further analysed.

The advice for Company X would be to evaluate the results and see whether workarounds cause a threat to the company or are inefficient. Those inefficiencies should be analyzed and changes to the system should be made.

TABLE 7.1 ROADMAP FOR DETECTION OF WORKAROUNDS

Nr.	**Steps.**
1.	Building general business process
2.	Compare business process with ERP system
3.	Notice all the steps logged in the system
4.	Provide list with employee responsibilities
5.	Develop De Jure model in Petri-Net
6.	Validate with accountant
7.	Receiving event data
8.	Separate data in different processes (modules)
9.	Rename activities with same terminology as De Jure model
10.	Conduct analysis (Appendix D)

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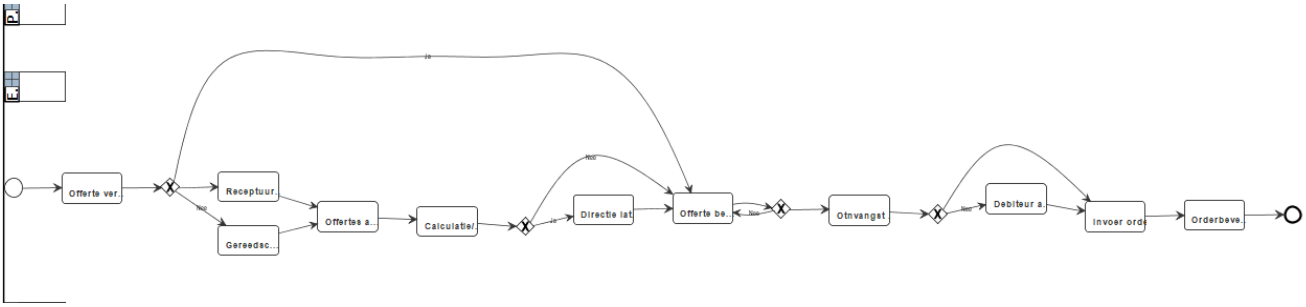
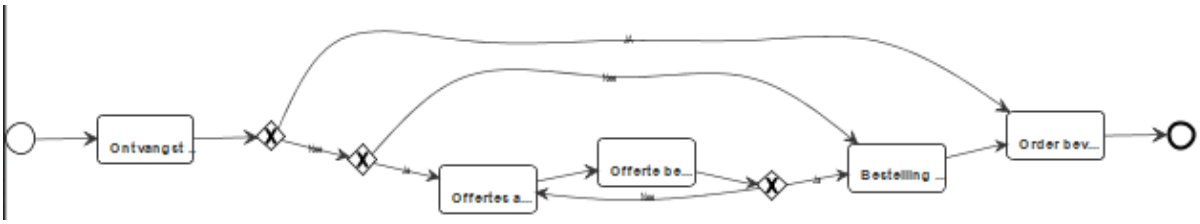
Appendix A BPMN processes



