Providing insight into the price deviations between purchase orders and invoices at Company X

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Preface

Dear reader,

You are about to read my Bachelor thesis that I completed as a final assignment for the Bachelor's degree in Industrial Engineering and Management at the University of Twente. This research was conducted at Company X[1]. This is a company that supplies printed matter products to professionals through a self-developed web application. They have their own production locations as well as suppliers who make the products for Company X. This research is focused on providing insight into the price deviations between purchase orders and invoices at Company X.

At Company X, I learned a lot about business management and I am grateful for this opportunity. Especially since my research was conducted in times of COVID-19. I would like to thank Company X for allowing me to do my thesis at this time.

First, I would like to thank my supervisor at Company X in particular for his confidence in me. He let me work very independently, but despite his very busy schedule, I could always ask him questions or schedule meetings. On top of this, I would like to thank the employees of the finance and HR department at Company X for a pleasant and educational time.

Moreover, I would like to thank my first supervisor from the University of Twente, Rogier Harmelink. I have had several very useful online meetings with him in which he took his time. He gave critical feedback and suggestions. This kept me focused and improved the quality of this thesis. In addition, I have gained knowledge about writing a thesis. I would also like to thank Ipek Seyran Topan for the preparation phase of my thesis. She was always there for questions and kept me very motivated. I would additionally like to thank Guido Bruinsma for his final feedback.

Lastly, I would like to thank fellow student Bram Benneker. He also kept me motivated and was always there to spar about things I encountered in the research.

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[1] The company I conducted my research for is referred to by Company X for confidentiality reasons. In addition, several suppliers and prices are marked in black in this thesis.

Management summary

Company X is a company that supplies printed matter to professionals. Company X's ambition is to further internationalise. However, this is not possible due to the action problem:

At Company X, the process of treating incoming printed matter invoices is not scalable for handling more printed matter invoices.

Company X has a WebApp which receives a huge number of orders every day. There are suppliers who produce the orders for Company X and Company X receives the invoices from them. However, these invoices do not always correspond to the expected cost price that Company X has calculated per purchase order. Because of the money and work involved in these deviations, the process of treating incoming printed matter invoices cannot be scaled up, which is holding back internationalisation. Because there are more invoices coming in and therefore more deviations when Company X gets more customers. And Company X cannot handle those extra invoices with deviations.

Using a problem cluster by Heerkens et al. (2017), we came to the conclusion that the core problem of Company X is:

At Company X, it is not clear which and how many invoices differ nor what the origin and financial impact of the deviations are.

This led to the following research question:

How can Company X monitor the price deviations between Company X's purchase orders and the suppliers' invoices?

We have answered this research question with the help of six knowledge questions that have shaped this study.

We created an appropriate conceptual dashboard that should give Company X insight into the deviations between the purchase orders and the invoices. This was done by mapping the order and invoicing process, a literature study on the visual design of a dashboard, a literature study on the creation of KPIs, and brainstorming on the design of a dashboard. It has become a conceptual dashboard, because during the research the implementation of a new module in the financial package of Company X was delayed. Therefore, the link between that module and the data warehouse, which the dashboard uses, has not yet been realised.

The Product Guide of engineering from Company X can use the conceptual dashboard created in this study in the future in our recommended way to monitor the deviating invoices against the purchase orders. So, on a weekly and monthly basis with the monthly analysis using the Plan Do Check Act cycle.

When the conceptual dashboard is put into use in the way we recommend. Then the core problem is solved and so is, in part, the action problem. The norm of the action problem is that there should be a proactive solution that will lead to almost no deviations. In addition, Company X wants an efficient and effective way to solve the deviations that still come in. The dashboard will then easily provide insight into the deviations so that targeted action can be taken, and proactive solutions can be devised. This is not possible without insight into the deviations. In addition, Company X could solve the deviations efficiently if the dashboard is implemented in the process flow as recommended. Because the time-consuming information transfer between the product guide and finance has been eliminated. The deviations can also be resolved more effectively because the Product Guide can then prioritise, based on the dashboard, which deviations he will resolve first

However, no attention has been paid in this research to making price agreements between Company X and the suppliers. The price agreements obviously have a major impact on the price differences between the prices applied by company X and the prices charged by suppliers. We therefore recommend not putting all the focus on the dashboard to find the causes of the price deviations, but to also investigate the process of making price agreements.

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List of acronyms

PO	Purchase Order
BI	Business Intelligence
WebApp	Web Application
KPI	Key Performance Indicator
BPMN	Business Process Model and Notation
MPSM	Managerial Problem-Solving Method
API	Application Programming Interface
SKU	Stock Keeping Unit
KRI	Key Result Indicator
RI	Result Indicator
PI	Performance Indicator
KPI	Key Performance Indicator
PDCA	Plan Do Check Act
SMART	Specific Measurable Attainable Realistic Timely

1 Introduction

For businesses, it is important to keep an eye on the profit margin. This certainly applies to Company X as it is a fast-growing online company where new products are often added to the assortment. A key aspect of the profit margin is the cost of sales and this will be examined in this research. This Bachelor Thesis has been performed at Company X. The research is aimed at mapping the price deviations on printed matter incoming invoices compared to the Company X's Purchase Orders (POs) by means of a Business Intelligence (BI) dashboard. This chapter briefly introduces Company X (Ch. 1.1), the research motivation (Ch. 1.2), the problem-solving approach (Ch. 1.3), the problem identification with problem cluster (Ch. 1.4), and finally the research design with research and knowledge questions (Ch. 1.5).

1.1 Company introduction

As they say, Company X is an inspiring place where craftmanship, passion, and creativity are united. What started as a small group in 2017 has grown into an international printing platform. The crew works every day in the Netherlands, Belgium, France, and Germany on the ultimate platform. The crew consists of 100+ employees. Company X provides printed matter, business to business, for the true graphic professionals. They developed a Web Application (WebApp) for the graphic professionals, in which the professional can order easily and confidentially, see Figure 26 Appendix A. Company X offers a wide range of products and specifications to their customers. For example, postcards, flyers, posters, banners, coffee-cups, wallpaper, up to printed clothing. Their WebApp, the wide range of products and specifications, and their co-creation, sets them apart from the competition.
Company X's head office is in the Netherlands. From here, purchasing is done centrally for all entities and, among other things, the printed matter invoices that are the focus of this research are received in the head office. The office in the Netherlands consists of the departments: Global (management), Co-Creation, Product & Process, Brand & Concept, Finance & Family (HR), Customer Love, and Development. The entities abroad are mainly focused on customer contact, the other activities are largely carried out at the head office. Company X has a few of its own production locations, but also many suppliers who produce for Company X.

1.2 Research motivation

Company X has indicated that they regularly experience problems with their suppliers' invoices. The problems with the suppliers' invoices concern the suppliers of the printed matter only. The amounts billed do not match what Company X has calculated in her purchase orders and this will affect the margin that Company X will make if they accept the price difference. Company X has many variations in its product range, which makes the different product possibilities enormous. There are already hundreds of product compositions for business cards due to the large selection of paper types, finishes, inks, formats, etc. The expected price for the product towards the supplier is made up of various elements that are part of the end product. The exact composition of these determines the price. So, the cost price of business cards for Company X consists largely of the sum of the prices of the choices made in the product specifications as just described. The supplier may deviate on certain elements from the calculation that Company X uses, resulting in a different price billed to Company X than expected by the purchase order from Company X. This problem has been happening since the start of Company X. However, they found out, at the end of 2020, that the problem with deviating incoming invoices compared to the purchase orders is bigger than they thought. At one supplier they paid 20% too much in one year!

Besides that, Company X is a company with a huge flow of incoming invoices. Currently, a rough estimation of 10% of those invoices contain deviating purchase orders. That equates to about 1000 per year. The other 90% of incoming invoices are processed smoothly. Company X roughly estimates that they spend 80% of their time processing incoming invoices, on processing 10% of the incoming

invoices. It is a daily task for the Product Guide to find out where the deviation comes from and to make adjustments in the prices/calculations that Company X uses for the purchase orders if the fault is with Company X and not with the supplier. He has a lot of contact with the suppliers for this.

Company X 's ambition is to internationalise and they are doing well. However, when they go live in other foreign countries, the orders will increase and so will the flow of deviating invoices. The Product Guide is already unable to find out all the deviations that the finance department forwarded to him, because he has plenty of other important tasks to fulfil. Imagine when more deviations come in. Besides, the margin in the branch that Company X is in is not very big. As a result, a lot of man hours cannot be afforded in solving the deviations.

In fact, this happened with the implementation of a new function (Scan and Capture) in the financial system Company X uses. The implementation took place during the research. When we first came in at Company X, they manually and randomly checked the purchase orders on the invoices, because it took too much time to check all the separate purchase order on the incoming invoices. This means that a lot of invoices with deviations were unnoticed. The new implementation automatically matches and check all the purchase orders on the invoice with the purchase orders in the financial system from Company X. The invoices with price deviations that would be booked and paid in the old method, because of the random checks, are now also detected. This makes the problem for the Product Guide even bigger than Company X stated at the start of the research. Company X no longer pays too much to suppliers unnoticed, but there are now more deviations that need to be resolved. These deviations have always existed but were not noticed. This effect of Scan and Capture was already foreseen and was also an important motivation for Company X to let me do research.

The deviations on the incoming printed matter invoices against Company X's purchase orders are a problem for Company X because:

- Company X paid too much to suppliers, causing Company X to lose its margin.
    - The unnoticed overpaying to suppliers has now been solved by Scan and Capture.
- Far too many deviations come in that cost too much time and therefore money in the first place.
- Too many actions are involved with processing the deviating invoices, which costs time and therefore money.
- The margin per product differs from what the sales price is based on.

Company X wants to solve the problem with deviating invoices as quickly as possible, because it will only get worse as they continue to internationalize. The action problem is therefore:

At Company X, *the process of treating incoming printed matter invoices is not scalable for handling more printed matter invoices.*

Company X would like a proactive solution that will reduce the number of deviating invoices. They already have a reactive solution by solving the deviations afterwards, one by one. This approach has not solved the problem in recent years. They could hire extra people in the future to solve the deviations, but they do not know whether that would be profitable at all. In addition, it is difficult to resolve the deviations if you have not made the price agreements yourself with the supplier. That is also the reason that there is only one person who solves the deviations.

So, Company X's norm is a proactive solution(s) that leads to hardly any deviating incoming printed matter invoices, and they want an efficient and effective way to process the deviating invoices that still arrive. Efficient in the sense of no unnecessary extra actions and by effective they mean that the seriousness of the deviations is recognized so that they can be remedied quickly.

1.3 Problem-solving approach

To solve the action problem, we will use a problem-solving approach. With a problem-solving approach we can systematically reach a solution. The problem-solving method will be explained in Chapter 1.3.1.

1.3.1 Managerial Problem-Solving Method

We have chosen the Managerial Problem-Solving Method (MPSM) from Heerkens (2017) for the research at Company X. We have chosen this method because We have been familiar with it for a number of years and because it is well applicable within companies. In addition, the following points convinced us also (Heerkens et al., 2017, p. 16):

- The MPSM is applicable to various problems encountered in various situations in all areas of expertise.
- The MPSM takes into account that no problem is an isolated issue. A problem is embedded in the context of an organisation and needs a fitting solution.
- The MPSM should be considered a framework, a grid for you to fill in as you need. Each of the phases allows you to use different models, techniques, and methods for a custom problem-solving approach.

The MPSM consists of the seven phases below. Per phase we will briefly explain how this applies in this research:

1) Defining the problem

Defining the problem has already partly started in Chapter 1.2 and is continued in Chapter 1.4 with the help of a problem cluster.

2) Formulating your approach

This is shown schematically in Figure 1 and Chapter 1.5 addresses the knowledge questions that structure the research.

3) Analysing the problem

In Chapter 2, we are going to map the entire order and invoicing process at Company X. This means from the customer's order up to and including the processing of the suppliers' invoices. The data generated in this process will also be mapped. In the following chapter, we will do a literature study. Chapters 2 and 3 will help us to better understand the problem and may give us insights into possible solutions.

4) Formulating (alternative) solutions

In Chapters 4 Key Performance Indicators (KPIs) will be set up with the help of brainstorm sessions. Those KPIs will be converted to figures in the dashboard in Chapter 5. Making the figures will be an iterative process with constant feedback from Company X. Different KPIs and figures will be created from which the best choice must be made.

5) Choosing a solution

At the end of Chapter 4, a choice has to be made from the established KPIs. And at the end of Chapter 5, the actual dashboard is put together. Ultimately, the most useful KPIs with the corresponding best visualization per KPI will be chosen to create a dashboard that communicates the necessary information for Company X.

6) Implementing the solution

An implementation plan of the dashboard will be written in Chapter 6. This will be a recommendation because the conceptual dashboard cannot be used immediately by Company X. An explanation about how and when the dashboard can be used will be given. There will also be a verbal explanation of the dashboard given to the stakeholders.

7) Evaluating the solution

A separate evaluation will not take place. The conceptual dashboard will be designed together with Company X. So, there will be constant feedback from them. In addition, the dashboard cannot yet be put into use. Therefore, the implementation cannot be evaluated.

Steps to take

Figure 1 shows the steps we will take in this research

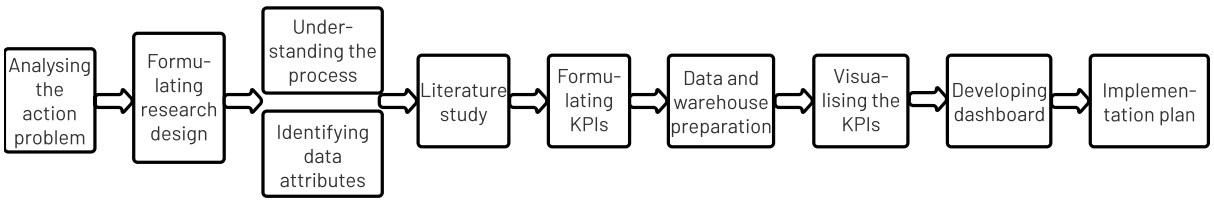

Figure 1: Steps to take

1.4 Problem identification

We have analysed the action problem at Company X to find the core problem causing the action problem. We did this with the help of interviews and orientation days. We found several causes. Figure 2 in Chapter 1.4.1 shows these causes in a problem cluster. There are several causes found for the action problem in yellow. If you proceed down the chain of cause and effect until you reach the causes which are the furthest removed from the action problem, you end up in the four red boxes. These causes are no longer the effect of other causes and it is possible to influence them. According to Heerkens (Heerkens et al., 2017, p. 50) you can label these causes as core problems.

1.4.1 Problem cluster

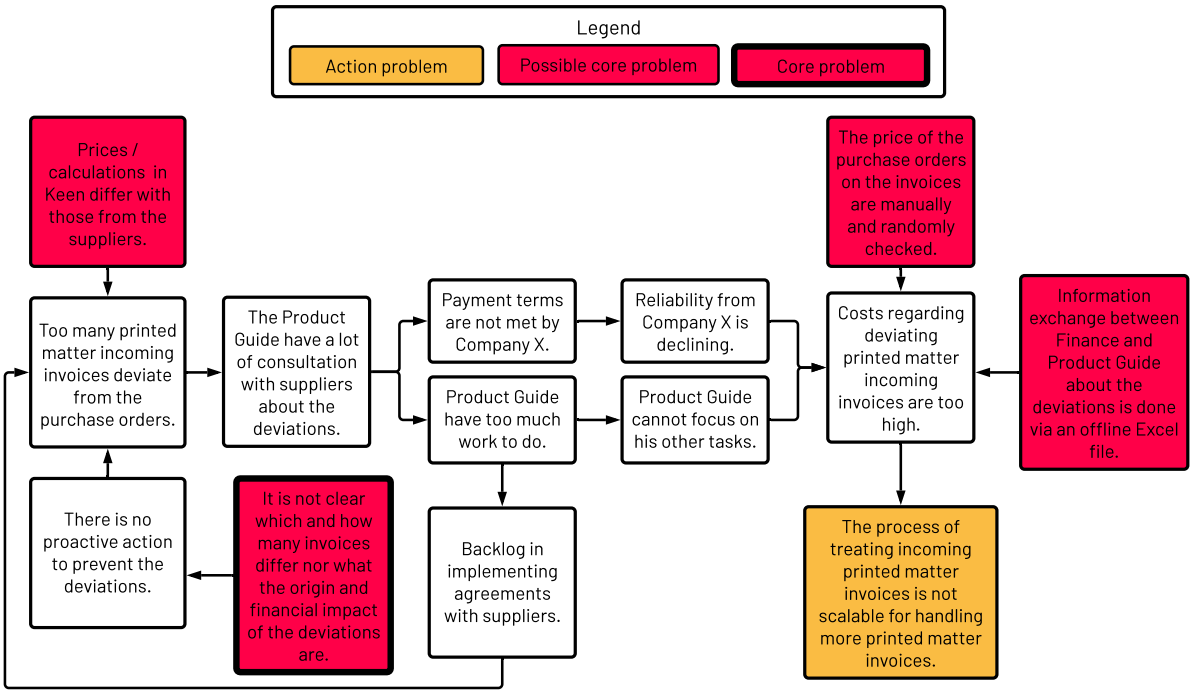

Figure 2: Problem cluster

We found four possible core problems causing the action problem from Company X.

Possible core problem 1

A possible core problem is the one at the top right of Figure 2: *The price of the purchase orders on the invoices are manually and randomly checked*. Company X receives a lot of orders. Those orders are automatically forwarded to one of their suppliers who is best able to produce that specific order. Because Company X bundles its orders, it is not sent to the supplier per customer but per purchase order. As a result, Company X receives invoices with a huge number of purchase orders on a weekly or monthly basis, depending on the supplier. The invoices were manually checked. It is not possible to check all purchase orders per invoice, as this can sometimes amount to 500 purchase orders. For this reason, they randomly checked around 30 of the 500 purchase orders on an invoice. They checked if the price of the purchase order on the invoice matches the purchase order from Company X, which could be found in Keen (their order system). The moment deviations are discovered, the entire invoice was passed on to engineering as a deviation. Due to the random check of the incoming invoices, there are many deviations that were paid unnoticed. Company X loses margin if they pay the invoices where more is invoiced than is stated on the purchase order from Company X.

However, in the first three weeks of the research they implemented Scan and Capture to their financial system (NetSuite). Scan and Capture automatically matches the price of the purchase orders on the incoming invoices with the purchase order in NetSuite. On the one hand, Scan and capture notices every deviation and make sure that there are no longer unnoticed overpayments to suppliers. On the other hand, this does mean that even more deviating purchase orders are found that must be processed, while too many are already coming in. The implementation of Scan and Capture partially resolved the action problem because the costs of overpayments are disappeared. So, the top right possible core problem is already resolved by Company X in the first weeks of the research.

Possible core problem 2

The second possible core problem is: *Information exchange between Finance and the Product Guide about the deviations is done via an offline Excel file*. When the Finance department detects deviations, first by means of a manual check and now with the help of Scan and Capture, they record those deviating purchase order numbers in an Excel file. This is an offline Excel file, which means that the different employees in the finance department have different Excel files. This sometimes creates confusion about what the most up-to-date Excel file is. The Excel file is sent to the Product Guide once a week, the Product Guide deals with the deviations. This way of exchanging information takes a lot of time and is prone to errors. For example, a deviation that is detected on Monday will not be received by the Product Guide until the following week. The invoice with this deviation is not yet paid by Company X and in this way, they are already lost the first week of the payment term before even looking at the deviation. And when the product guide has checked the deviation, he informs the finance staff verbally or by e-mail, which also takes time and is prone to errors.

Possible core problem 3

A third possible core problem is: *The prices/calculations in Keen differ with those from the suppliers*. This is the main cause of the deviating invoices. No or hardly any deviating invoices would be received if Company X and the suppliers used the same prices/calculations in their systems. The price differences on the invoice compared to the purchase order largely leads to the costs that Company X incurs in handling the incoming invoices. The many deviations mean that the Product Guide spends a lot of time consulting with suppliers about the deviations. Because the talks with the suppliers take a long time and because time has already been lost before he became aware of the deviations, Company X sometimes does not meet the payment term. Of course, Company X does not pay the invoice with deviating purchase orders before consultation with the supplier. If Company X does not meet the payment terms, this can be at the expense of their reliability and any discounts that Company X has with suppliers, which costs money. In addition, it happens that the Product Guide does not have time at all to process the deviations before the payment term has expired. Then there is pressure from the suppliers and the invoices with an excessive amount are paid anyway. This means that the same deviations keep coming back. This also happens when the Product Guide has been in contact with the suppliers and has come to

a decision that the prices/calculations at Company X need to be adjusted, but that he does not have time to make the adjustments. Due to the many deviating invoices, the Product Guide cannot divide its hours properly. Too many come in to solve in addition to his other important tasks. If he decides to resolve a lot of deviating invoices, it will be at the expense of his own tasks and that costs money. The number of deviating invoices increased, because 100% of the deviations are detected due to Scan and Capture. And will only increase due to internationalizing. It is therefore necessary to reduce the number of deviating invoices, especially with a view to the future. This problem cannot be tackled effectively and efficiently given the core problem.

Core problem

Finally, the core problem at the bottom left of Figure 2: *At Company X, it is not clear which and how many invoices differ nor what the origin and financial impact of the deviations are*. At the finance department, they know that many invoices deviate, because they take them out and leave them to the Product Guide. However, there is no data on exactly how much deviates. Nor is it known which products and which suppliers cause the most deviations There is also no insight into the exact monetary deviation of the deviating invoices, per supplier for example. Resulting in the financial seriousness of the deviations being unknown. In short, there is no insight into the deviating invoices. Company X has never kept data on this, only random temporally via the Excel files. Company X can only make estimates based on the experience of the people dealing with this issue. Now with the new Scan and Capture module it is possible to create that insight since Scan and Capture creates the necessary data. Because there is no insight into the deviating invoices, it is not possible to act proactively to prevent the deviations. Company X does not have a complete overview of the deviations from which they can draw conclusions and perhaps find reasons why many deviations arise. Due to this lack, they can only reactively resolve deviations one by one. Over the years, it has become apparent that this does not lead to fewer deviating invoices.

1.4.2 Core problem

Reducing the number of deviating invoices is a very high priority at Company X. They want to prevent the deviations instead of reactively solving them. Since there is no data available to analyse, it is very difficult to solve the possible core problem at the top left of Figure 2. Therefore, we chose as core problem:

At Company X, it is not clear which and how many invoices differ nor what the origin and financial impact of the deviations are.

Reality

The reality is that there is no ready to use data available on the deviations, which makes it difficult to identify general causes for the price differences between Keen and the suppliers. It is only possible to act based on specific deviations that have been obtained manually and randomly from a certain period or based on the experiences of employees. This is not effective and is very time consuming. In addition, in this way you only solve specific deviations and not entire deviation groups at once.

Norm

The norm is that data on the deviations is almost live, automatic provided and that it is easy to interpret, so that conclusions can be drawn. If patterns are found, Company X can act accordingly. Based on the possible patterns, Company X can gain knowledge so that future deviations can be prevented. In addition, Company X would like to have almost live insight into the financial seriousness of the deviations so that they can prioritize which deviations should be resolved first. And there must be a working method so that action is taken in accordance with the insight into the deviations, this must be more efficient than the current way of acting. Company X wants, in addition to the financial seriousness, at least insight into the type (which products), the amount, and the origin (corresponding supplier) of the deviations.

1.4.3 Candidate core problem

When the core problem is solved, the candidate core problem below can probably be solved more easily and quickly:

At Company X, prices/calculations in Keen differ with those from the suppliers.

This is the root cause of the deviating incoming printed matter invoices. The reality is that the prices/calculations in Keen are not the same as the prices that the suppliers charge. Company X 's norm is that these prices are equal. In this way, Company X hardly receives any deviating invoices. 0% deviating invoices cannot be guaranteed, that would be a utopia. Company X can solve the candidate core problem itself, but it could also set up a follow-up study after gaining insight into the deviations.

1.4.4 Deliverables

In this research, a BI dashboard will be presented as a solution to the core problem. Together with a Business Process Model and Notation (BPMN) flow chart, these will be the two deliverables of this research.

Dashboard

A BI dashboard must be the solution to Company X's core problem. In view of the norm set by Company X, this is the most logical solution. The data concerning the deviations must be able to be viewed almost live and in such a way that any patterns can be found. You could then work with automatic separate sheets that provide insight into the data, but to compare the sheets with each other and for the overview, a dashboard is much easier. The dashboard will be created with Tableau. This is a requirement from Company X because they already work with Tableau.

Business Process Model and Notation (BPMN) flow chart

This flow chart will map all the steps from an order placed by the customer to processing the invoice from the suppliers. The flow chart will provide a detailed visual overview of the working methods and information flows. Besides the fact that we will need a detailed overview of the information flows with data attributes, Company X can use these flow charts in the future for: making processes more efficient, responding better to new circumstances, standardization, quality management, training for employees, and for conformity compliance (Lucidcharts, 2021). We specifically chose the BPMN method because we have experience with BPMN.

1.5 Research Design

In this chapter, the research and knowledge question and their corresponding research design, in Table 1, will be discussed.

1.5.1 Research questions

To solve the core problem, the following research question has been formulated:

How can Company X monitor the price deviations between Company X's purchase orders and the suppliers' invoices?

To answer the research question and to arrive at a solution to the core problem, knowledge should be acquired. The following knowledge questions have been formulated and will be answered in the upcoming chapters.

1. *What does the process look like from customers placing an order up to and including processing the incoming printed matter invoices at Company X?*
    - Will be answered in Chapter 2.

2. *Where is the generated data in the order and invoicing process stored and how are the data attributes linked to each other?*
    - Will be answered in Chapter 2.

3. *What is known in literature regarding requirements or techniques for a good visual design of a dashboard?*
    - Will be answered in Chapter 3.

4. *How to set up good KPIs?*
    - Will be answered in Chapter 3.

5. *Which KPIs would the different stakeholders like to see in a dashboard?*
    - Will be answered in Chapter 4.

6. *How can the link be established between the Tableau dashboard and Company X's data warehouse?*
    - Will be answered in Chapter 5.

1.5.2 Research design

Table 1: Research design

	Knowledge Questions	Type of Research	Research Population	Subjects	Research Strategy	Method of Data Gathering	Method of Data Processing
1.	What does the process look like from customers placing an order up to and including processing the incoming printed matter invoices at Company X?	Descriptive	Company X	Development, Engineering, Finance, and customer love department	Qualitative	Observational, Semi structured interviews (cross-sectional)	Visual representation using BPMN model
2.	Where is the generated data in the order and invoicing process stored and how are the data attributes linked to each other?	Descriptive	Company X	Development department	Qualitative	Semi structured interviews (cross-sectional)	Visual representation using BPMN and data attributes tables
3.	What is known in literature regarding requirements or techniques for a good visual design of a dashboard?	Exploratory	BI dashboards	Visual design techniques	Qualitative	Literature study (cross-sectional)	Essay with recommendations and requirements
4.	How to set up good KPIs?	Exploratory	Finance, invoice management	KPIs	Qualitative	Literature study (cross-sectional)	Essay with recommendations
5.	Which KPIs would the different stakeholders like to see in a dashboard?	Exploratory	Company X	Finance department, Management	Qualitative	Semi structured interview, brainstorm sessions (cross-sectional)	List of KPIs
6.	How can the link be established between the Tableau dashboard and Company X's data warehouse?	Exploratory	Company X, Tableau	Development department, Dashboard connection	Qualitative	Semi structured interviews (cross-sectional)	Briefly described

2 Analysing the order and invoicing process

Now that the research plan is in place, we can map the current situation at Company X. This chapter focuses on mapping the ordering and invoicing process with the generated data. The process will be mapped to gain more insight into where the problem occurs in the process. In this way, it will also become clear where in the process the dashboard should be placed. The first two knowledge questions will be discussed in this Chapter. Chapter 2.1 answers the first knowledge question: "*What does the process look like from customers placing an order up to and including processing the incoming printed matter invoices at Company X?".* Chapter 2.2 answers the second knowledge question: "*Where is the generated data in the order and invoicing process stored and how are the data attributes linked to each other?".*

2.1 Order and invoicing process

All actions of the systems and persons in the order and invoice process are discussed in this chapter. The entire BPMN process flows can be found in Appendix A. The lanes in the process flows will be explained in Chapter 2.1.1. Figure 30 in Appendix A zooms in on the processing and verification of incoming invoices before the Scan and Capture module was added to Company X's financial system (NetSuite). Figure 31 in Appendix A illustrate the entire process in the current situation from customer ordering through to verification and processing of suppliers' invoices. The process flow from Figure 31 in Appendix A will be explained in separate parts in Chapter 2.1.2.

2.1.1 Lanes in the process flows

The lanes in the process flows indicate who does what in the process. The complete current process, as shown in Figure 4 of Appendix A, consists of the eight lanes. The lanes: Customer in WebApp, Customer, Supplier in Eager, Carrier, Supplier, and Engineering illustrates human actions. The customer and supplier execute respectively operations in the WebApp and Eager applications. The lanes: Keen and NetSuite by finance employees illustrates both human actions as automatic actions by the applications Keen and NetSuite. The applications WebApp, Keen, NetSuite, and Eager will be briefly explained below.

WebApp

Company X developed the WebApp itself. This is the special online environment where professional customers can put together and order their products.

Keen

Keen is the program that Company X uses for the entire order process. Keen contains all products with purchase and sale prices. In Keen all orders are created with the order numbers.

NetSuite

NetSuite is Company X's financial system. Order information from Keen is forwarded to NetSuite. Keen partially overlaps NetSuite, but in NetSuite the invoices from the suppliers arrive. These are matched in NetSuite by means of Scan and Capture with the purchase orders that have been placed in NetSuite from Keen. The invoices are booked and paid in NetSuite. Data such as turnover can also be seen in NetSuite. In short, NetSuite is really the financial package and Keen is the central program for the ordering process.

Eager

The suppliers use the program Eager that is linked to Company X. When the product is ready for shipment at the supplier, the supplier enters the purchase order number in Eager, by barcode or manually see Figure 27 in Appendix A. They can then download a shipping label for shipping. Several carriers are connected to Eager. When the purchase order number is entered in Eager, a carrier is automatically

selected. The carrier collects the order from the supplier and delivers the order to the customer from Company X. With the purchase order number, carriers can invoice Company X. The shipping invoices receive Company X and are passed on to an employee who checks them in bulk based on the data in Eager. In the future, Company X wants to check the shipping invoices at purchase order level, as happens with the invoices from suppliers. This is possible at the moment a purchase order is created for shipping, but that does not happen yet. Scan and Capture would then be able to match the invoices of the carriers based on the purchase order number with the purchase orders that have been transferred from Keen to NetSuite.

2.1.2 Process flows

Now that the lanes have been explained, the process flows shown in Figures 30 and 31 in Appendix A will be briefly discussed. We will start with the current process flow, Figure 31 of Appendix A.

Ordering and file check

The process starts when a customer places an order in the WebApp. A sales order is created in Keen as soon as an order is placed. That sales order is immediately forwarded to NetSuite and an invoice is already created for the customer. The order items of the sales order created in Keen first go through a file check, as displayed in Figure 3. Based on certain rules, some order items immediately go through the manual file check and some only go through the quick file check. For example, certain order items are always manually checked. It is checked on the delivered file, format, resolution, thickness, etc. With some products this is very accurate work, and those order items will immediately go through the manual check. If errors are discovered during the checking or adjustments need to be made, the customer will be contacted. If it is approved, the purchase order will be updated, because the thickness of the paper has changed which entails different purchase costs for example. If an order is received via an Application Programming Interface (API), the file check can be bypassed. An order will then arrive at Company X through a third-party web shop. Orders are placed from that third party and that web shop is linked to Company X by means of an API. Company X will take care of the production. Agreements have been made about bypassing the file check with the web shops that place an order at Company X via an API.

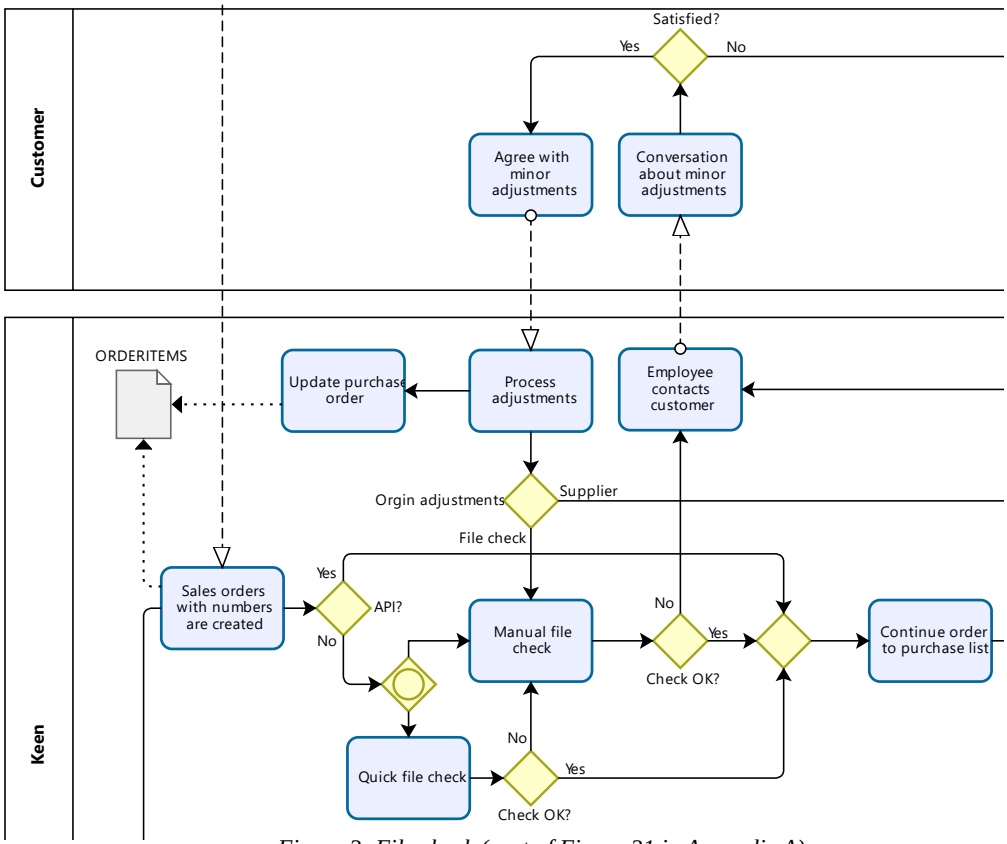

Figure 3: File check (part of Figure 31 in Appendix A)

Purchase list

Once on the purchase list, the supplier can still be changed for an order item, see Figure 4. The suppliers are automatically linked to the order items when the customer place an order. The choice of supplier influences the selling and purchase price. However, the supplier can still be changed when the order is on the purchase list. This can have a positive or negative effect on the margin. If the new supplier is cheaper than the original matched supplier, more margin is created because the customer has already received a price. So, the selling price will not be changed anymore. Less margin is created when Company X has to switch to a more expensive supplier. When a supplier is changed, the purchase order in Keen is of course updated with the new purchase prices. The orders on the purchasing lists are passed on to the suppliers. Just like the file check, this is a continuous process. This is done both manually and automatically. It is a rough estimation by Company X that about 80% of the orders are automatically forwarded to the suppliers. The other 20% is done manually. Based on certain rules/risks, purchases are made automatically or manually. Consider, for example, a large order amount. This will be passed on manually to a supplier. When an order is placed manually, it may be decided to switch supplier.

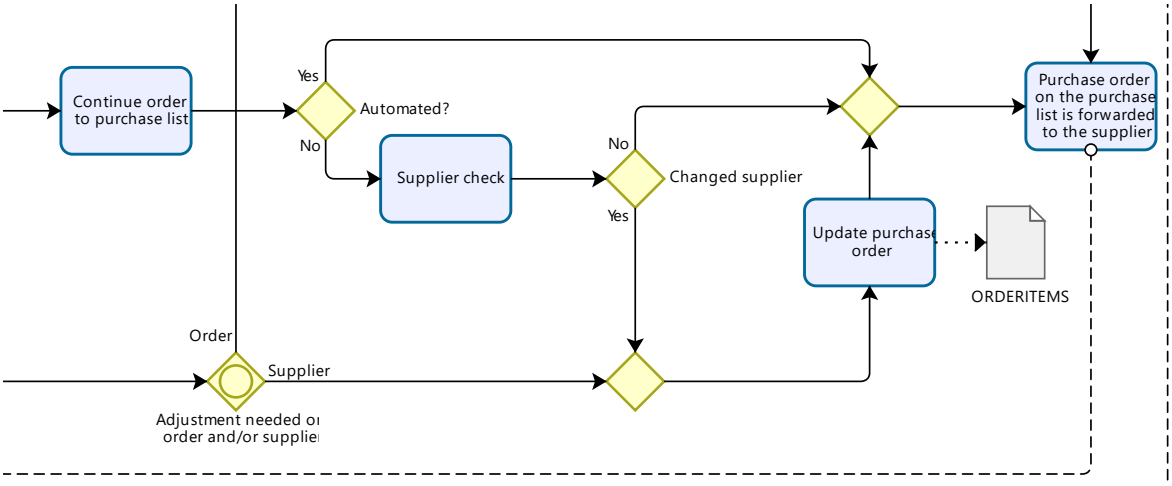

Figure 4: Purchasing at supplier (part of Figure 31 Appendix A)

Production and shipping

When the order items are forwarded to the supplier, the supplier can accept or decline, see Figure 5. There are several reasons why the supplier does not accept an order. For example, because they cannot meet the due date provided by Company X due to a lot of orders that week. In this case Company X may contact the customer to ask if the delivery date can be postponed a bit. In such a case, a different supplier can also be chosen. When the supplier has accepted, production will start. The supplier itself creates the shipping label in Eager as discussed in Chapter 2.1.1. When the shipping label has been created, the purchase order is transferred from Keen to NetSuite. The creation of the shipping label has been deliberately chosen as a trigger for this, because now no more adjustments will be made to the product and therefore no updates are required to the purchase order in Keen. If the purchase order would be immediately transferred to NetSuite, an updated purchase order from Keen will have to be transferred to NetSuite with every change to the order item. In addition, the supplier invoices Company X after creating the shipping label. The creation of the shipping label is also a trigger from Keen to NetSuite for sending the invoice to the Company X customer.