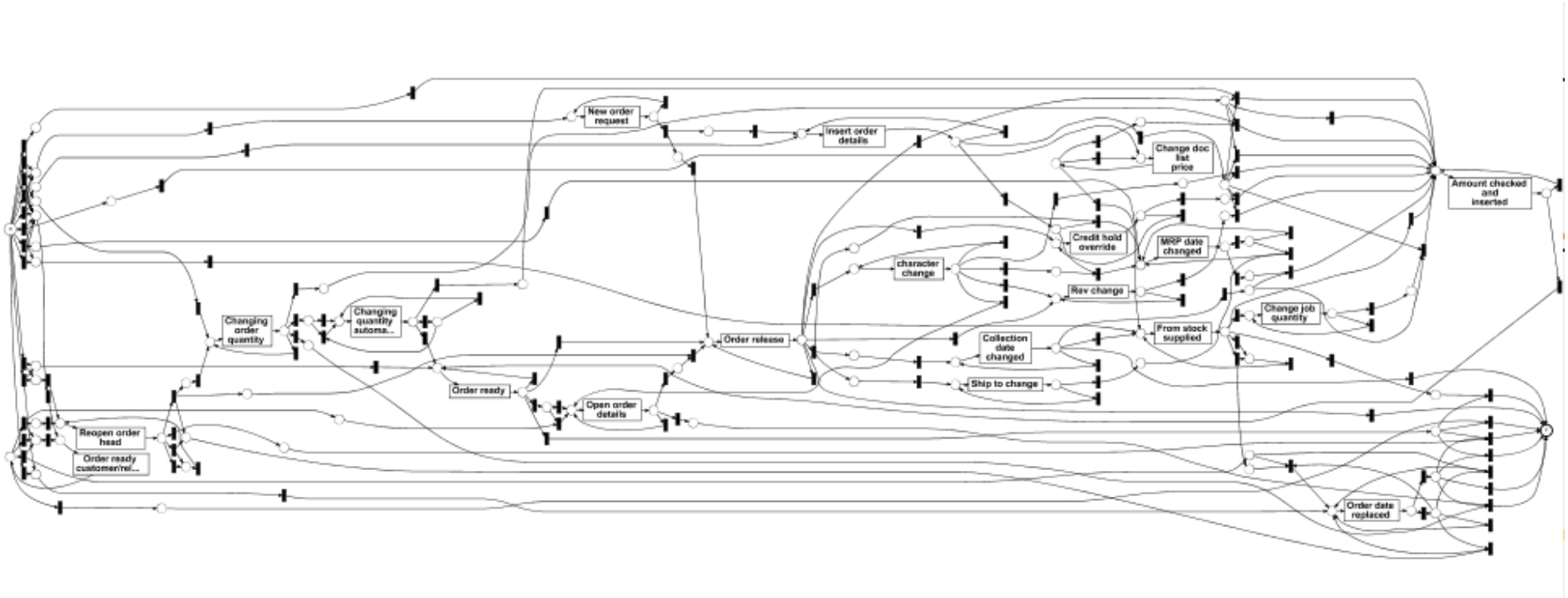
APPENDIX A1 SALES PROCESS BPMN



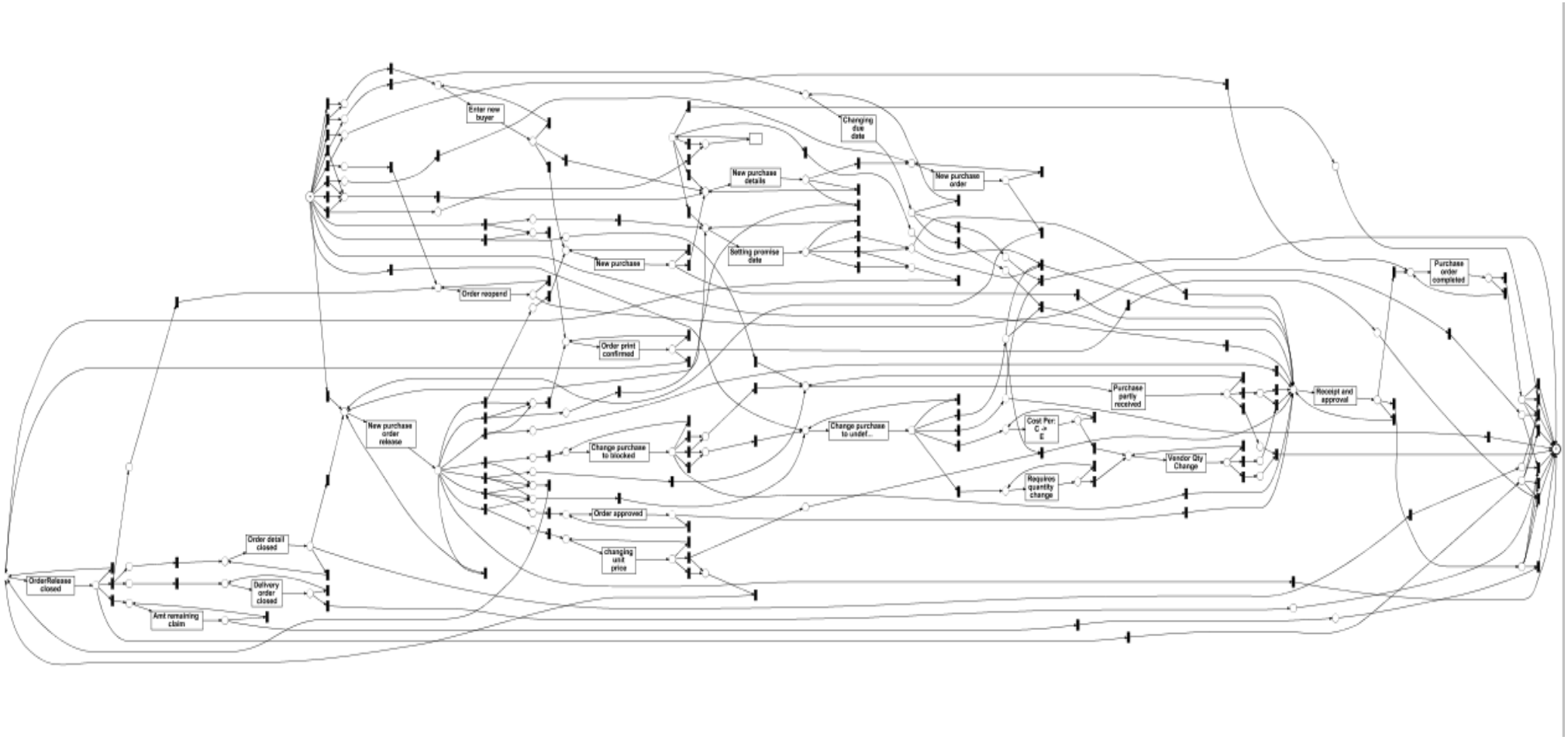
APPENDIX A2 PURCHASE PROCESS BPMN

APPENDIX A3 PRODUCTION PROCESS BPMN

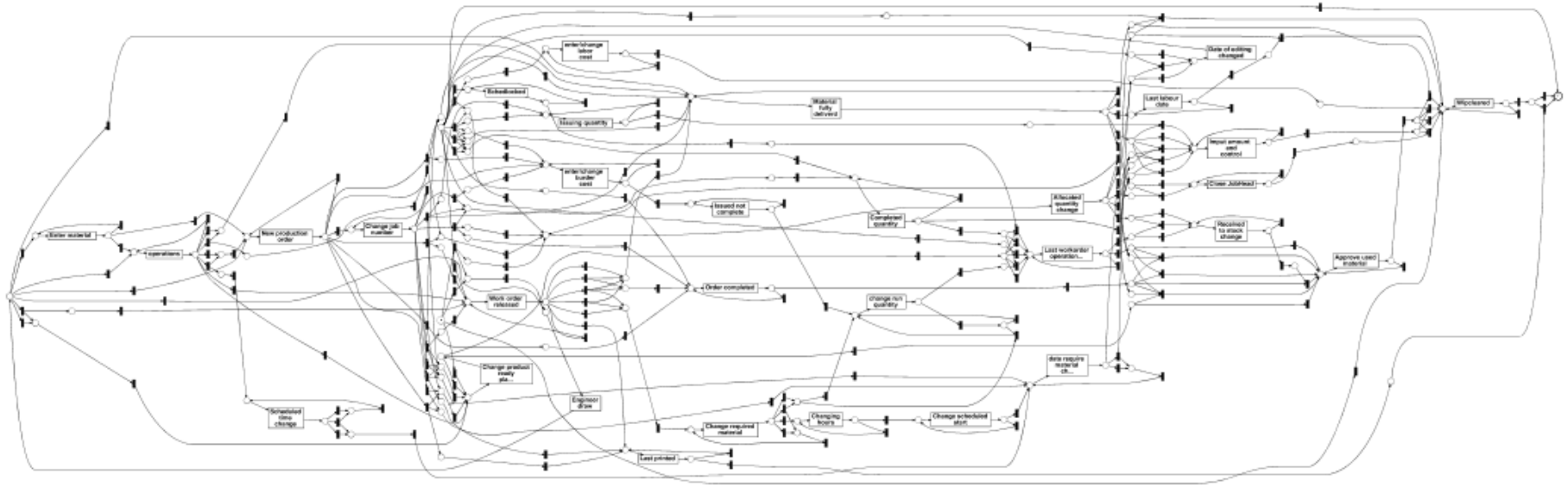
Appendix B spaghetti models



APPENDIX B.1 SALES PROCESS SPAGHETTI



APPENDIX B.2 PURCHASE PROCESS SPAGHETTI

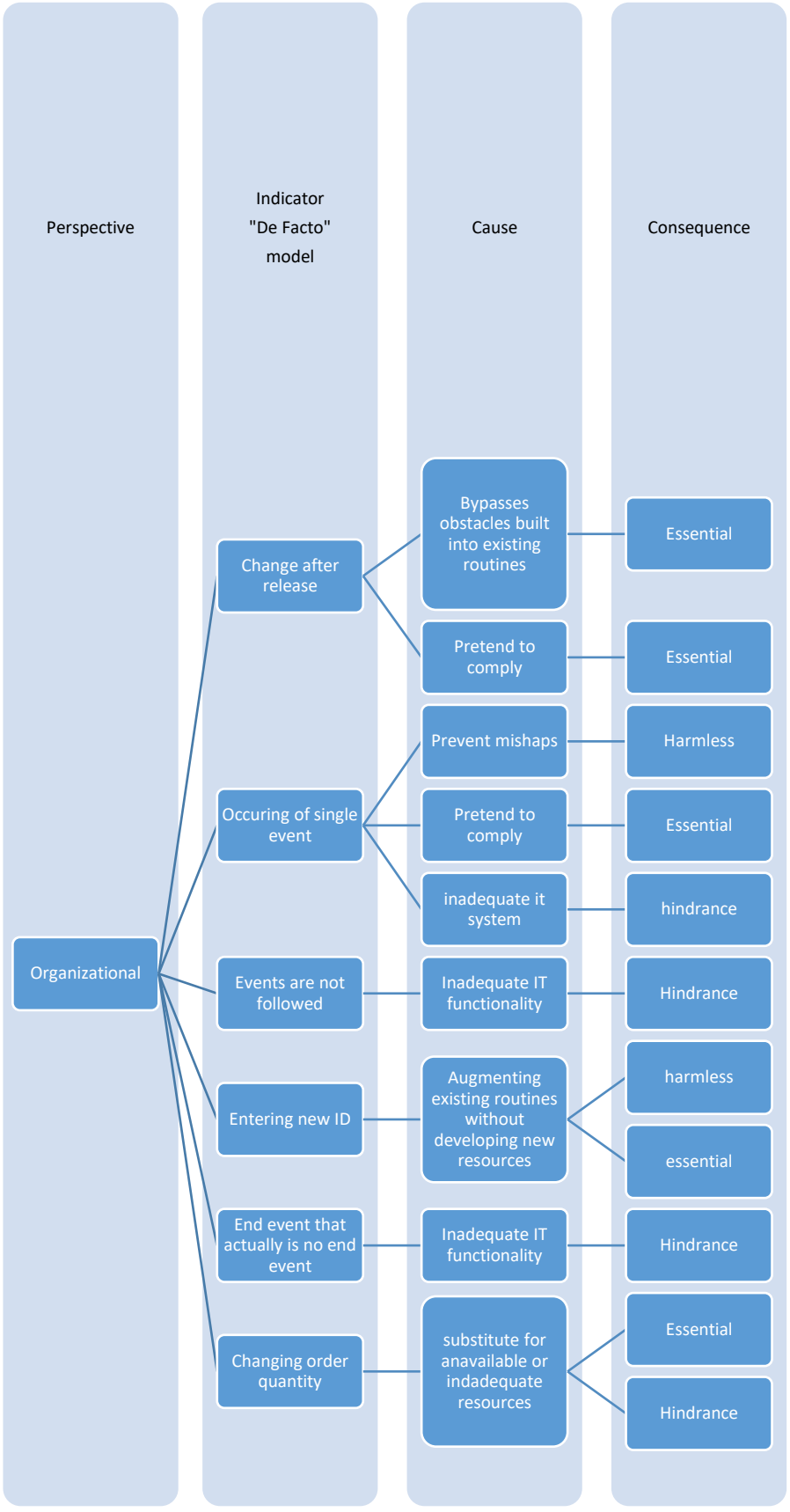