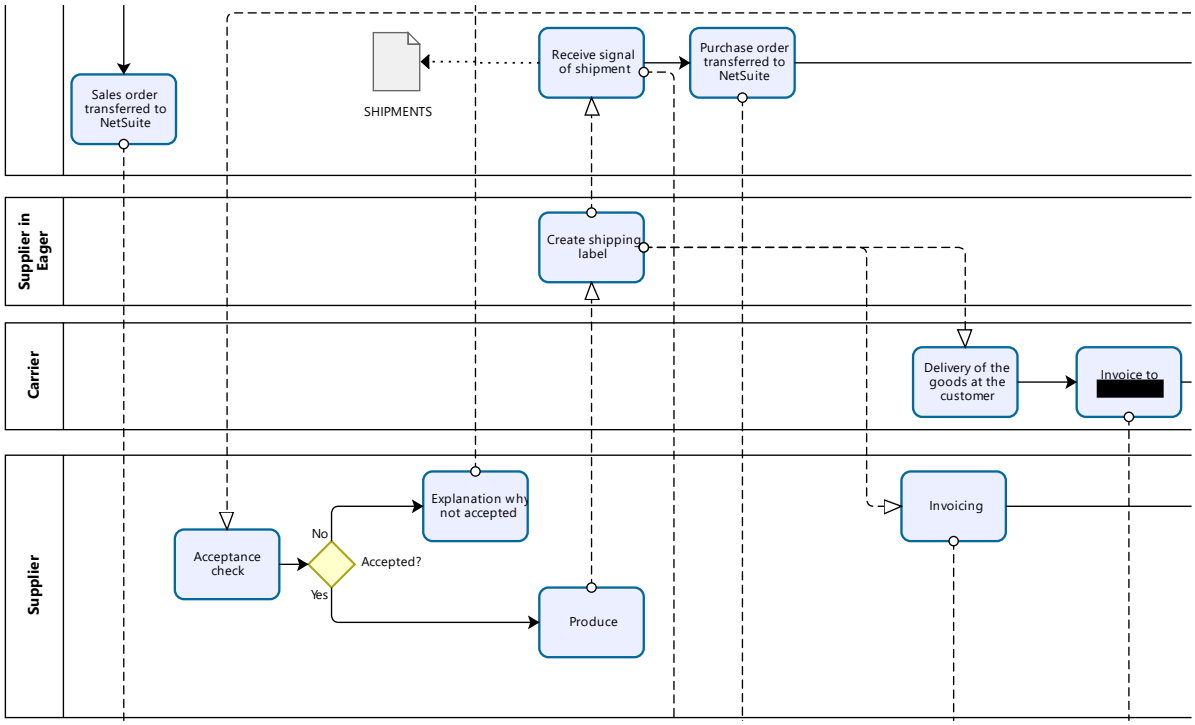

Figure 5: Production and shipping (part of Figure 31 Appendix A)

Control by Scan and Capture

The purchase order from Keen and the invoices from the supplier come together in NetSuite, as shown in the bottom lane of Figure 6. There Scan and Capture takes care of the matching based on the purchase order number. Scan and Capture reads the stated purchase order numbers on the pdf invoices with the prices. These are then checked against the purchase prices that Company X has calculated on the purchase order from Keen. The purchase order numbers are always numbers starting with 6000. In Figure 28 in Appendix A, such a number is highlighted in yellow on an invoice form a supplier. The entire order contains an order number that always starts with 6000. Each line on that order, for which a purchase order is created, has an order item number that is the same as the order number but with a 1, 2, 3, etc. behind it.

The purchase order turns red in NetSuite when there is a difference in the price on the invoice compared to the purchase order, see figure 29 in Appendix A. The purchase order is then put on a list and is forwarded by means of an Excel file to engineering, which discusses the price deviation in consultation with the supplier. If Company X itself is wrong, an adjustment is made to the prices or calculations in Keen so that the purchase order indicates the correct purchase price the next time. If the supplier is wrong, Company X will receive a credit invoice. Ultimately, the finance employees book the invoices. If Scan and Capture does not find any deviations, the invoices are immediately booked by the finance employees. After booking, the invoices are placed on a payment list and are paid by Company X.

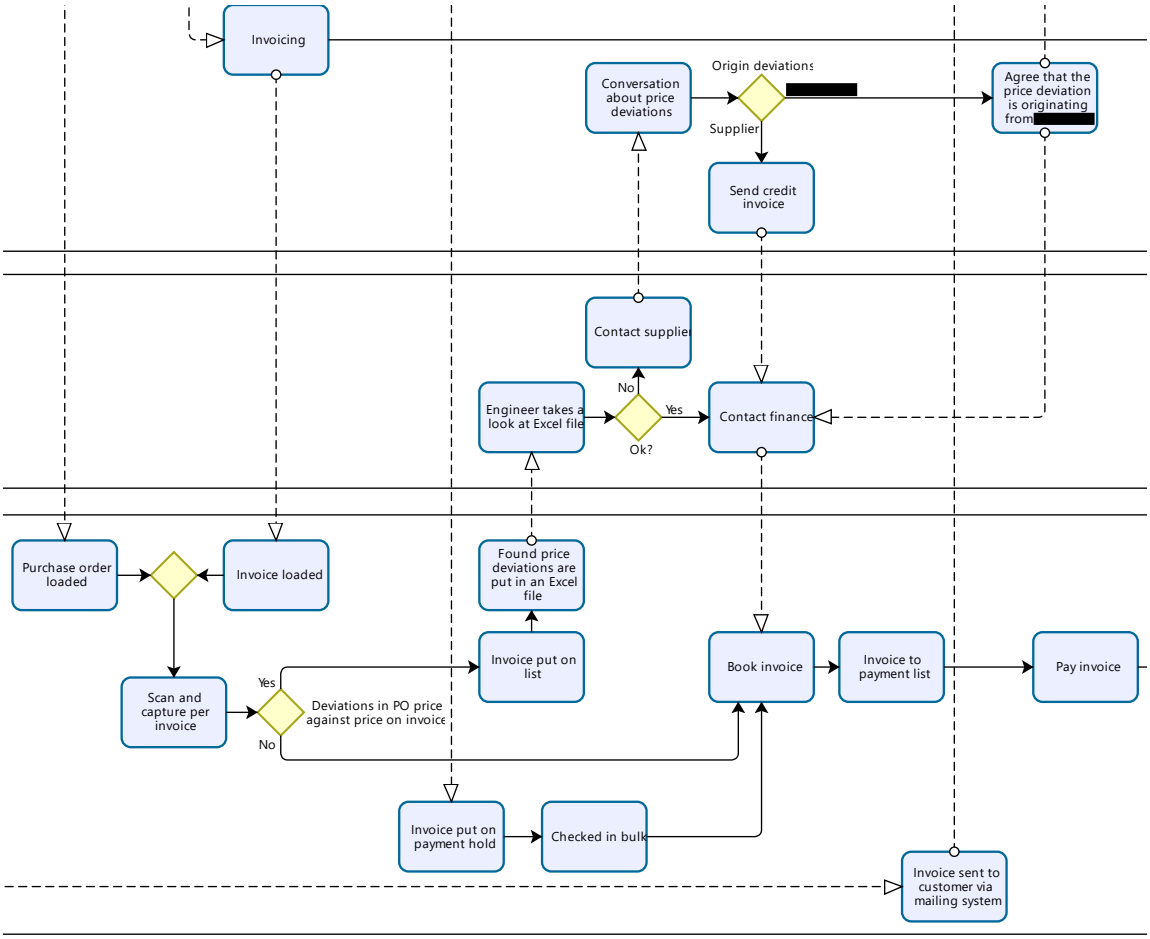

Figure 6: Scan and Capture (part of Figure 31 Appendix A)

Scan and Capture is a self-learning system. It has just been implemented and is therefore not working optimally yet. Scan and Capture does not always read all purchase order numbers from the invoices. As a result, you still have to manually enter purchase order numbers in Scan and Capture on a regular basis. Scan and Capture learns from the manual actions, making it function better every time. Also, the finance employees still have to book the invoices themselves. In the future, this should be automatic. In any case, Scan and Capture is already a big improvement in comparison with how the invoices were first checked, even if it does not work optimally yet. Figure 30 of Appendix A shows how it was before. Previously, the purchase orders on the invoices were manually and randomly checked. The purchase orders were then manually searched for and it was manually checked whether the invoiced price corresponded with the price calculated by Company X on the purchase order. The red rectangle in Figure 30 has now been replaced by Scan and Capture as shown in Figure 31 of Appendix A. This saves a lot of work and ensures that 100% of the purchase orders are checked and without Scan and Capture an estimated 10% of the purchase were checked.

2.2 Data generation and storage

Obviously, data is generated and stored in the process described in Chapter 2.1. Part of that data will be needed for the dashboard because it will serve as input for the dashboard. In this chapter we will find out what data is already in Tableau and how it was obtained, so we will get an idea of how to obtain the data from Scan and Capture in Tableau. First it will be explained in Chapter 2.2.1 where the data is stored and then Chapter 2.2.2. discusses the actual generated data. The information in this chapter was obtained through interviews with development.

2.2.1 Data storage

Company X already has five tables in Tableau with data that can already be analysed. In the process described in Chapter 2.1.2, three of those five tables can be found, namely: ORDERS, ORDERITEMS, and SHIPMENTS. These three tables are shown in Figure 31 in Appendix A as data objects. The other two data tables are created outside the described process. These are the tables: CUSTOMERS and COMPLAINTS.

All this data is stored in the Keen database. This is a lot of unstructured data and not yet ready for analysis. The data from the Keen database is copied to Snowflake. Snowflake is a database which Company X uses for analyses. Snowflake structures the data and thus makes it ready for analysis. Snowflake works with almost live data. For example, order data are copied to Snowflake every hour. Customer data on the other hand is copied once every six hours because that data does not refresh as quickly. A transformation application ensures that five tables with data attributes from Snowflake are moved to Tableau. Table 2 shows the data transformation to Tableau per data table.

Table 2: Existing data tables

Tables	Created when	Stored by	Structured by	Data moved to Tableau by
ORDERS	Placing an order	Keen database	Snowflake	Transformation application
ORDERITEMS	Placing an order	Keen database	Snowflake	Transformation application
CUSTOMERS	Customers is admitted to the WebApp	Keen database	Snowflake	Transformation application
SHIPMENTS	Order items are shipped	Keen database	Snowflake	Transformation application
COMPLAINTS	Customer has complaints	Keen database	Snowflake	Transformation application

2.2.2 Generated data

Tables 3, 4, 5, 6 and 7 are the tables with data in Tableau, see the next page. The complete Tables 3 and 4 can be found in Appendix A, Tables 10 and 11 respectively. The five tables are linked to each other via ORDER_ID, CUSTOMER_ID, SHIPMENT_ID, and ORDERITEM. The table ORDERITEMS, Table X, contains the attribute ORDERITEM_NUMBER. This is the 6000 number which defines each order line and for which there is an expected cost for Company X in the purchase order. In the table COMPLANTS the attribute ORDERITEM do contain the 6000 number. Thus, the complaints, if any, are linked to the corresponding order items via ORDERITEM.

All the data attributes in the tables could be used for the dashboard if the data from Scan and Capture is linked to one of the five existing tables.

Table 3: part of attributes COMPLAINTS table

Complaints		
ID	VARCHAR(256)	
STATUS	VARCHAR(256)	
DESCRIPTION	VARCHAR(4096)	
ISSUE_TYPE	VARCHAR(256)	
CAUSE_ACCORDING_PRINT_COM_ASSIGNEE_	VARCHAR(256)	
ORDERITEM	VARCHAR(256)	
DATA_COMPLETE_DATE	DATE	
ISSUE_CREATED	TIMESTAMP_TZ(9)	

Table 5: part of attributes ORDERITEMS table

Order items		
ORDER_ID	NUMBER(38,0)	
SKU	VARCHAR(255)	
MARKET	VARCHAR(256)	
CATEGORY	VARCHAR(256)	
ORDER_INCREMENT_ID	VARCHAR(255)	
ORDERITEM_NUMBER	VARCHAR(255)	
PRINT_JOB_ID	VARCHAR(255)	
STATUS	VARCHAR(255)	
PICKUP_DATE	TIMESTAMP_NTZ(9)	
ORIGINAL_PICKUP_DATE	TIMESTAMP_NTZ(9)	
REQUEST_SOURCE	VARCHAR(16777216)	
ACTUAL_SHIPPING_DATE	TIMESTAMP_TZ(9)	
SUPPLIER_CODE	VARCHAR(255)	
PRODUCT_PRICE	NUMBER(12,4)	
SALES_PRICE	NUMBER(12,4)	
ORIGINAL_SALES_PRICE	NUMBER(12,4)	
URGENCY_PRICE	NUMBER(12,4)	
SHIPPING_PRICE	NUMBER(12,4)	
DELIVERY_PROMISE_PRICE	NUMBER(12,4)	
PRODUCT_COST	NUMBER(12,4)	
URGENCY_COST	NUMBER(12,4)	
SERVICE_COST	NUMBER(12,4)	
REPRINT_ORDERITEM_NUMBER	VARCHAR(255)	
REPRINT_DISCOUNT_PRODUCT	NUMBER(38,0)	
REPRINT_DISCOUNT_SHIPPING	NUMBER(38,0)	
ORDERITEM_ID	NUMBER(38,0)	
OPTION_CUSTOM_SHAPE	VARCHAR(16777216)	
OPTION_COVER_MATERIAL	VARCHAR(16777216)	
OPTION_COPIES	FLOAT	
OPTION_SIZE	VARCHAR(16777216)	
OPTION_MATERIAL	VARCHAR(16777216)	
OPTION_FINISH	VARCHAR(16777216)	

Table 4: attributes ORDER table

Orders		
ORDER_ID	NUMBER(38,0)	
ORDER_NUMBER	VARCHAR(32)	
CUSTOMER_ID	NUMBER(38,0)	
ORDER_DATE	TIMESTAMP_TZ(9)	
STATUS	VARCHAR(32)	
CUSTOMER_REFERENCE	VARCHAR(256)	
INVOICE_STATUS	VARCHAR(255)	
INVOICE_ID	VARCHAR(255)	

Table 6: attributes SHIPMENTS table

Shipments		
SHIPMENT_ID	NUMBER(38,0)	
ORDERITEM_ID	NUMBER(38,0)	
CUSTOMER_ID	NUMBER(38,0)	
SHIPPING_PRICE	NUMBER(12,4)	
SHIPPING_COST	NUMBER(12,4)	
DELIVERY_DATE	TIMESTAMP_NTZ(9)	
LATEST_DELIVERY_DATE	TIMESTAMP_NTZ(9)	
DELIVERY_METHOD	VARCHAR(255)	
COPIES	NUMBER(38,0)	
FIRSTNAME	VARCHAR(255)	
LASTNAME	VARCHAR(255)	
ZIPCODE	VARCHAR(255)	
STREET	VARCHAR(65535)	
CITY	VARCHAR(255)	
COUNTRY	VARCHAR(255)	
EMAIL	VARCHAR(255)	
COMPANY	VARCHAR(255)	
TELEPHONE	VARCHAR(255)	

Table 7: attributes CUSTOMER table

Customers		
CUSTOMER_ID	NUMBER(38,0)	
EMAIL	VARCHAR(255)	
CREATED_DATE	TIMESTAMP_TZ(9)	
PREFERRED_LANGUAGE	VARCHAR(256)	
REGION	VARCHAR(256)	
FIRSTNAME	VARCHAR(16777216)	
LASTNAME	VARCHAR(16777216)	
ZIPCODE	VARCHAR(16777216)	
STREET	VARCHAR(16777216)	
CITY	VARCHAR(16777216)	
COUNTRY	VARCHAR(16777216)	
BILLING_EMAIL	VARCHAR(16777216)	
COMPANY	VARCHAR(16777216)	
TELEPHONE	VARCHAR(16777216)	
VATNR	VARCHAR(16777216)	

2.3 Conclusion

In this chapter we have answered the questions: "*What does the process look like from customers placing an order up to and including processing the incoming printed matter invoices at Company X?"* and "*Where is the generated data in the order process stored and how are the data attributes linked to each other?"*. We have gained a deeper insight into the problem of deviating invoices from the purchase orders. We know where the problem occurs in the process and what data is involved. This enables us to set better KPIs and therefore a better dashboard. It also gives us insights into how the data generated by Scan and Capture can be placed in Tableau. Before we start setting up KPIs and the dashboard, we will first conduct two literature reviews in Chapter 3, one on dashboards and one on KPIs.

3. Literature review

We now know where what data is created in the order process and where that data is stored. Also, the link between the data and Tableau is clear. In this Chapter we are going to gain knowledge regarding the design of the dashboard. In Chapter 3.1, the fourth knowledge question: "*What is known in literature regarding requirements or techniques for a good visual design of a dashboard?"* will be answered by means of a literature review. In Chapter 3.2, the fifth knowledge question: "*How to set up good KPIs?*" is also answered through a literature review. In Appendix B the search history of the two literature searches can be found.

3.1 Visual design dashboard

The question: "*What is known in literature regarding requirements or techniques for a good visual design of a dashboard?"* will be answered in the following Chapters: definition BI dashboard (Ch. 3.1.1), visual design dashboard (Ch. 3.1.2), visual design KPIs (Ch. 3.1.3), change blindness (Ch. 3.1.4), the use of colour (Ch. 3.1.5), and validation (Ch. 3.1.6).

3.1.1 Definition BI dashboard

Nowadays, companies have more and more data. Not all this data is of enormous importance for making decisions. Decision-makers want to have the most critical data available.

"Business Intelligence is the concept of collecting data, storing data, and selecting data to provide information to help and improve the quality of business decision making for companies"
(Gaol, Abdillah, & Matsuo, 2020, p. 2).

So, there are information systems that generate the data. In this study, these are Keen, NetSuite, and Scan and Capture. Business intelligence can convert that data into new knowledge and insights for a company. Dashboards have become a popular way to make crowded data sets available and clear to decision makers. Dashboards try to provide companies with useful insights into their data that would otherwise not have been possible. With those insights they try to increase the number of sales, save costs, or to spot opportunities (Hwang and Hongjiang, cited in Olbrich & Poeppelbuss et al., 2011). In this research at Company X, we try to use the dashboard to gain insight into the deviations so that they can be reduced. In this literature review, we found the following definition of a dashboard most often:

"*A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance*" (Few, 2006, p.34).

3.1.2 Visual design dashboard

Dashboards offer a unique and powerful solutions to an organisation's need for information, but usually fall short of their potential (Few, 2006). They fail in efficient and effective communication, not because of bad technology, but because of poorly designed implementations. The expertise of visual perception and understanding of efficient and effective single screen dashboards is often not found in the business world. Not because they are so difficult to learn, but because it is rarely recognized that it is important to learn (Few, 2006). Few (2006) indicates how important the design is in the following way:

"*No matter how great the technology, a dashboard's success as a medium of communication is a product of design, a result of a display that speaks clearly and immediately. Dashboards can tap into the tremendous power of visual perception to communicate, but only if those who implement them understand visual perception and apply that understanding through design principles and practices that are aligned with the way people see and think. Software won't do this for you. It's up to you" (Few, 2006, p. 4).*

An effective dashboard is not a product of cute gauges and rainbow colours, but an informed design. The dashboard ultimately serves for communication. For Company X, the dashboard should communicate the current performance of the deviations, but also the insights so that targeted action can be taken to resolve the deviations.

In a genuine effort to please the customer, the dashboard designers try to tick off all the customer's requirements. The customer is satisfied until they see a really good design (Few, 2006). "*Customers are expert in knowing what they need to accomplish, but not in knowing how software ought to be designed to support their needs. Allowing customers to design software through feature requests is the worst form of disaster by committee" (Few, 2006, p. 5).* Gaol and Abdillah (2020) recommend, just like Few (2006), to remain critical about your data visualization, because the end user is often very enthusiastic as they often have insight into certain data for the first time. It can therefore happen that the end user is already very enthusiastic and satisfied while the visualization can be even better. Therefore, when visualising the KPIs, we will not immediately choose the first visualisation that appeals to Company X. We will show the stakeholders in Tableau different visualisations of the same KPI.

Achieving a goal with a dashboard often requires a collection of information from a variety of sources related to different business functions. In addition, the dashboard must be displayed in one screen so that you can see everything at a glance. "*The objective is to have the most important information readily and effortlessly available so you can quick absorb what you need to know*" (Few, 2006, p. 35). The primary task of a dashboard is to communicate that you must act at a glance. It serves you when it immediately gives you the extra information you need to be able to act. For this, a different display is allowed or navigational methods such as drilling down (Few, 2006). In de paper from Dilla and Raschke (2015) we found several interactive data visualisation techniques that we will use, to provide that extra information that Few (2006) describes. Dilla and Raschke (2015) describe the data visualisation techniques: encode, reconfigure, connect, select, elaborate / abstract, filter, and explore. The techniques can be found in Table 14 in Appendix B.

In the paper by Froese and Tory (2016), they do not claim that a dashboard must necessarily consist of a single-screen. They emphasise that your screen should not become overcrowded and that you should make the right choices about which tabs to place certain figures in. Comparing figures that are in different tabs of the dashboard, for example, is not useful.

3.1.3 Visual design KPIs

According to Few (2004), there are two fundamental challenges in effectively representing quantitative data: 1) Selecting the best medium of display (e.g., a table or a graph, and the appropriate kind of either). 2) Designing the visual components of the display to convey the message as clearly as possible. A table works best when you need to look up individual values and when it is necessary that the values are precisely expressed. A graph, on the other hand, works best when the message is in the form of the data (e.g., patterns, trends, exceptions to the norm) and when large value sets must be compared. Few (2004) indicates that when graphs are displayed, the relationships always amount to one or more of the following specific relationships: time series, ranking, part-to-whole, deviation, distribution, correlation, geospatial, and nominal comparison. Few has added a graph selection matrix about which value-encoding objects can be used for the various relations. This can be seen in Figure 33 in Appendix B.

Sperandei (2014) thinks the same about the various types of graphs than Few (2004), Sperandei only emphasizes that pie charts are worthless. The human eye cannot properly distinguish the size of pieces of the pie charts, unless the difference between those pies is very large. In addition, it becomes more difficult when a pie chart contains many categories, especially when you want to keep the use of colours to a minimum. You could use numbers with pie charts, but why would you then use a graph? Sperandei therefore advises against the use of pie charts and suggests using a bar plot (Sperandei, 2014, pp. 5-6).

Sperandei (2014) discussed also several important rules to prevent useless information. Do not expect everyone understand your data so add axis with units. In addition, if necessary, provide legends. Be careful with the scales, you can easily mislead people leading to wrong decisions. And all parts and components of a statistical graphic must to be designed to transmit important information to the reader. We will take the graph selection matrix into account together with the advice from Sperandei when visualising the KPIs for Company X.

Yigitbasioglu and Velcu (2012) describe in their paper a number of statements regarding presentation formats and dashboards that are in line with the views from Few (2004, 2006) and Sperandei (2014). Besides, Yigitbasioglu and Velcu (2012) emphasise that there is no one way of presenting that is best in every situation. So, in addition to all the advice from the literature, it is important to remain critical when visualising the KPIs for Company X.

3.1.4 Change blindness

Stehle and Kitchin (2020) emphasize the danger of change blindness in dashboards. Small, brief, or dispersed changes to a visual display introduce opportunities for missed perception of the change and potentially introduce the phenomena of change blindness; that is, a diminishing ability of viewers to identify changes to a visualisation when there is a transition between states (Rensink, Goldsberry & Battersby, in Stehle & Kitchin, 2020). Change blindness is more common when it is a very rapid change and when multiple visualizations change at the same time (Fish, in Stehle & Kitchin, 2020). It is very important to take this into account in the design of a dashboard. For example, by displaying percentage changes or specific alerts. Davenport and Prusak (in Bumblauskas, 2017) claim that data without context or reference points analysis has no meaning but is essential to create information. People give meaning to data by adding context and reference points that are relevant and pass that information on to a recipient. The interpretation of the recipient makes it possible to decide whether the information has value. These reference points will significantly reduce the chance of change blindness. We will definitely take this into account when designing the dashboard.

3.1.5 The use of colour

Selecting the best medium of display and designing the visual components of display to convey the message as clearly as possible are important for the right communication of the dashboard. However with no doubts, colour plays a very important role in visual communication (Kang, 2016). "*To process a series of context infographic, people have to store the most important information in their short-term memory. If certain colours can catch more attention, those colours are more likely to be stored in short-term memory, and furthermore helps people to compare, analyse and make judgments"* (Kang, 2016, p. 1). Based on experimental results, Kang (2016) has developed the following two colour selection guidelines to improve information communication of infographics (Kang, 2016, p. 2):

- Sorted out the information by importance, and use bright, primary colour like magenta, red, yellow, and cyan for the most significant information to grab more attention.
- Grouping equally important information, use one hue with different lightness to code the information.

3.1.6 Validation

Dashboard users may lose momentum by becoming immune to alerts. For example, constantly flashing red indicators. There is no longer the ability to prioritize or determine the severity of the problem, which often leads to laxity in relation to the warning signals. A validation process for the presentation and for the relevance of the KPIs is therefore periodically required to verify whether valuable information leads to communication and action (Bumblauskas, Nold, Bumblauskas, & Igou, 2017, p. 12). The validation process could be done with the Plan Do Check Act (PDCA) cycle.

3.2 Setting up KPIs

The question: "*How to set up good KPIs"* will be answered in the following Chapters: definition KPI (Ch. 3.2.1), use of KPIs (Ch. 3.2.2), setting up KPIs (Ch. 3.2.3), the amount of KPIs (Ch. 3.2.4), and selecting KPIs (Ch. 3.2.5).

The dashboard for Company X is going to be a dashboard that will display the performance of a specific process. That is the reason that the literature on the performance management of an entire business or organization has not been looked at in depth. Simply because it is not of added value in this research. In fact, there is a lot of literature on setting KPIs by means of balanced scorecards, performance measurement matrix, and performance prism. It is about general broad goals of a company with KPIs such as: revenue, delivery time, customer satisfaction, etc. Because we are looking for very specific KPIs that fit the order and invoicing process of Company X, a lot of literature on KPIs related to the performance management of an entire company has been omitted.

3.2.1 Definition KPI

First, it is important to have a clear definition of a KPI. According to Parmenter (2015), it is a myth that all performance measures, are key performance measures. Parmenter (2015) has defined four performance measures that can be divided into two groups: result indicators and performance indicators. Result indicators represent many measurements that are a result of the work of different teams. They are useful, but do not help management immediately because it is difficult to pinpoint the team responsible for the performance or non-performance. Performance indicators, on the other hand, can do that. Performance indicators thus provide clarity and ownership.

The four types of performance indicators that Parmenter (2015, p. 4) distinguishes are:

1. *Key result indicators* (KRIs) give the board an overall summary of how the organization is performing.
2. *Result indicators* (RIs) tell management how teams are combining to produce results.
3. *Performance indicators* (PIs) tell management what teams are delivering.
4. *Key performance indicators* (KPIs) tell management how the organization is performing in their critical success factors and, by monitoring them, management is able to increase performance dramatically

The word "key" indicates that management places more value on these, these are the indicators that management acts on. The RIs and the PIs are not the indicators that management looks at first.

The following information in Chapter 3.2 does not distinguish between the four types of indicators as Parmenter does. So, in the rest of this chapter only the term KPI is used, as the authors do not explicitly distinguish between different type of indicators. They call it al KPIs.

3.2.2 Use of KPIs

Through KPIs, managers gain insight into their business operations. Muchiri et al. (2010) and West (2011) state that: "*Well-defined indicators can potentially support the identification of current and desired performance and provide us with information on the progress of individual performances*" (in Milichovský & Hornungová, 2013, p. 2). Moreover, according to Maria (2009), it can be a link between strategy and management, promoting the creation and implementation of initiatives related to the improvement of the company (in Milichovský & Hornungová, 2013). This is exactly what the KPIs should do for Company X. They should map the current performance so that Company X can set goals for the future. And the KPIs should map individual performance of suppliers, products, etc. so that Company X can work in a focused way to achieve its goals.

Provided the KPIs are set up correctly, they provide information on how the company is pursuing its goals (Collins, Hester, Ezell, & Horst, 2016). Only not all KPIs are set up correctly because it is a non-trivial process that requires a good knowledge of the company and or processes (Meyers and Hester, 2011; in Collins et al., 2016). So how do you set up good KPIs?

3.2.3 Setting up KPIs

For the best possible performance indicators it is important to have all the data of the company in a central data warehouse (Kallab & Ghawi, 2014). This data warehouse can contain data from various databases of for example, Enterprise Resource Planning (ERP) systems. Data warehouses are designed to quickly retrieve data, even from the most complex queries. Once this is done you can start setting up KPIs using the data from the data warehouse. It is also possible to determine the KPIs before looking at the data, you then look at the KPIs you need to measure. You may end up with more KPIs, but there is a chance that you cannot measure them because the data is not available. There is no one right way. It is a trade-off that must be made. You will probably end up with more diverse KPIs when you have not looked after the data yet. However, you may have to do a lot of work to get the data available for some KPIs and it may not be profitable anymore.

In the literature, there are all kinds of KPIs to be found only according to Kaganski et al. (2017) successful metrics of one company, can be worthless metrics in another company. Even if the companies are in the same industry. You cannot just adopt KPIs that are known within an industry. KPIs are a form of communication and should really reflect useful information for a company or a certain process. KPIs should encourage behaviour to achieve goals (Kaganski et al., 2017). It is logical that the success of KPIs also depends on them being continuously measurable (Schmidt, 2016; in Kaganski et al., 2017). Metrics must be adapted to the structure of the company, the production process, and the internal/external data flows. This is the reason why each management has to set their own KPIs (Kaganski et al., 2017).

In order to draw up performance measurements, Shamsaei et al. (2011) first of all mapped out the relevant process for which measurements had to be drawn up. He then formulated the desired goal of the company. Based on the goal and the process, he determined KPIs with the corresponding importance level. He et al. (2021) first conducted a literature search for possible KPIs related to the topic at hand. After that, interviews were held to find out new KPIs and to validate the found KPIs. In the interviews, the requirements regarding the KPIs were asked, but also what people currently look at to assess the performance (He et al., 2021). The final KPIs have He et al. (2021) divided into categories as shown in Figure 34 in Appendix B. We will make a similar figure for the KPIs for the dashboard from Company X, so that we have a clear overview of the KPIs.

The view of Kaganski et al. (2017) that Metrics must be adapted to the structure of the company, the production process, and the internal/external data flows, together with the practices of Shamsaei et al. (2011) and He et al. (2021) have led us to the practice of holding brainstorming sessions to establish KPIs for Company X. Brainstorming sessions will be held based on the core problem and norm, the process flow, and on the already existing generated data.

In addition to the company's goal, it is of course also good to know what the goal per KPI is, why the goal is important, how you are going to measure it, how you can influence it, and who is responsible for the outcome (Klipfolio, 2021). In addition, Klipfolio (2021) gives another ten important criteria that you could consider when setting up performance measures:

1. Be based on quantities that can be influenced, or controlled, by the user alone or in cooperation with others.
2. Be objective and not based on opinion.
3. Be derived from strategy and focus on improvement.
4. Be clearly defined and simple to understand.
5. Be relevant with an explicit purpose.
6. Be consistent (in that they maintain their significance as time goes by).
7. Be specific and relate to specific goals/targets.
8. Be precise – be exact about what is being measured.
9. Provide timely and accurate feedback.
10. Reflect the "business process" – i.e., both the supplier and customer should be involved in the definition of the measure.

3.2.4 The amount of KPIs

Too many KPIs can lead to a loss of focus on the factors that really matter. On the other hand, too few KPIs can lead to overlooking important factors (Brint, Genovese, Piccolo, & Taboada-Perez, 2021). Brown (1996) noted that when constructing performance measurement systems: "*The most common mistake organizations make is measuring too many variables. The next most common mistake is measuring too few*" (in Brint et al., 2021, p. 2). The KPIs for Company X's order process will be displayed in a dashboard. Few's (2006) view of dashboards is easy to reconcile with Brown's quote. As stated in Chapter 3.1.2: A dashboard does not have to show all the details to tell you that you should act. The primary task of a dashboard is to communicate that you must act at a glance. It serves you when it immediately gives you the extra information you need to be able to act. For this, a different display is allowed or navigational methods such as drilling down (Few, 2006). So, taking a single screen as the guiding principle in a dashboard prevents you from using too many KPIs. That screen should tell you at a glance whether action is required or not. Other tabs or drilling down methods can show the extra details that may be needed in order to act and thus prevent you from losing focus on the initial screen. So, we will take a single screen as guiding principle for the dashboard for Company X.

3.2.5 Selecting KPIs

The SMART method can be used for both setting up and validating the KPIs. Scholars and practitioners claim Peter Drucker's (1954) book, The Practice of Management, is instrumental in starting the development of the SMART acronym (Morrison, 2010; in Blaine Lawlor & J. Hornyak, 2012). SMART is defined by Williams (2012) as: "*Specific – define exactly what is being pursued?, Measurable – is there a number to track completion?, Attainable – can the goal be achieved?, Realistic – doable from business perspective, and Timely – can it be completed in reasonable amount of time?*" (in Blaine Lawlor & J. Hornyak, 2012, p. 259). Blaine Lawlor & J. Hornyak (2012) also cite the extended SMART method; SMARTER. They give the 'er' the meaning Exciting and Recorded. Klipfolio (2021) by contrast, use Evaluate and Reevaluate for the 'er' to keep validating whether your KPIs are still relevant and to explain why certain goals have or have not been reached. The Evaluate and Reevaluate could be done after the dashboard has been in use for several months at Company X. The evaluation is also discussed in Chapter 3.1.6. The PDCA cycle could also be used for validating whether your KPIs are still relevant and to explain why certain goals have or have not been reached, where the PDCA steps are more precise than with Evaluate and Reevaluate.

3.3 Conclusion

In this chapter, we have gained specific knowledge with regard to the visual design of a dashboard and the determination of KPIs. Thereby the knowledge questions: "*What is known in literature regarding requirements or techniques for a good visual design of a dashboard?"* and "*How to set up good KPIs?*" have been answered. We have received answers to both questions in the form of advice. There are no hard-and-fast rules or requirements for a good dashboard and good KPIs. With the knowledge of chapter 2 and this chapter, we will set up KPIs in Chapter 4.

4 Key performance indicators

Now that we know both what a dashboard should look like and how to set up KPIs, in this Chapter we will actually set up the KPIs for the dashboard of Company X. Chapter 4.1 explains the brainstorming sessions. The knowledge question: "*Which KPIs would the different stakeholders like to see in a dashboard?"* is answered in Chapter 4.2 by selecting from the KPIs established in Chapter 4.1.

4.1 Brainstorming about the key performance indicators

The aim of the management of Company X is to gain insight into the deviations between the invoices and the purchase orders. With this goal in mind, KPIs were set up to.

Two brainstorming sessions were held with the stakeholders about the possible KPIs. In order to determine as many KPIs as possible and to be sure that all possible KPIs have been addressed, it was decided to start brainstorming about these. The view of Kaganski et al. (2017) and the approaches of Shamsaei et al. (2011) and He et al. (2021) in Chapter 3.2.3 have inspired us to divide the brainstorm session into three rounds:

- First, we brainstormed with the core problem and the norm of Company X in mind.
- Then, in round two, we showed the stakeholders the process flow, discussed in Chapter 2, and then brainstormed again with the idea that this would make them think more out of the box.
- Finally, we showed the stakeholders the five data tables as inspiration for new KPIs.

In this way, we avoided getting into tunnel vision with the most obvious KPIs. In Appendix C, the first rough list of KPIs can be found as they were conceived in the brainstorming sessions. This list has been reviewed and some KPIs have been merged and phrased better. In this way, we arrived at the second structured list of KPIs, which can also be found in Appendix C.

To clarify the KPIs, a purchase order from Company X can be matched with an invoice. Then the invoiced amount matches the expected cost of the purchase order. A purchase order can also be over- or under-invoiced. In that case, more or less is invoiced than expected. So, there are three types of deviations: matched invoice, over-invoiced, and under-invoiced.

4.2 Selecting KPIs

So far, we have referred to the KPIs we have just drawn up as KPIs, but in Chapter 3.2.1, it was discussed that Parmenter (Parmenter, 2015) distinguishes between four indicators. If we would keep to these names, we would only have result indicators in the structured list of KPIs in Appendix C. The KPIs under the heading global KPIs are all KRIs and all other KPIs in the structured list are RIs. This is because they are indicators of a specific process, not of an entire organisation. In addition, there is not one person or one group that is 100% responsible for certain indicators. The suppliers and Company X both have an influence on the results of the indicators. Because 'KPI' is in our opinion the most commonly used term and because they also talk about KPIs within Company X, we decided to keep calling the indicators KPIs in this research.

The fact that they are actually result indicators means that the SMART method is not entirely applicable. So, we can judge the KPIs on Specific, Measurable, and Realistic. But not on Attainable and Timely, because a concrete goal has not yet been set and there will not be a concrete goal for each KPI. Except that there should be as few deviations as possible. In addition, it is hard to set a goal for a KPI while the current performance is not yet known because the data created by Scan and Capture is not yet in the database of Company X. However, the KPIs could be used in an attainable and timely context.

4.2.1 Dropped KPIs

The KPIs that have been dropped are coloured red in the structured list of KPIs in Appendix C. The KPIs related to product category and the KPIs related to the customers were dropped first for the reason that they are not relevant. There are so many product categories that those KPIs amount to almost the same as the KPIs related to the Stock Keeping Units (SKUs). The KPIs related to the SKUs are more specific, and that is what we are going for. The KPIs related to the customers are not relevant because they do not give the desired insight. The customer has no influence on the deviations, so the KPIs do not provide useful insights.

In addition, the KPI; processing time of the deviations has been dropped. This is a very good KPI, because it can show how well the dashboard is being used. The KPI can for example measure how long it takes on average before deviations larger than € 500 are resolved. If this takes longer than deviations of a few euros, this is a sign that the dashboard is not being used properly. However, this KPI has been dropped on Measurability from the SMART method. No data is kept on this yet and therefore it cannot be measured. To create this data is a serious point to consider when linking the created data from Scan and Capture to the database of Company X.

The top *n* suppliers and SKUs causing the most deviations per deviation type over time were not used either. The reason being that the numbers are less important to Company X than the monetary amounts. So, we are going to use the top *n* suppliers and SKUs to rank the suppliers and SKUs that provide the largest amount of money in deviations per deviation type over time.

Finally, the KPIs with percentages under the heading KPIs related to markets have been dropped. There are only five markets, so the underlying relationships between the markets are already very clear and the percentages are therefore unnecessary. There are many more suppliers and SKUs so percentages would be useful there.

4.2.2 Selected KPIs

Figure 7 shows the KPIs finally selected from the structured list, last page of this chapter. All these KPIs are Specific, Measurable, and Realistic in the sense that there is a way to influence them. In addition, they meet the ten criteria from Klipfolio (2021) which are in Chapter 3.2.3. The degree of Specific does differ slightly per KPI. Specific means that the KPI defines exactly what is aimed for. The aim is to gain insight into the deviations between invoices and purchase orders and ultimately to minimise deviations.

In Figure 7, the selected KPIs are placed in columns. Some KPIs can be combined into one figure. In Figure 7, the first four KPIs of the first column are combined and will all be shown in the figure; *# and € deviations per month*. Within the figures, the KPIs are ranked from most to least specific. For example, the first two KPIs in the first column of Figure 7 are more specific than three and four in that column. This also applies to figure *deviation info. per supplier* and the first three KPIs in *deviation info. per SKU.* Those KPIs with percentages give a better overview and make comparison easier. The other KPIs in the figures provide context and some additional information.
During the design of the dashboard, an additional KPI was developed; money amount from the top *n* SKUs (first KPI in third column of Figure 7) divided over the suppliers. This KPI provides more specific insights. It indicates the suppliers from whom the money amount from the deviations of a SKU originates.

The figures with KPIs are arranged by 1, 2, or 3 in Figure 7. As discussed in Chapter 3.1.2, the primary task of a dashboard is to communicate that you must act at a glance. It serves you when it immediately gives you the extra information you need to be able to act. A different display or navigational methods are allowed for the extra information. The figures marked with a 1 are therefore those that must communicate to Company X whether or not action is required. These are the broadest KPIs. The figures marked with a 2 already provide some detailed information about where to act. The figures marked with a 3 are the most detailed. *Top n greatest € deviations* is even at purchase order level. The numbers 1, 2, and 3 indicate in which tab of the dashboard the KPIs will be placed.

The three KPIs in the right column of Figure 7 are KPIs that provide information on the product options level. Many more KPIs can be added in that column as there are a huge number of product options as can be seen in Table 7 in Appendix A. The three KPIs that are now in the third column are the broadest KPIs of these. The other KPIs that could be set up have been left out because that would create too many tabs in the dashboard and because it would lead to a deep analysis which is not necessary in a dashboard.

4.3 Conclusion

In this chapter, we have set up KPIs with the help of brainstorming sessions. From these KPIs, a number were dropped when discussing their usefulness for Company X. They were also evaluated on Specific, Measurable, and Realistic. Subsequently, certain KPIs were combined into figures and those figures were arranged in such a way that they have to communicate at a glance whether action is required. De knowledge question: "*Which KPIs would the different stakeholders like to see in a dashboard?"* is hereby answered. In the next chapter, the dashboard will actually be made.