APPENDIX B.3 PRODUCTION PROCESS SPAGHETTI

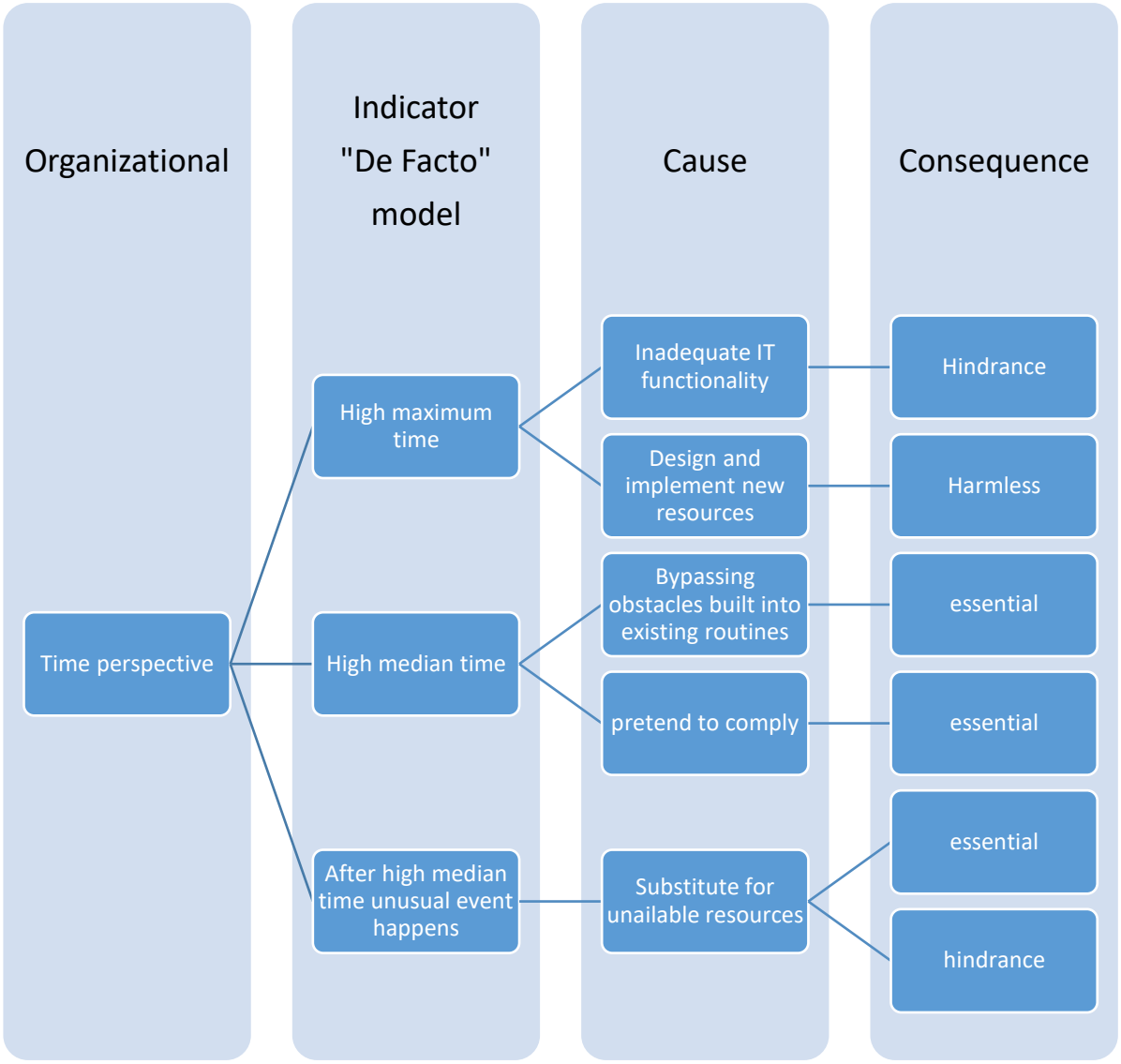
Appendix C role analysis

Name system	Name	Function	JB	PO	SO	Competence ERP system
Admin		Admnistration				ADM~ADMMNGT~LEZEN~APPL~INK~INKMNGT~KWAL~KWALMNGT~MAG~MAGMNGT~MRP~PLANN~PROD~PRODMNGT~UREN~VERK~VERKMNGT~WVB~WVBMNGT
AVE	Ad Verdult	Group Controller	x	x	x	ADM~ADMMNGT~APPL~INK~INKMNGT~PRODMNGT~UREN