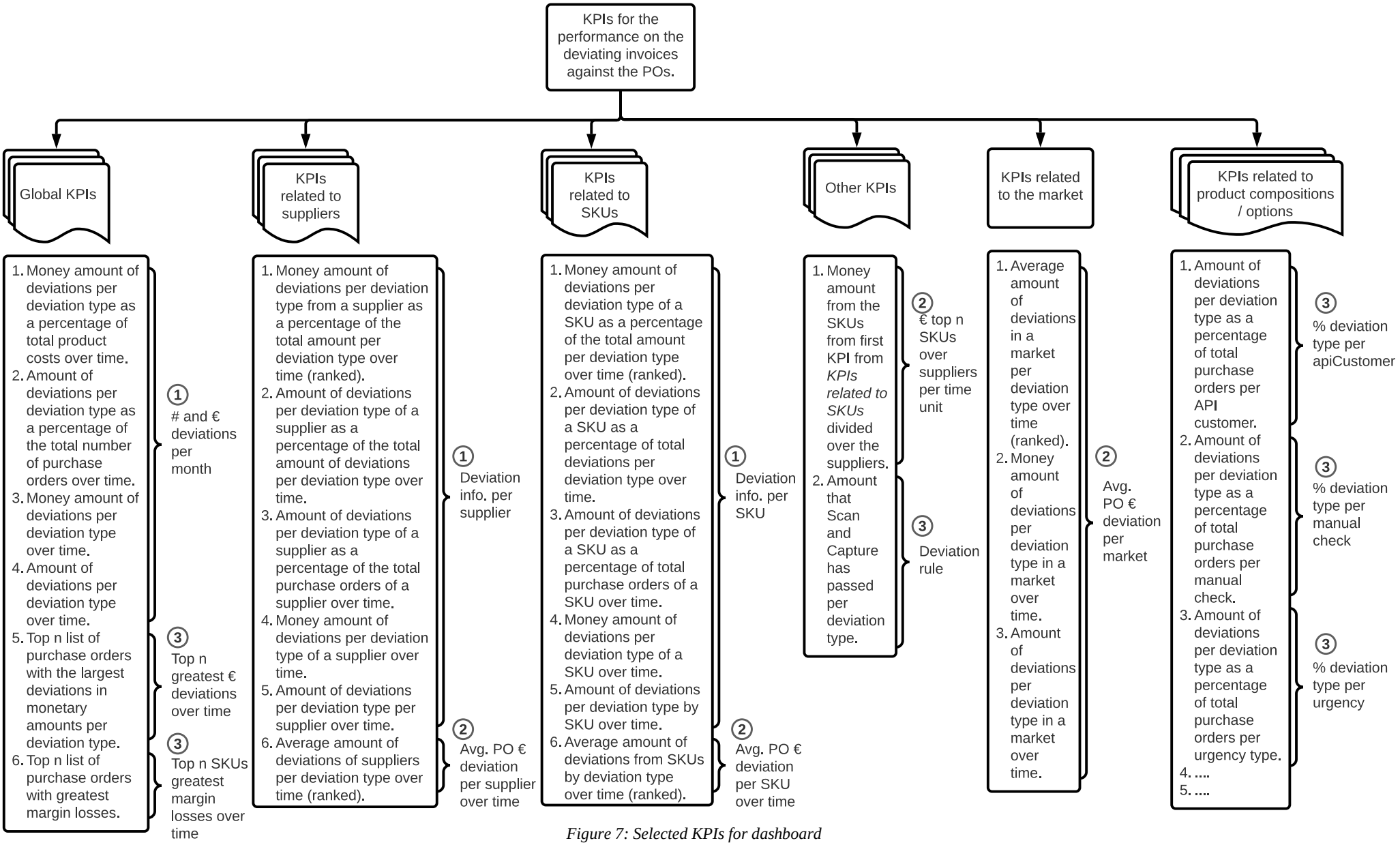

Figure 7: Selected KPIs for dashboard

5 Developing the dashboard

Before the dashboard can actually be created, the knowledge question: "*How can the link be established between the Tableau dashboard and Company X's data warehouse?"* remains. This question is answered in Chapter 5.1. Chapter 5.2 then explains the figure choice and how the KPIs were set up. The figure choice has been an iterative design process with feedback from the stakeholders.

5.1 Missing data link

The development and implementation of Scan and Capture took longer than Company X had expected. Because of this, the data generated by Scan and Capture has not yet been connected to Snowflake. All data that is currently in Snowflake comes from the Keen database. For the data from Scan and Capture a link needs to be made via NetSuite because Scan and Capture is located there. This link requires SuiteAnalytics Connect. When this is ready, a sixth table will be added in Tableau as shown in Table 8. The SCANANDCAPTURE table will then contain at least the data attribute invoiced price per purchase order and the ORDERITEM_NUMBER. Through the ORDERITEM_NUMBER the SCANANDCAPTURE table will be linked to the existing tables in Tableau, Table 2 Chapter 2.2.1.

Table 8: Future extra data table

Tables	**Created when**	**Stored by**	**Structured by**	**Data moved to Tableau by**
SCANANDCAPTURE	PO and invoice are loaded in Scan and Capture	NetSuite database	Snowflake	Transformation application

The live data in Tableau still lacks the data attribute that Scan and Capture generates: invoiced price per purchase order. To give Company X an example of the functionality and insights that the dashboard will provide, dummy data has been used. From Tableau all data of the first half year of 2020 has been downloaded. In that data file, the data attribute; PRODUCT_INVOICED has been created with randomly generated invoiced prices per purchase order. A number of rows and columns are shown in Figure 36 in Appendix D. This data enables us to generate the dashboard exactly as it would have been done if the link between Snowflake and NetSuite had been ready.

5.2 Designing the KPIs

The figures that will appear in the dashboard are now briefly explained per tab in the dashboard. How exactly the figures are built with the created calculated fields is explained per figure in appendix D.

5.2.1 Dashboard tab 1

For *# and Euros deviations per month*, a line diagram has been chosen. This is supported by the graph selection matrix, Figure 33 in Appendix B, of Few (2004). The four KPIs have been placed below each other in order to be able to compare trends. This figure shows the numbers and amount of money involved in the deviations over time. Both absolute and percentage wise. For example, Figure 8 shows that the number of over-invoiced purchase orders increases while the percentage decreases over the first six months of 2020.
The two lines in magenta colour are added to prevent change blindness as described by Stehle and Kitchin (2020). Company X can use these two lines as reference points or goals. The lines are now just set at 25 and 6 per cent. Company X has yet to set these targets when they know their current performance. The colour choice of magenta was chosen based on the research of Kang (2016).
When you move your cursor over the figure, you will get additional information as shown in Figure 8. The colour legend of the deviation types is the same for each figure in the dashboard. This allows you, for example, to highlight all over-invoiced.

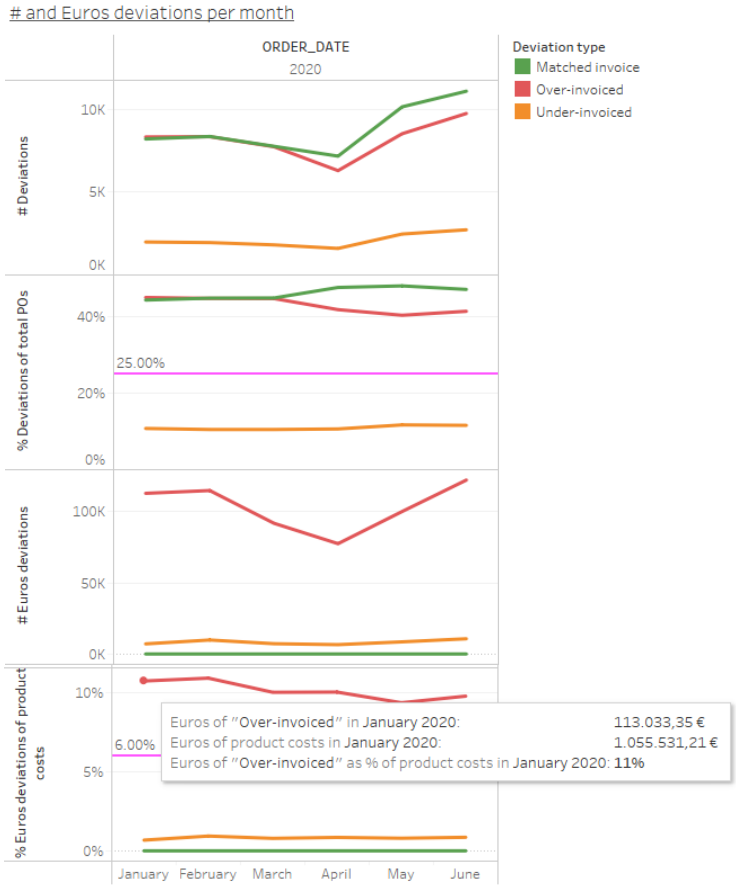

Figure 8: # and Euros deviations per month

For *Deviation info. per supplier* and *Deviation info. per SKU*, a bar chart has been chosen as shown in Figure 9. These figures are constructed similarly, except that the left one is at supplier level and the right one is at SKU level. They show the amount of money per deviation type that a supplier or SKU is responsible for, as a percentage of the total monetary amount per deviation type in a month. A bar chart was the clearest and most logical visualisation method. The figures are in descending order. A pie chart would not be clear, because there are very many suppliers and SKUs. A pie chart was already discouraged by Sperandei (2014). In addition, the graph selection matrix by Few (2004) also indicates that a bar chart is the best way to go.

The two figures on the right can be filtered by year, month, and deviation type. The figure of the suppliers is now filtered on over-invoiced and that of the SKUs on under-invoiced. In addition, the top three of both are shown. The *n* of the top *n* can be filled in as desired per supplier and per SKU.

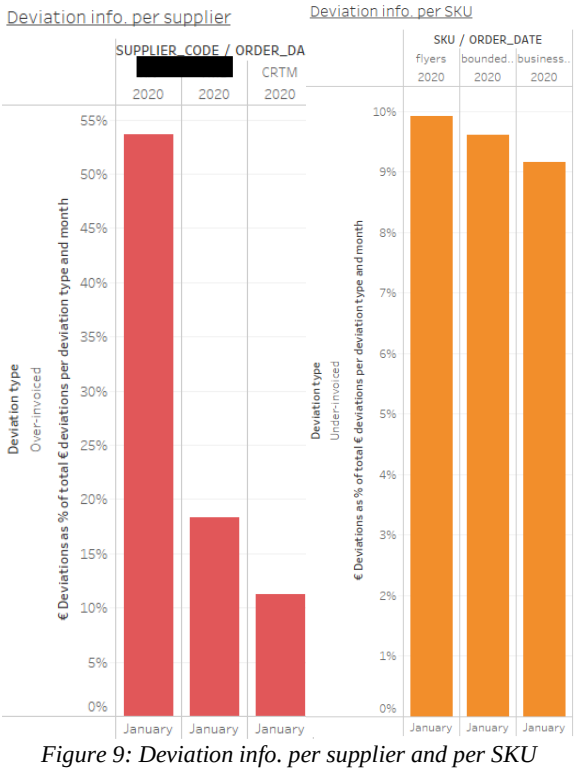

Figure 9: Deviation info. per supplier and per SKU

If you move your cursor over the two figures in Figure 9, you will get additional information. For example, Figure 10 will be displayed when you place your cursor on CRTM in *Deviation info. per supplier*. The two percentages in magenta colour are important to compare with each other. In the example in Figure 10, CRTM only takes care of 1.49% of the amount of over-invoiced purchase orders in January 2020 while they take care of 11% of the amount of money over-invoiced in that month.

Figure 10: Hovering over January 2020 from CRTM

5.2.2 Dashboard tab 2

The figures *Avg. PO € deviation per supplier over time*, *Avg. PO € deviation per SKU over time*, and *Avg. PO € deviation per market* are visualised in the same way as the figures in Figure 9 for the same reasons. They are only shown horizontally as this is more convenient for the dashboard later on.

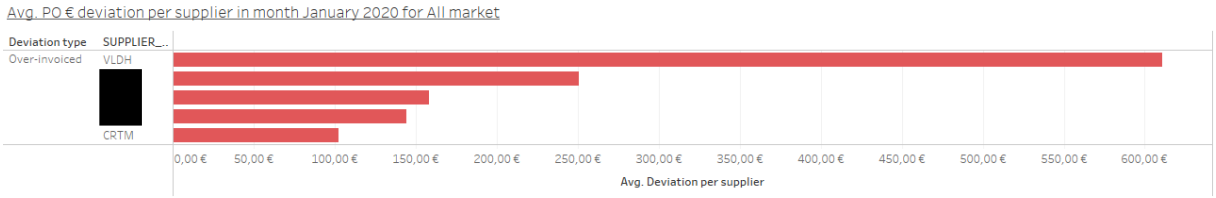

Figure 11: Avg. PO € deviation per supplier over time

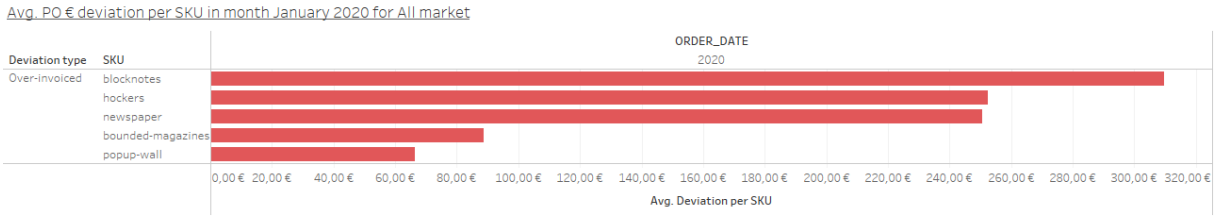

Figure 12: Avg. PO € deviation per SKU over time

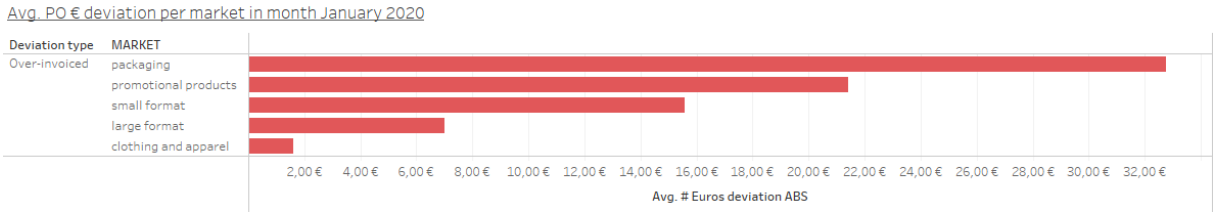

Figure 13: Avg. PO € deviation per market over time

Figures 11 and 12 are now ranked separately on the top five. This number can be changed separately as desired. Figures 11, 12, and 13 are arranged in descending order. There are only five markets, so Figure 13 always shows the top five.

When you move your cursor over Figure 11, 12, or 13, you will get a pop-up. The pop-up you get when you hover over supplier VLDH in Figure 11 is shown in Figure 14. In Figure 12 and 13, the format of the pop-up is the same as in Figure 11. Supplier VLDH did not appear in Figure 9 because the total amount of money is not so large since VLDH only over-invoiced once.

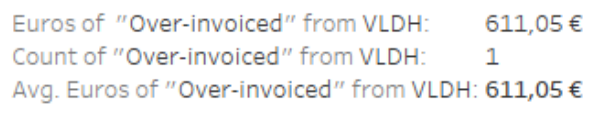

Figure 14: Hovering over avg. over-invoiced from VLDH in 2020

For *€ top n SKUs over suppliers per time unit*, a table has been chosen, as shown in Figure 15. A visualisation does not add anything. Moreover, Few (2004) indicated that a table works best when you have to look up individual values.

€ top n SKUs over suppliers in month January 2020 for All market

				SUPPLIER_CODE								
SKU	Year of OR..	Month of O..	Deviation type	[redacted]					VLDH	[redacted]		
flyers	2020	January	Under-invoiced	7,36 €	5,09 €	94,82 €	255,93 €	4,49 €		171,86 €	166,01 €	
bounded-magazines	2020	January	Under-invoiced				162,70 €		371,58 €	114,22 €	35,43 €	
businesscards	2020	January	Under-invoiced		92,93 €		149,55 €	13,57 €		112,24 €	282,87 €	

Figure 15: € top n SKUs over suppliers per time unit

In Figure 15 you see the three SKUs that *Deviation info. per SKU* in Figure 9 also displays. Figure 15 provides detailed information on which suppliers the total amount of money per SKU per deviation type comes from. Again, you can enter the *n* as desired for which top *n* the table should display, as you wish.

In tab 2 of the dashboard the filters on date, market, SKU, and supplier apply to all KPIs in tab 2. For example, you can display only the market large format. Then you get the top *n* suppliers with on average the largest deviations per deviation type in monetary terms in the market large format, the top *n* SKUs with on average the largest deviations per deviation type in monetary terms in the market large format, and the top *n* SKUs with the largest total amount of deviations per deviation type spread across the suppliers in the market large format. This filtering technique and the pop-ups in the other KPIs were also indicated by Dilla and Raschke (2015) as possible data selection tools.

5.2.3 Dashboard tab 3

For the same reason as for *€ top n SKUs over suppliers per time unit*, the *Top n SKUs greatest margin losses over time*, *Top n greatest € deviations over time* and *Deviation rule* are also tabulated, respectively Figure 16, 18, and 19.

Top n SKUs greatest margin losses in month March 2020

	Deviation type	Year of ORDE..	Month of ORDER_D..	Count of De..	# Euros deviation A..	Avg. % lost from margin	SUPPLIER_CO..	
squeegee-felt-strip	Over-invoiced	2020	March	1	1,20 €	421.74%	[redacted]	421.74%
hardcover-books	Over-invoiced	2020	March	8	743,49 €	192.58%		341.06%
				12	244,45 €	192.58%		93.60%
playing-cards	Over-invoiced	2020	March	1	250,02 €	176.93%		176.93%
stapled-magazines	Over-invoiced	2020	March	1	189,00 €	137.21%	VLDH	240.22%
				5	236,52 €	137.21%	[redacted]	63.60%
				17	855,19 €	137.21%		97.77%
				96	9.316,99 €	137.21%	CRTM	75.98%
				104	2.171,21 €	137.21%	[redacted]	43.32%
				150	3.045,57 €	137.21%		48.22%
				204	12.564,72 €	137.21%		283.90%
pillow-packs	Over-invoiced	2020	March	1	86,67 €	135.43%		135.43%

Figure 16: Top n SKUs greatest margin losses over time

137.21% is the average margin lost from **stapled-magazines** in **March 2020**
240.22% is the average margin lost from **stapled-magazines** invoiced by **VLDH**.in **March 2020**

The total Euros of deviations of the 1 Over-invoiced stapled-magazines by VLDH is **189,00 €**

Figure 17: Hovering over stapled-magazines from VLDH

When you hover your cursor over the table in Figure 16, you get the pop-up shown in Figure 17. In Figure 17, the cursor was on the first row of stapled magazines in Figure 16.

Top n greatest € deviations in month January 2020

ORDERITEM_NUMBER	Deviation type	SUPPLIER_CODE	SKU	
6000133634-1	Over-invoiced	[redacted]	stapled-magazines	836,36 €
6000136377-1	Over-invoiced		flyers	783,30 €
6000128292-1	Over-invoiced		stapled-magazines	720,12 €
6000127289-1	Over-invoiced		folders	660,74 €
6000131026-1	Over-invoiced	VLDH	bounded-magazines	611,05 €
6000130636-1	Over-invoiced	[redacted]	flyers	597,69 €
6000135846-1	Over-invoiced		folders	549,15 €
6000125682-1	Over-invoiced		stapled-magazines	546,83 €
6000131032-1	Over-invoiced		hockers	490,57 €
6000137527-1	Over-invoiced	CRTM	bounded-magazines	464,79 €

Figure 18: Top n greatest € deviations over time

Top n greatest € deviations over time is filterable by week. This table can be filtered per week as well as per month, as it is intended to be looked at on a weekly basis. Chapter 6 will go into this in more detail. Figures 16 and 18 can be filtered by year, month, market, SKU, and supplier.