BHN	Bart Henzen	Toolmaker	x	x		INK~MAG
BSM	Berdien Smeulders	Administration employee	x		x	ADM~ADMMNGT~UREN~VERK
CWE	Chris Wernsen	Logistic employee	x	x	x	INK~INKMNGT~MAG~MAGMNGT~PROD~PRODMNGT~UREN~VERK~VERKMNGT
Data						
DDO	Daniël Dolman	Logistic leader	x		x	MAG~MAGMNGT~UREN
DMI	Dirk Mijnbeek					
Fabhoe1						
Fabhoe2						
Fabhoe3						
HKA	Henk Kamphorst	Logistic employee	x		x	MAG~MAGMNGT~UREN
HOL	Henri Olsman			x		LEZEN~INK~INKMNGT~KWAL~KWALMNGT~MAG~MAGMNGT~PLANN~PROD~PRODMNGT~UREN~VERK~VERKMNGT~WVB~WVBMNGT
HVB	Herman van de Belt	Quality employee	x			KWAL~KWALMNGT
JHI	Jan Hilhorst	Engineering	x	x		LEZEN~INK~PLANN~PROD~PRODMNGT~WVB~WVBMNGT
JVB	Jan van Bekkum	Production leader	x	x	x	INK~INKMNGT~KWAL~KWALMNGT~MAG~MAGMNGT~PLANN~PROD~PRODMNGT~UREN~VERK~VERKMNGT~WVB~WVBMNGT
JKL	,	Production leader	x			PLANN~PROD~PRODMNGT~UREN
KBO	Kees Boor	Planner	x	x	x	ADM~INK~INKMNGT~MAG~MAGMNGT~PLANN~UREN~VERK~VERKMNGT~WVB
LBL	Leonien Bleeker	Buyer	x	x	x	ADM~INK~INKMNGT~MAG~MAGMNGT~PLANN~UREN~VERK~VERKMNGT~WVB
RMA	Rob Magendans	Quality manager	x			KWAL~KWALMNGT