The deviation rule in Figure 19 has been set to 5%. The deviation rule is now set to mark an invoice as deviating if the deviation from the purchase order is 5% or more (-5% and 5%). This rule can be adapted to the rules that Scan and Capture will use to mark deviations. However, these rules are not yet known. For now, we have come up with the 5% ourselves, as there is no data yet from which we can derive a good percentage and perhaps the rule should be changed completely to, for example, a combination of percentage and absolute rules. If the current rule is set to 5%, Scan and Capture will let through a total of €11275.43 in over-invoiced invoices for the first six months of 2020. If you set the rule to 0%, Scan and Capture will extract all deviations. It is possible to adjust the deviation rule percentages in the dashboard. Company X can use this KPI to weigh up how many deviations are allowed to slip through. They can also use this KPI to gain insight into the effect of various rules that label deviations. This KPI can be filtered per month

Deviation rule in month All 2020

Matched over-invoiced	11.275,43 €
Matched under-invoiced	4.751,81 €
Over-invoiced	608.955,42 €
Under-invoiced	45.242,76 €

Figure 19: Deviation rule

For the last three KPIs: *% deviation type per apiCustomer*, *per manual check*, and *per urgency*, bar charts are used again to show the difference per deviation type. Respectively they can be seen in Figure 20, 21, and 22. All three are constructed in the same way and can be filtered by month.

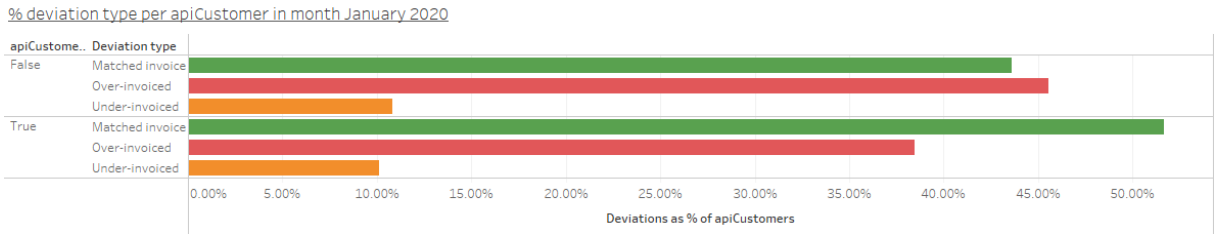

Figure 20: % deviation type per apiCustomer

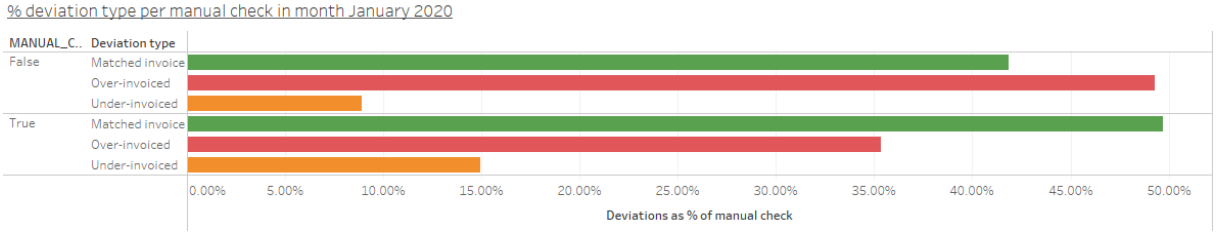

Figure 21: % deviation type per manual check

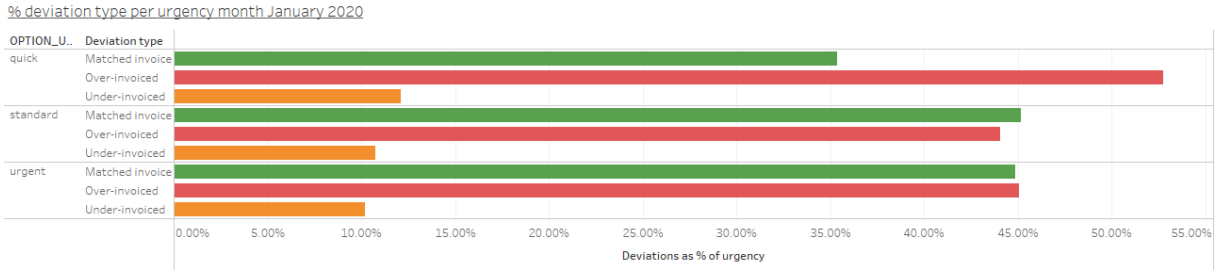

Figure 22: % deviation type per urgency

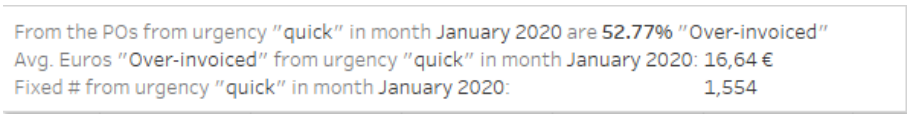

Figure 23: Hovering over urgency type quick over-invoiced in January 2020

Figure 22 shows that in January 2020 there are more over-invoiced invoices of the urgency type quick than of the other urgency types, see Figure 23.

5.3 Placing the KPIs in the dashboard

All figures from Chapter 5.2 are placed in the appropriate tab of the dashboard. They are placed so that there are no white spaces in the dashboard. The tabs of the dashboard can be found in Appendix D, Figures 36, 37 and 38. On the right side of the dashboard you will find the colour legend for highlighting, the filters, the slides to display the top *n*, and the deviation rule. For example, if you change the month in tab 1 to January, the dashboard will automatically filter tab 2 and 3 accordingly. At the top right of the dashboard, you will find the three buttons that navigate you to the different tabs of the dashboard for ease of use.

During the design of the dashboard itself, the design requirements of the stakeholders were taken into account. Those design requirements were won by us through a short interview at the end of the second brainstorming session. Company X, for instance, wanted really a visual dashboard. The dashboard should not be full of numbers, because that would immediately put people off and not be user-friendly. This is in line with the found literature described in chapter 3. So most of the KPIs are displayed in graphs and the specific information is revealed when you move your cursor over it. In this way, the dashboard remains clear and you can draw conclusions from it without overwhelming information in the first instance.

In addition, the stakeholders from experience advised us not to use too many unnecessary colours in the dashboard, as this would not benefit the dashboard. We were able to apply this well by only giving different colours to the three different deviation types. And we only used one extra colour to emphasize important information.

Finally, the stakeholders emphasised that they would like to have the information in the dashboard grouped together. This was in fact already done for a large part in the structured list with KPIs in Appendix C, but they would also like to see it back in the dashboard. For example, tab 1 of the dashboard on the left shows the overall performance with regard to the deviations. The figures to the right show the performance per supplier and SKU. When you hover your cursor over these figures, the extra information associated with them appears in a pop up. The *avg. PO € deviation per supplier / SKU* is deliberately not included in this pop up, because we wanted to rank it on the average deviation as shown in tab 2 of the dashboard. The two figures on the right in tab 1 of the dashboard are already ranked on the largest monetary deviations per supplier or SKU.

5.4 Conclusion

In this chapter we have answered the knowledge question: "*How can the link be established between the Tableau dashboard and Company X's data warehouse?"*. The answer forced us to design a conceptual dashboard instead of an already working one for Company X. In the next chapter we will give advice on how to implement the dashboard.

6 Recommendation on dashboard implementation

In this chapter, recommendations are made about the dashboard created in Chapter 5. In Chapter 6.1 two recommendations are made about the dashboard in the process flow. In Chapter 6.2 there is a recommendation on how to put the dashboard into use.

6.1 Recommendation for the dashboard in the process flow

The list of purchase orders extracted by Scan and Capture is highlighted in green in Figure 24 and 25. In Scan and Capture a margin can be set so that for example a deviation of € 1,- on € 1000,- is not extracted. That purchase order will not appear on the list of deviations. It will cost more than €1,- to solve that deviation and then it is not profitable to solve.

However, we advise that all the data created by Scan and Capture is going to be input for the dashboard. In this way, the dashboard can show all deviations, including those of only €1,- because if they occur very often you would like to have them solved. And so, the matched and under-invoiced purchase orders can also be displayed in the dashboard. Moreover, you do not want to leave data out of the dashboard, because then you might draw conclusions from patterns you have found because you left data out. And so, the KPI *deviation rule* can be used, together with the data already created, to weigh up how many KPIs are not noticed by Scan and Capture. This all is not possible when only purchase orders that are on the deviation list are used as input for the dashboard, because then you only display the over-invoiced.

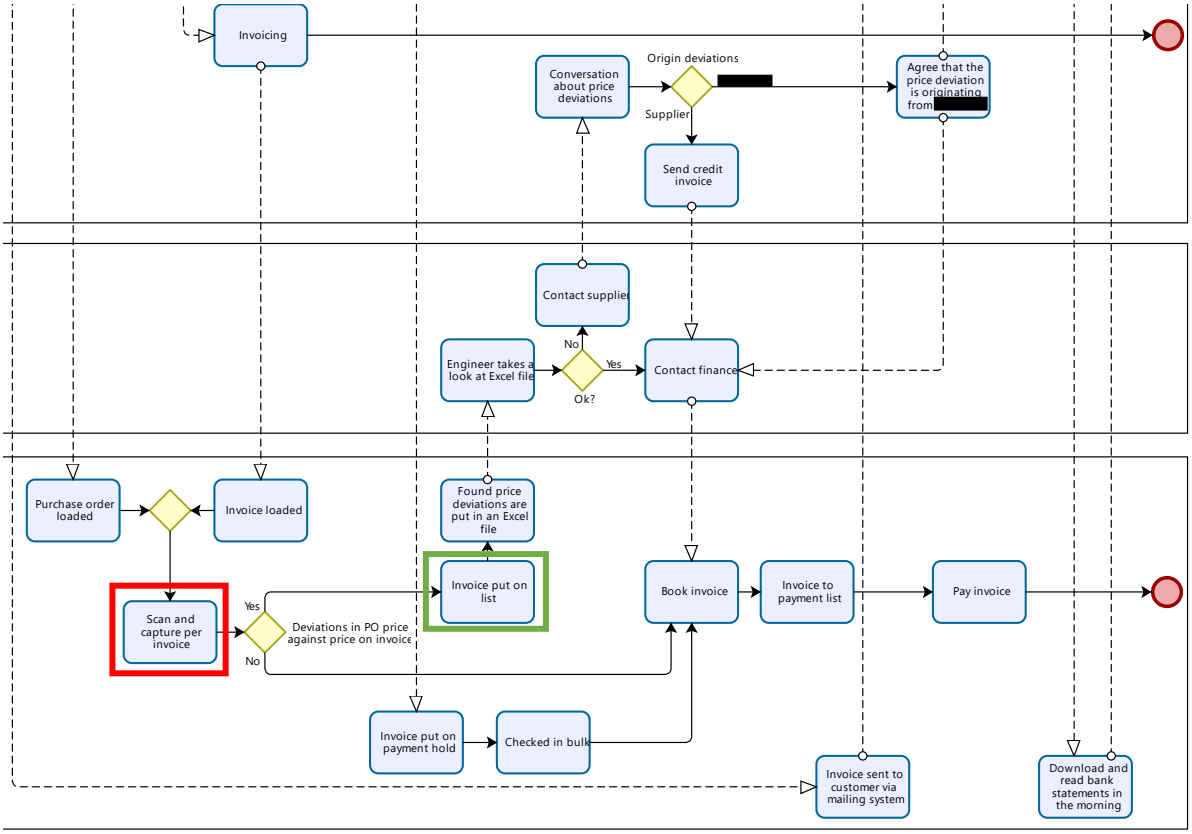

Figure 24: Screenshot of the bottom right corner from the old process flow

In Figure 25, the data object SCANANDCAPTURE has been added in the process flow. This is the point from which all created data must be transferred by Scan and Capture to Snowflake and thus ultimately be used as input for the dashboard.

Besides the data object, there is another difference between Figure 24 and Figure 25. Figure 25 is a screenshot of the recommend future process flow at Company X shown in Figure 32 in Appendix A. Our recommendation is that the engineering Product Guide will work in NetSuite. The process flow then looks like Figure 25. The middle lane, engineering, in Figure 24 has disappeared in Figure 25 because the product guide in our recommended process flow then works in NetSuite. The product guide can then see the list of deviations in NetSuite and determine whether the deviation is acceptable or not. If not, he can contact the supplier. The offline Excel files are no longer necessary and the confusion about what is the most up-to-date Excel file is also gone. Moreover, the processing of deviations could be faster because the product guide can view the deviations whenever he wants, and if a deviation is resolved, he can book the invoice himself. The transfer of information from finance to the product guide and from the product guide to finance is thus eliminated. That makes this process less error-sensitive and more efficient. Possible core problem 2 is solved with this.

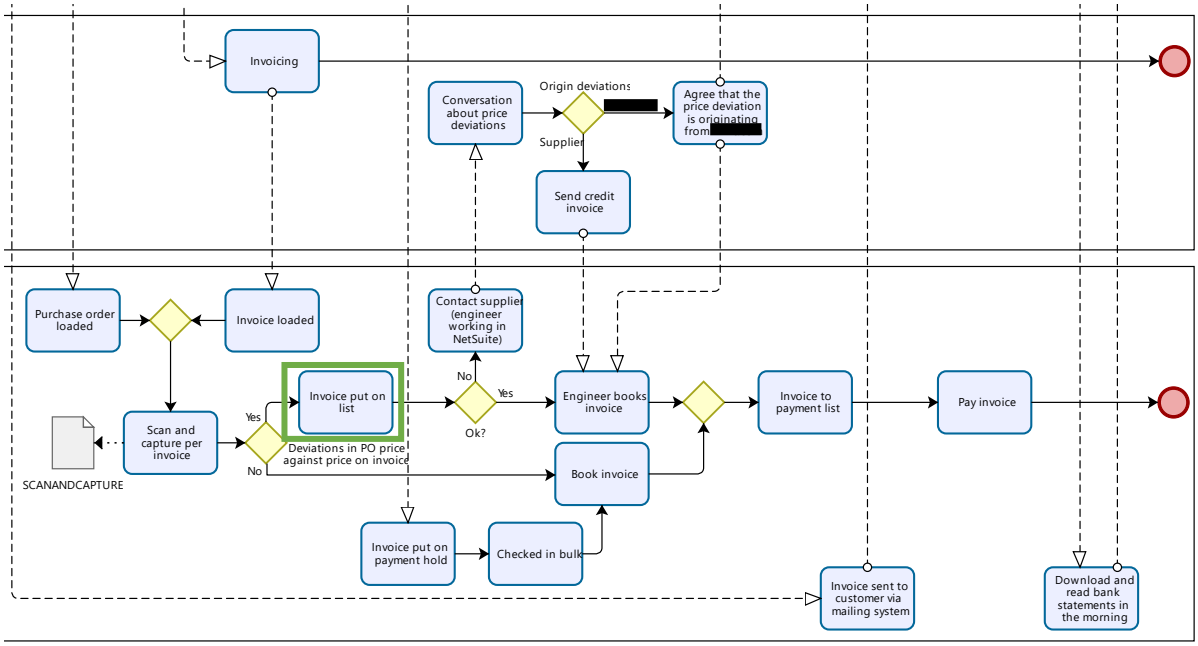

Figure 25: Screenshot the recommend future process flow Figure 32 Appendix A

6.2 Recommendation for the use of the dashboard

Instead of the product guide immediately looking at the list of deviations created by Scan and Capture, in green in Figure 25, we recommend that the product guide weekly look at *Top n greatest € deviations over time* in tab 3 of the dashboard. For example, every Monday he can filter that KPI to the previous week and thus solve the top *n* greatest deviations in monetary terms of that week. The expectation is that the list of deviations created by Scan and Capture is huge. In addition, it is a raw list that is not easy to oversee. So the list with deviations created by Scan and Capture itself cannot be used efficiently and the *Top n greatest € deviations over time* can be used efficiently instead of the Scan and Capture list with deviations.

We advise Company X to analyse the entire dashboard on a monthly basis. Suppliers invoice by means of collective invoices. So, there are large weekly differences in the number of invoices that Company X receives. When the data of the dashboard of the previous month is analysed on the first day of the month, this gives a better analysis than if it were done on a weekly basis.

We propose to use the PDCA cycle for this. In the Plan phase, Company X must therefore set targets for some KPIs. The dashboard may have revealed, for example, that Supplier Y causes major deviations. In the Do phase, Company X is going to act on a KPI in the dashboard to achieve the target. In the example, they are going to find out why Supplier Y causes major deviations and try to solve it. The Check phase is the first of the following month. The dashboard can then be used to check whether the

goal has been achieved. In other words, whether the amount of money in deviations due to supplier Y has disappeared or decreased. In the Act phase, the plan can be adjusted to meet the target if it has not yet been met. If it has been achieved, the PDCA cycle can begin again. Of course, a distinction can be made here between general targets, such as for example no more than 5% of the quantity of purchase orders may deviate, and more specific targets per month.

6.3 Conclusion

By loading all generated data from Scan and Capture into the Company X database, the dashboard can provide many useful insights. The advice is to use the dashboard on a weekly and monthly basis. When done correctly, this should be reflected in the number of deviations and or the amount of money in the dashboard. By using the dashboard weekly, the largest deviations in amounts of money could be resolved. The monthly analysis of the dashboard and the resulting plan will ensure that the deviations will be dealt with on a broader level at the core. The dashboard gives the opportunity to make these weekly and monthly analyses. Ultimately, the weekly and monthly analysis should ensure that the deviations at Company X will be reduced.

7 Conclusion, recommendation, discussion

We have now arrived at the conclusion of the research. In this chapter, the research question will be answered (Ch. 7.1), recommendations will be made (Ch. 7.2), and a discussion will be held (Ch. 7.3).

7.1 Conclusion

In this research we have answered several knowledge questions in order to be able to answer the following research question:

How can Company X monitor the price deviations between Company X's purchase orders and the suppliers' invoices?

The Product Guide of engineering can use the conceptual dashboard created in this study in the future in our recommended way to monitor the deviating invoices against the purchase orders. So, on a weekly and monthly basis with the monthly analysis using the PDCA cycle. This dashboard was created with knowledge of the process to which the dashboard applies and with the necessary literature on the visual design of a dashboard and on KPIs. The knowledge of the process together with the literature enabled us to set up appropriate KPIs and display them in a dashboard.

With this answer to the research question, the found core problem of Company X can be solved in the future. The core problem is:

At Company X, it is not clear which and how many invoices differ nor what the origin and financial impact of the deviations are.

The moment Company X actually starts to use the conceptual dashboard and implement it as recommended in this study, the core problem will have been solved and the set norm for the core problem will have been achieved. In the final presentation of the dashboard, the stakeholders were asked whether the norm had been met. As can be seen in Table 9. The norms from Table 9 are set out in chapter 1.4.2 under the heading 'Norm'. It is still a conceptual dashboard and therefore not yet operational, which means that the norms cannot yet be fully verified as to whether they have actually been achieved. Hence the combined nuanced responses in the right-hand column of Table 9.

Table 9: Achieved norm

Norm	**Achieved?**
Almost live data about the deviations	Yes, if the link between NetSuite and Company X's database is established.
Automatic provided insights about the deviations.	Yes, if the link between NetSuite and Company X's database is established.
Easy to interpret data.	Yes, the figures in the dashboard speak for themselves. The KPI *deviation rule* only needed some explanation, but is very useful!
Financial seriousness of the deviations is clear	Yes, however not with real data yet.
The amount of deviations is clear.	Yes, however not with real data yet.
Insight in the deviations per SKU	Yes, actually even on different levels. Not with real data yet.
Insight in the deviations per supplier	Yes, actually even on different levels. Not with real data yet.
There is a more efficient working method for acting on the deviation insights	Yes, the advice on using the dashboard is very clear and that it will be more efficient is very plausible. But of course, that can only be said with certainty once the dashboard is actually in use.

When the core problem has been solved, Company X takes a step in the right direction to solve the action problem below:

At Company X, the process of treating incoming printed matter invoices is not scalable for handling more printed matter invoices.

The norm of the action problem is that there should be a proactive solution that will lead to almost no deviations. In addition, Company X wants an efficient and effective way to solve the deviations that still come in. The dashboard will then easily provide insight into the deviations so that targeted action can be taken, and proactive solutions can be devised. This is not possible without insight into the deviations. In addition, Company X could solve the deviations efficiently if the dashboard is implemented in the process flow as recommended. Because the time-consuming information transfer between the product guide and finance has been eliminated. The deviations could also be resolved more effectively because the Product Guide can then prioritise, based on the dashboard, which deviations he will resolve first.