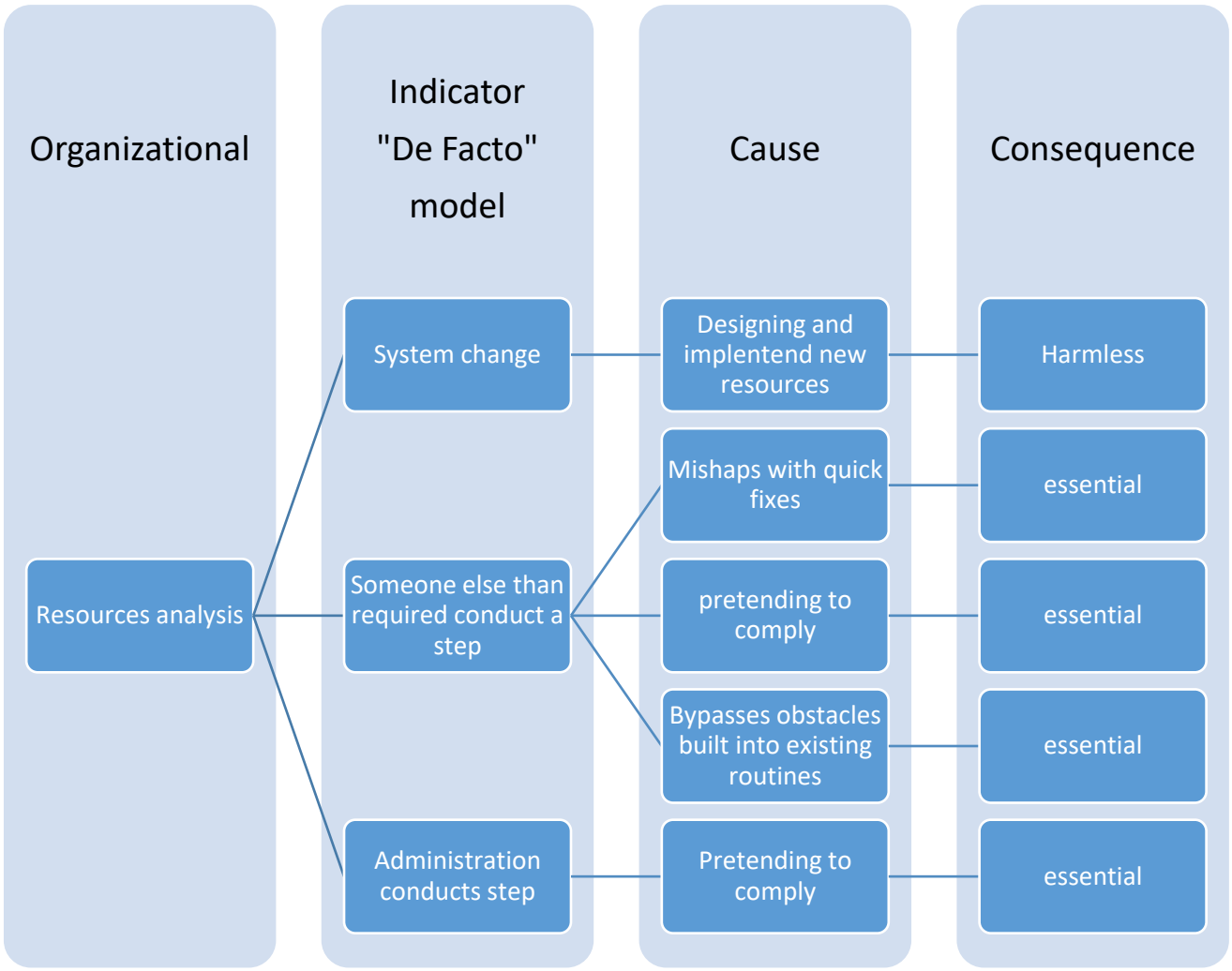
Appendix D guide for detecting workarounds