7.2 Recommendation

There are a number of recommendations for Company X in addition to those in Chapter 6:

- Make the data connection between NetSuite and Tableau as recommended in Chapter 6.1 so that the dashboard can be made workable.

- If it is clear what the performance of Company X is on the deviations, targets must be set per KPI. Especially for figure *# and Euros deviations per month* in tab 1 of the dashboard.

- For even more specific analyses, additional figures could be created as in tab 3 of the dashboard on product options / compositions. Regression with all product options / compositions would also be possible for an analysis.

- The ER from SMARTER (Evaluate and Reevaluate) should be done after the dashboard has been in use for a few months. This could also be done with the PDCA cycle. It should be checked whether the dashboard is being used properly. That is, whether the deviations are decreasing. It should also be evaluated whether the design of the dashboard works well in practice. It may turn out that certain KPIs are not being used and can therefore be replaced by other KPIs, if necessary.

- One KPI was not possible to realise because no data is kept on it yet. It concerns the KPI: processing time of the deviations. If the time is tracked from the moment a purchase order is marked as deviations, then this would be possible by, for example, taking the difference with the time the purchase order is booked. In this way, performance could be tracked on the handling of the deviations.

7.3 Discussion

Setting up, selecting, and visualising the KPIs has been an iterative process together with the stakeholders. The choices made here were therefore influenced by the stakeholders who ultimately also must work with them. It might have been better to involve several people in the company who are not directly stakeholders in this process in order to arrive at new insights.

In addition, no attention has been paid in this research to making price agreements between Company X and the suppliers. The price agreements obviously have a major impact on the price differences between the prices in Keen and the prices applied by the suppliers. We therefore recommend not putting all the focus on the dashboard to find the causes of the price deviations, but to also investigate the process of making price agreements.

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Appendix A – Order and invoicing process

Screenshots

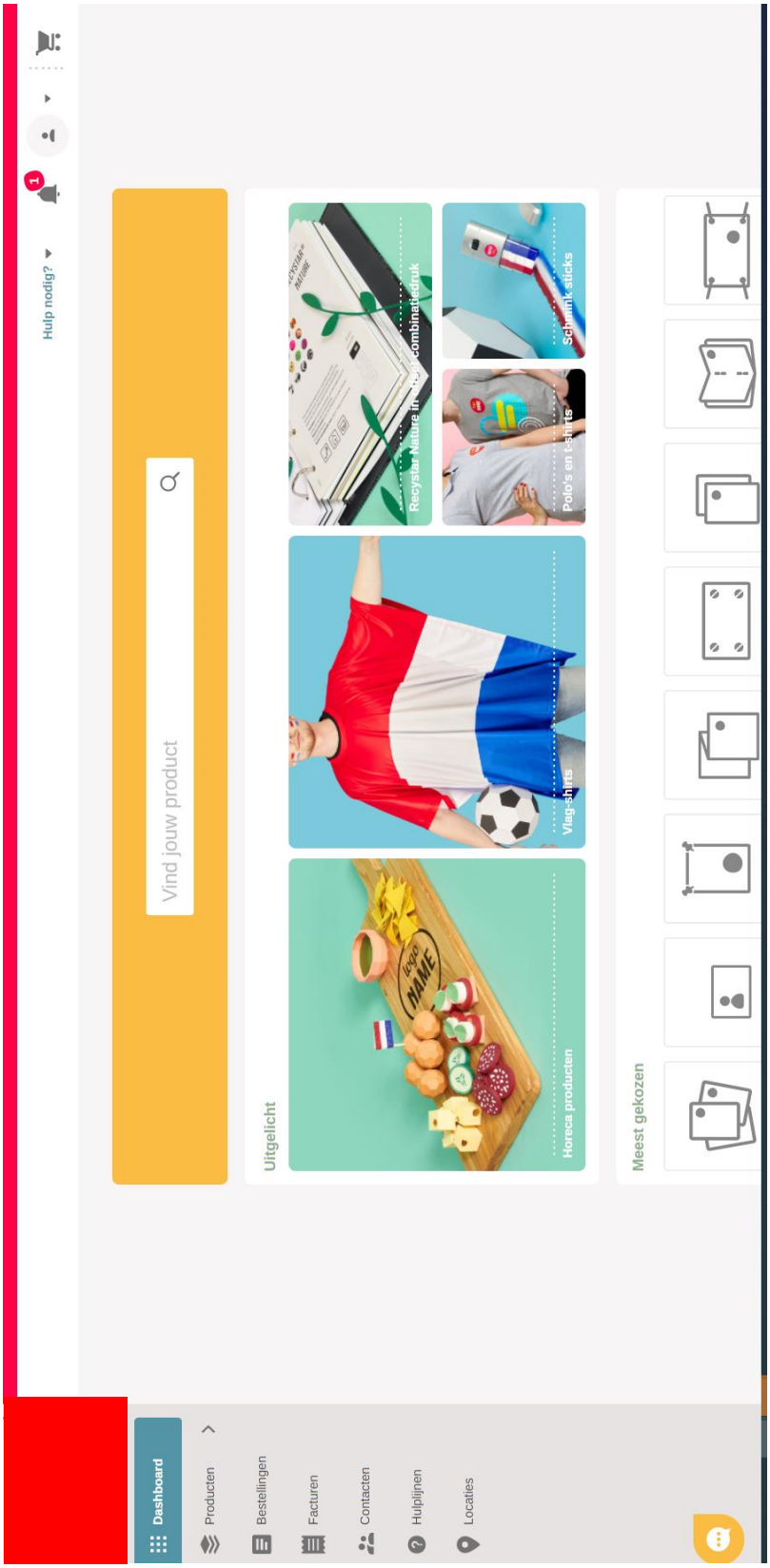


Figure 26: Screenshot WebApp

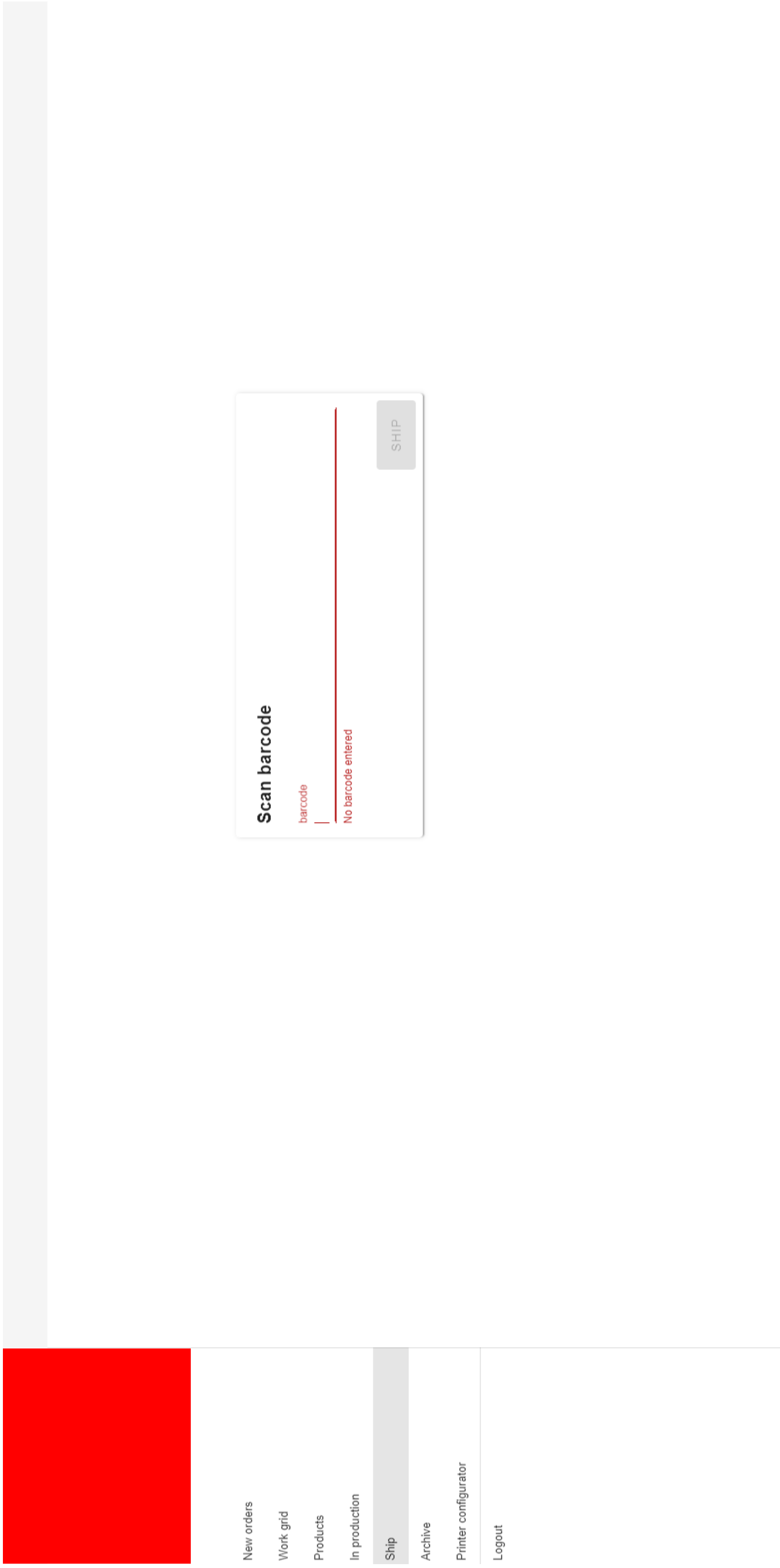


Figure 27: Screenshot Eager

Omschrijving	Aantal	Prijs	Korting	Totaal
Uw kenmerk : 6000414727-1 Order : 2178010 Visitekaartjes bc 6000414727-1 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000414727-2 Order : 2178089 Visitekaartjes bc 6000414727-2 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000415251-2 Order : 2178303 Posters b1 6000415251-2 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000415251-1 Order : 2178309 Flyers a4 6000415251-1 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000415261-2 Order : 2178311 Posters b1 6000415261-2 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000415261-1 Order : 2178313 Flyers a4 6000415261-1 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]
Uw kenmerk : 6000415275-1 Order : 2178354 Posters b1 6000415275-1 digitaal drukwerk incl. afwerking	1	[redacted]		€ [redacted]

Figure 28: Screenshot of a part of a collective invoice from a supplier

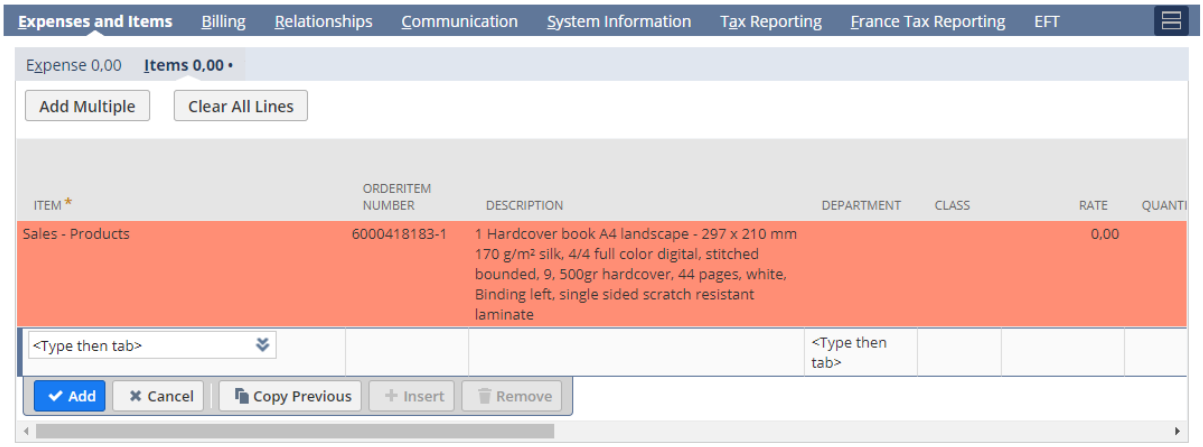


Figure 29: Scan and Capture indicating a deviation

Data

Table 10: ORDERITEMS table

Order items		
ORDER_ID	NUMBER(38,0)	
SKU	VARCHAR(255)	
MARKET	VARCHAR(256)	
CATEGORY	VARCHAR(256)	
ORDER_INCREMENT_ID	VARCHAR(255)	
ORDERITEM_NUMBER	VARCHAR(255)	
PRINT_JOB_ID	VARCHAR(255)	
STATUS	VARCHAR(255)	
PICKUP_DATE	TIMESTAMP_NTZ(9)	
ORIGINAL_PICKUP_DATE	TIMESTAMP_NTZ(9)	
REQUEST_SOURCE	VARCHAR(16777216)	
ACTUAL_SHIPPING_DATE	TIMESTAMP_TZ(9)	
SUPPLIER_CODE	VARCHAR(255)	
PRODUCT_PRICE	NUMBER(12,4)	
SALES_PRICE	NUMBER(12,4)	
ORIGINAL_SALES_PRICE	NUMBER(12,4)	
URGENCY_PRICE	NUMBER(12,4)	
SHIPPING_PRICE	NUMBER(12,4)	
DELIVERY_PROMISE_PRICE	NUMBER(12,4)	
PRODUCT_COST	NUMBER(12,4)	
URGENCY_COST	NUMBER(12,4)	
SERVICE_COST	NUMBER(12,4)	
REPRINT_ORDERITEM_NUMBER	VARCHAR(255)	
REPRINT_DISCOUNT_PRODUCT	NUMBER(38,0)	
REPRINT_DISCOUNT_SHIPPING	NUMBER(38,0)	
ORDERITEM_ID	NUMBER(38,0)	
OPTION_CUSTOM_SHAPE	VARCHAR(16777216)	
OPTION_COVER_MATERIAL	VARCHAR(16777216)	
OPTION_COPIES	FLOAT	
OPTION_SIZE	VARCHAR(16777216)	
OPTION_MATERIAL	VARCHAR(16777216)	
OPTION_FINISH	VARCHAR(16777216)	
OPTION_PAGES	FLOAT	
OPTION_BINDING	VARCHAR(16777216)	
OPTION_PRINTINGMETHOD	VARCHAR(16777216)	
OPTION_PRINTTYPE	VARCHAR(16777216)	
OPTION_PLANOWIDTH	FLOAT	
OPTION_PLANOHEIGHT	FLOAT	
OPTION_URGENCY	VARCHAR(16777216)	
OPTION_PLATE_PRINT	VARCHAR(16777216)	
OPTION_FOLD	VARCHAR(16777216)	
OPTION_ACCESSORIES	VARCHAR(16777216)	
OPTION_PERSONALIZE	VARCHAR(16777216)	
OPTION_SPOT_FINISH	VARCHAR(16777216)	
OPTION_VARIABLE_CREASING_LINE	VARCHAR(16777216)	
OPTION_PERFORATION	VARCHAR(16777216)	
OPTION_ROUNDED_CORNERS	VARCHAR(16777216)	
OPTION_DELIVERY	VARCHAR(16777216)	
OPTION_FINISH_LEFT	VARCHAR(16777216)	
OPTION_FINISH_RIGHT	VARCHAR(16777216)	
OPTION_FINISH_TOP	VARCHAR(16777216)	
OPTION_FINISH_BOTTOM	VARCHAR(16777216)	
OPTION_ROLL_UP_SYSTEMS	VARCHAR(16777216)	
OPTION_SPOT_FOIL	VARCHAR(16777216)	
OPTION_SIGN_MOUNT	VARCHAR(16777216)	
OPTION_PAVEMENT_BOARD	VARCHAR(16777216)	
OPTION_LANGUAGE	VARCHAR(16777216)	
HAS_COMPLAINTS	BOOLEAN	
MANUAL_CHECK	BOOLEAN	

Table 11: COMPLAINTS table

Complaints		
ID	VARCHAR(256)	
STATUS	VARCHAR(256)	
DESCRIPTION	VARCHAR(4096)	
ISSUE_TYPE	VARCHAR(256)	
CAUSE_ACCORDING_PRINT_COM_ASSIGNEE_	VARCHAR(256)	
ORDERITEM	VARCHAR(256)	
DATA_COMPLETE_DATE	DATE	
ISSUE_CREATED	TIMESTAMP_TZ(9)	
RESPONSIBLE_ACCORDING_SUPPLIER	VARCHAR(256)	
EXTERNAL_ASSESSOR	VARCHAR(256)	
DIFFICULTY_1_5	NUMBER(38,0)	
CUSTOMER_CONTACTED	VARCHAR(256)	
TOTAL_CREDIT_VALUE_FROM_CREDITS_	FLOAT	
CUSTOMER_NAME	VARCHAR(256)	
CAUSE_ACCORDING_SUPPLIER	VARCHAR(256)	
RESPONSIBLE_ACCORDING_PRINT_COM_ASSIGNEE_	VARCHAR(256)	
EN_NU_FROM_KLACHTENREGISTRATIE_	VARCHAR(256)	
UP_PICK_UP_FROM_KLACHTENREGISTRATIE_	DATE	
SUPPLIER	VARCHAR(256)	
TIME_ASSESSED_SUPPLIER	TIMESTAMP_TZ(9)	
EXPLANATION_SUPPLIER	VARCHAR(2048)	
_FIVETRAN_DELETED	BOOLEAN	
_FIVETRAN_SYNCED	TIMESTAMP_TZ(9)	
EXPLANATION_ASSIGNEE_	VARCHAR(2048)	
EXPLANATION_FILECHECK_	VARCHAR(2048)	
CAUSE_ACCORDING_PRINT_COM_FILECHECK_	VARCHAR(256)	
CAUSE_ACCORDING_PRINT_COM_PRODUCT_SPECIALIST_	VARCHAR(256)	
RESPONSIBLE_ACCORDING_PRINT_COM_PRODUCT_SPECIALIST_	VARCHAR(256)	
EXPLANATION_PRODUCT_SPECIALIST_	VARCHAR(1024)	
RESPONSIBLE_ACCORDING_PRINT_COM_FILECHECK_	VARCHAR(256)	
CLAIM_ACCEPTANCE_SUPPLIER_	VARCHAR(256)	
CLAIM_TYPE_SUPPLIER_	VARCHAR(256)	
TIME_CREATED_CLAIM_SUPPLIER_	TIMESTAMP_TZ(9)	
CLAIM_ACCEPTANCE_TIME_SUPPLIER_	TIMESTAMP_TZ(9)	
CLAIM_AMOUNT_SUPPLIER_	FLOAT	
ACCEPTANCE_DESCRIPTION_SUPPLIER_	VARCHAR(1024)	
CLAIM_AMOUNT_CARRIER_	FLOAT	
CLAIM_ACCEPTANCE_CARRIER_	VARCHAR(256)	