APPENDIX D.1 GUIDE DETECTING WORKAROUNDS ORGANIZATIONAL PERSPECTIVE

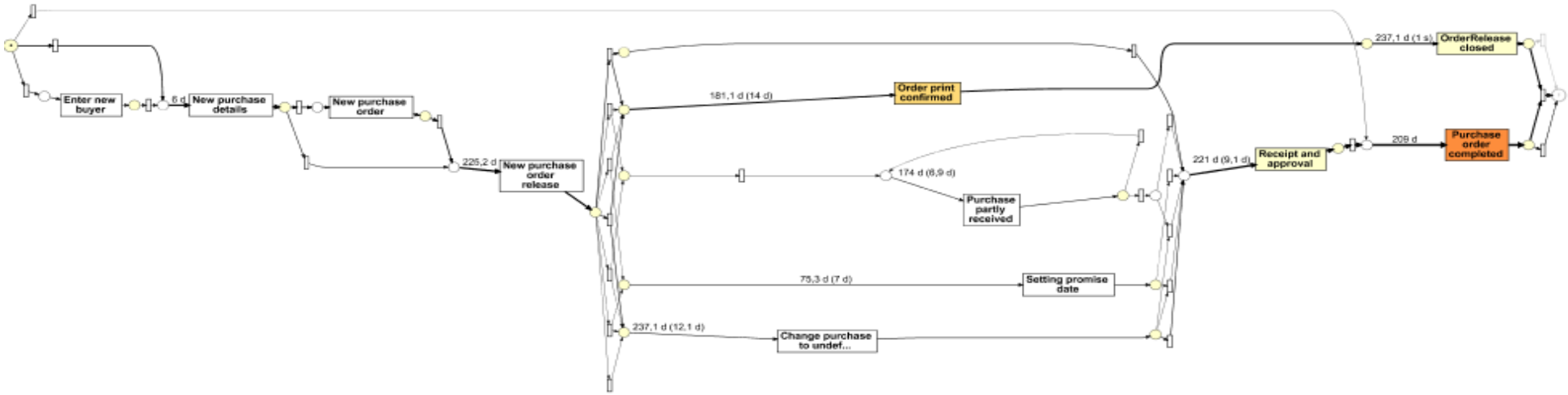


APPENDIX D.2 GUIDE DETECTING WORKAROUNDS TIME PERSPECTIVE

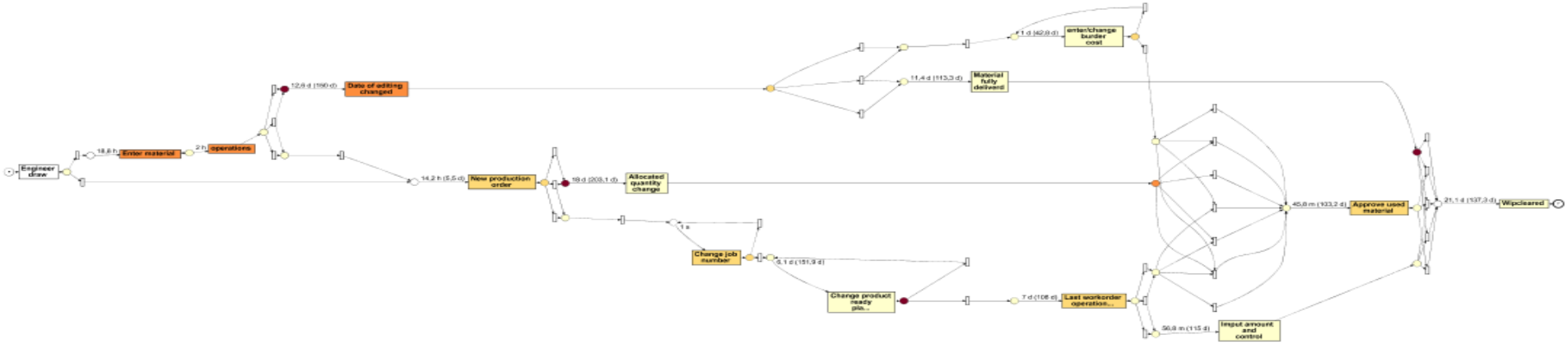


APPENDIX D.3 GUIDE DETECTING WORKAROUNDS RESOURCE PERSPECTIVE

Appendix E Time perspective models



APPENDIX E.1 PURCHASE TIME PERSPECTIVE



APPENDIX E.2 PRODUCTION TIME PERSPECTIVE