Process flows

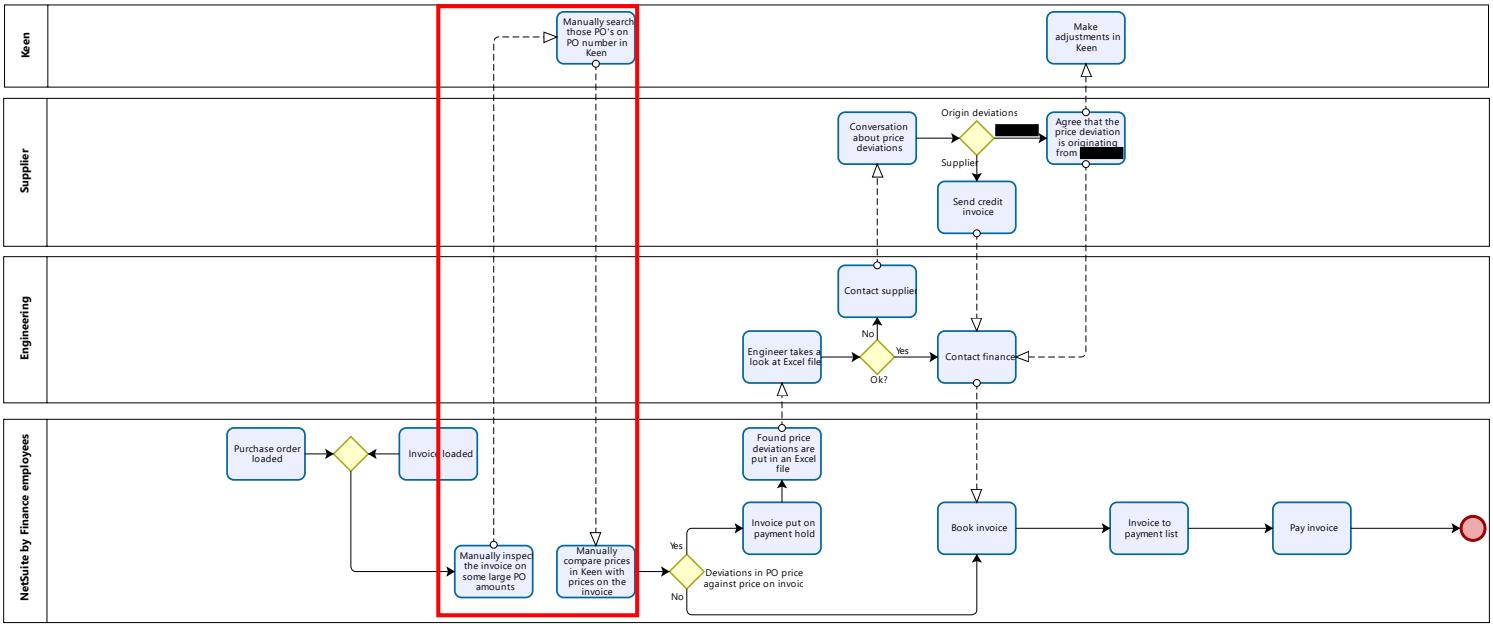


Figure 30: Old process flow

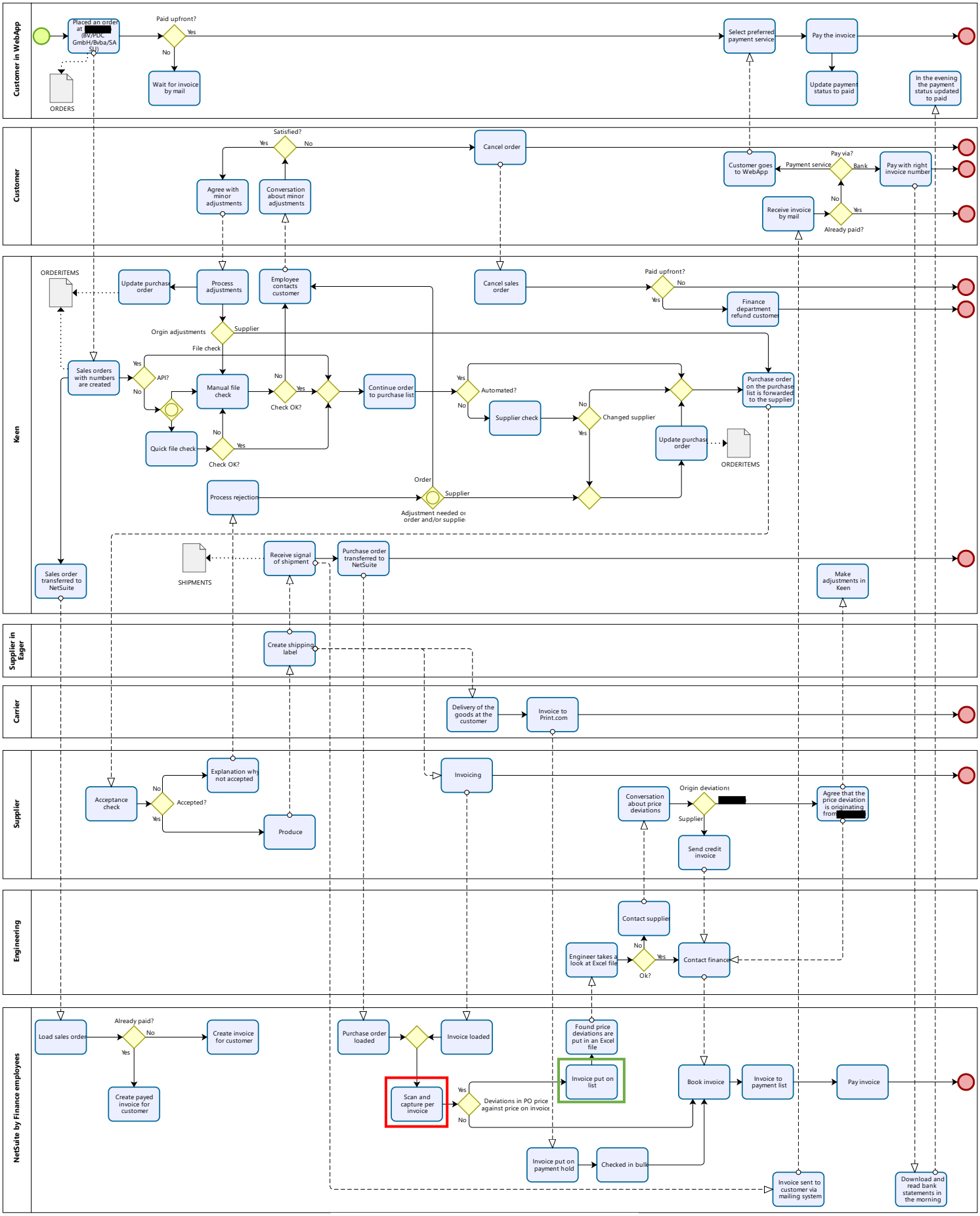


Figure 31: Current process flow

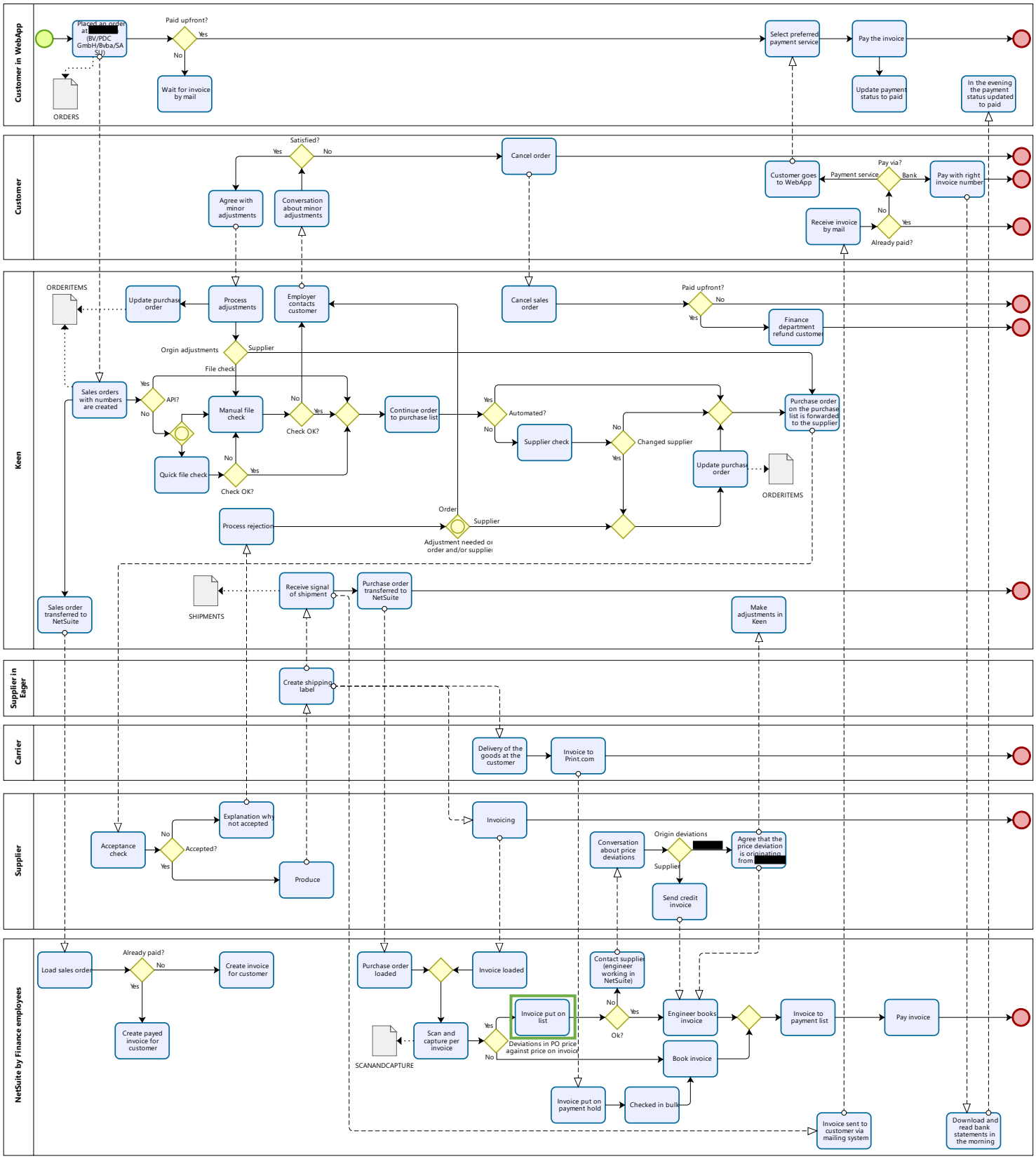


Figure 32: Recommend future process flow

Appendix B – Literature review

Here is an overview of the two literature reviews that were conducted. Starting with the literature review on the visual design of a dashboard. This is followed by the overview of the KPI literature review.

Visual dashboard design – search history

With the following search string we finally found the literature:

(dashboard*) AND (financ*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)

This search string is perfect for the Scopus database. This search string is too specific for the other three databases. This can also be seen in Table 13. That is why we have chosen to omit the key concept 'finance' from the search string for Web of Science, Business Source Elite, and Library, Information Science & Technology Abstracts. The search strings ultimately used are marked in yellow in Table 12. We can omit the term "finance" because we can also gain knowledge from the design of non-financial dashboards.

Table 12: Search history

Date	Where did I search?	Search string	Number of hits / relevancy
8-4-2021	Scopus	(dashboard* OR "control panel" OR "indicator panel" OR "instrument board" OR "business analytics" OR "business intelligence" OR "BI tool" OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND (design* OR architecture OR layout OR blueprint OR outline OR style)	10.787 document results. Ordered by relevance no useful resources found on the first page. The focus is not on the design and way of visualization.
8-4-2021	Scopus	(dashboard* OR "control panel" OR "indicator panel" OR "instrument board" OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND (design* OR architecture OR layout OR blueprint OR outline OR style)	4.056 document results. Ordered by relevance. Still not what we are looking for.
8-4-2021	Scopus	(dashboard* OR "control panel" OR "indicator panel" OR "instrument board" OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND ("visual design")	37 document results. Ordered by relevance. No access to many results. Two or three sources seem to be helpful.
8-4-2021	Scopus	(dashboard* OR "control panel" OR "indicator panel" OR "instrument board" OR	57.847 document results. Far too much, because we left out key concept finance with the idea that we

		"data visualization" OR "data visualisation") AND (design* OR architecture OR layout OR blueprint OR outline OR style)	would end up more on the visual design of dashboards.
8-4-2021	Scopus	(dashboard* OR "control panel" OR "indicator panel" OR "instrument board" OR "data visualization" OR "data visualisation") AND (design* OR architecture OR layout OR blueprint OR outline OR style) AND (tableau)	692 document results. Architecture, blueprint, and outline do not provide results focused on the layout, but rather on the technical aspects behind a dashboard.
8-4-2021	Scopus	(dashboard* OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND (design* OR layout OR style) AND (technique* OR requirement*)	1.891 document results. This is a somewhat more extensive search than the one in row 3.
8-4-2021	Scopus	(dashboard* OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*) AND (tableau)	48 document results. There seem to be some useful results. But we think too focused on Tableau.
8-4-2021	Scopus	(dashboard* OR "data visualization" OR "data visualisation") AND (financ* OR "purchase order" OR invoic* OR "invoice management") AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	1.266 document results. we have removed Tableau as a key concept. Because then we would find more papers describing visualization techniques that we could also apply in Tableau.
8-4-2021	Scopus	(dashboard*) AND (financ*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	311 document results. The synonyms and related concepts of dashboard have been removed that caused too many unusable results. The same goes for the related concepts of finance. These results seem better than those from two searches back.
9-4-2021	Web of Science	TS=(dashboard*) AND TS=(financ*) AND (TS= (design*) OR TS= (layout) OR TS=(style)) AND (TS=(technique*) OR TS=(requirement*)) AND TS=(visual*)	1 result. Not usable. It is the same search as the one above. Too specific search in this database probably by the term finance.
9-4-2021	Web of Science	TS=(dashboard*) AND (TS= (design*) OR TS= (layout) OR	107 results. Interesting results.

		TS=(style)) AND (TS=(technique*) OR TS=(requirement*)) AND TS=(visual*)	
10-4-2021	Business Source Elite	(dashboard*) AND (financ*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	2 results. Not usable. Probably too specific search in this database caused by the term finance.
10-4-2021	Business Source Elite	(dashboard*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	20 results. Seem very useful.
10-4-2021	Library, Information Science & Technology Abstracts	(dashboard*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	0 results.
10-4-2021	Library, Information Science & Technology Abstracts	(dashboard*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	11 results. Looks like there are a few useful ones here.

In Table 13 you can see how we selected the used articles.

Table 13: The elected articles

Search string	**Database**	**# Articles found**	**# Articles selected***	**# Accessible from selection**
(dashboard*) AND (financ*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	Scopus	311	9	5
Snowballing		13	8	4
TS=(dashboard*) AND (TS= (design*) OR TS= (layout) OR TS=(style)) AND (TS=(technique*) OR TS=(requirement*)) AND TS=(visual*)	Web of Science	107	2	1
(dashboard*) AND (design* OR layout OR style) AND (technique* OR requirement*) AND (visual*)	Business Source Elite	20	2	1
	Library, Information Science & Technology Abstracts	11	0	0
Total amount of selected articles				**11**

* Selection using inclusion and exclusion criteria. In addition, by reading the titles, abstracts, introductions, and conclusions. Titles have been selected first. Then on abstracts and the final selection is made on the introductions and conclusions. During the full reading of the articles, a few articles were also dropped.

Visual dashboard design – tables and figures

Table 14: Interactive data visualisation techniques (Dilla & Raschke, 2015, p. 3)

Technique	Definition	Example
Representation tools		
Encode	Show different representations of data.	Convert tabular representations to graphs or vice versa. Change graph type (e.g., from pie chart to histogram).
Reconfigure	Show different arrangements of data.	Adjust baselines or axis scales, reverse attributes displayed on x- and y-axes.
Connect	Show related data items.	View leveled set of data flow diagrams or entity relationship diagrams. Highlight patterns in complex transaction data.
Data selection tools		
Select	Mark data items of interest.	Highlight selected items in large spreadsheets or graphical displays. Item remains highlighted, so it can be located even after rearranging the display.
Elaborate/ abstract	Show more or less detail.	Move cursor over screen to view more or less detailed information (e.g., show data underlying a segment of a graphical display).
Filter	Show data based on specific condition(s).	Query tools embedded in database and spreadsheet products, enterprise computer programs (e.g., Oracle, SAP, PeopleSoft), or specialized audit programs (e.g., ACL, IDEA).
Explore	Show other data.	Panning or movement of cursor across a graphical display to view different segments of a display. Clicking on hyperlinks to navigate within large, complex textual documents.

Graph Selection Matrix

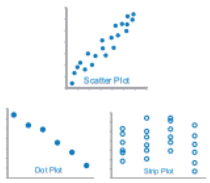
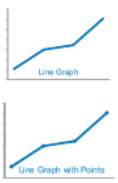
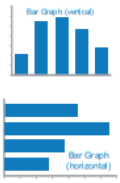
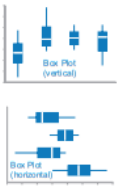
Featured Relationships	Value-Encoding Objects: Points	Lines	Bars	Boxes
				
Time Series Values display how something changed through time (yearly, monthly, etc.)	**Yes** (as a *dot plot*, when you don't have a value for every interval of time)	**Yes** (to feature overall trends and patterns and to support their comparisons)	**Yes** (vertical bars only, to feature individual values and to support their comparisons)	**Yes** (vertical boxes only, to display how a distribution changes through time)
Ranking Values are ordered by size (descending or ascending)	**Yes** (as a *dot plot*, especially when the quantitative scale does not begin at zero)	No	**Yes**	**Yes** (to display a ranked set of distributions)
Part-to-Whole Values represent parts (proportions) of a whole (for example, regional portions of total sales)	No	No	**Yes**	No
Deviation The difference between two sets of values (for example, the variance between actual and budgeted expenses)	**Yes** (as a *dot plot*, especially when the quantitative scale does not begin at zero)	**Yes** (when also featuring a time series)	**Yes**	No
Distribution Counts of values per interval from lowest to highest (for example, counts of people by age intervals of 10 years each)	**Yes** (as a *strip plot*, to feature individual values)	**Yes** (as a *frequency polygon*, to feature the overall shape of the distribution)	**Yes**	**Yes** (when comparing multiple distributions)
Correlation Comparison of two paired sets of values (for example, the heights and weights of several people) to determine if there is a relationship between them	**Yes** (as a *scatter plot*)	No	**Yes** (as a *table lens*, especially when your audience is not familiar with *scatter plots*)	No
Geospatial Values are displayed on a map to show their location	**Yes** (as bubbles of various sizes on a map)	**Yes** (to display routes on a map)	No	No
Nominal Comparison A simple comparison of values for a set of unordered items (for example, products, or regions)	**Yes** (as a *dot plot*, especially when the quantitative scale does not begin at zero)	No	**Yes**	No

Figure 33: Graph selection matrix (Few, 2004, p. 2)

Setting up KPIs – search history

With the following search string we finally found the literature:

(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*)

Table 15: Search history

Date	Where did I search?	Search string	Number of hits / relevancy
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Establish* OR "Setting up" OR "Set up" OR Method*) AND (Financ* OR "Invoice Management")	5.057 document results. Relevant results but not especially about how to set up the KPIs.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND ("Setting up" OR "Set up" OR Method*) AND (Financ* OR "Invoice Management")	4.842 documents. On relevance sorted and first 20 results the same as previous search string. So better.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND ("Setting up" OR "Set up") AND (Financ* OR "Invoice Management")	85 document results. Not very useful.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Create*) AND (Financ* OR "Invoice Management")	5.276 document results. Same results as first two search strings.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Develop*) AND ("Invoice Management")	0 document results. Because of 'invoice management'.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*)	5.162 document results. A lot of results because there is a lot of information about KPIs. We cannot narrow the search string further. We already used 'financ*' and adding 'invoice management' doesn't work.
26-5-2021	Scopus	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*) AND (LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (EXACTKEYWORD, "Key	192 document results. Filtered on subject areas: 'Business, Management and Accounting' and 'Economics, Econometrics and Finance'. Filtered on keyword: 'Key Performance Indicators'. Filtered on language: English.

		Performance Indicators")) AND (LIMIT-TO (LANGUAGE, "English"))	
	Business source elite	(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*)	10 results, one seems usable.

Table 16: The selected articles

Search string	**Database**	**# Articles found**	**# Articles selected***	**# Accessible from selection**
(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*) AND (LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (EXACTKEYWORD, "Key Performance Indicators")) AND (LIMIT-TO (LANGUAGE, "English"))	Scopus	192	11	4
Snowballing		5	5	4
(KPI* OR "Key Performance Indicator" OR "Key Performance Indicators") AND (Method* OR Select*) AND (Financ*)	Business Source Elite	10	1	1
Total amount of selected articles				**9**

* Selection using inclusion and exclusion criteria. In addition, by reading the titles, abstracts, introductions, and conclusions. Titles have been selected first. Then on abstracts and the final selection is made on the introductions and conclusions. During the full reading of the articles, a few articles were also dropped.

Setting up KPIs – figure

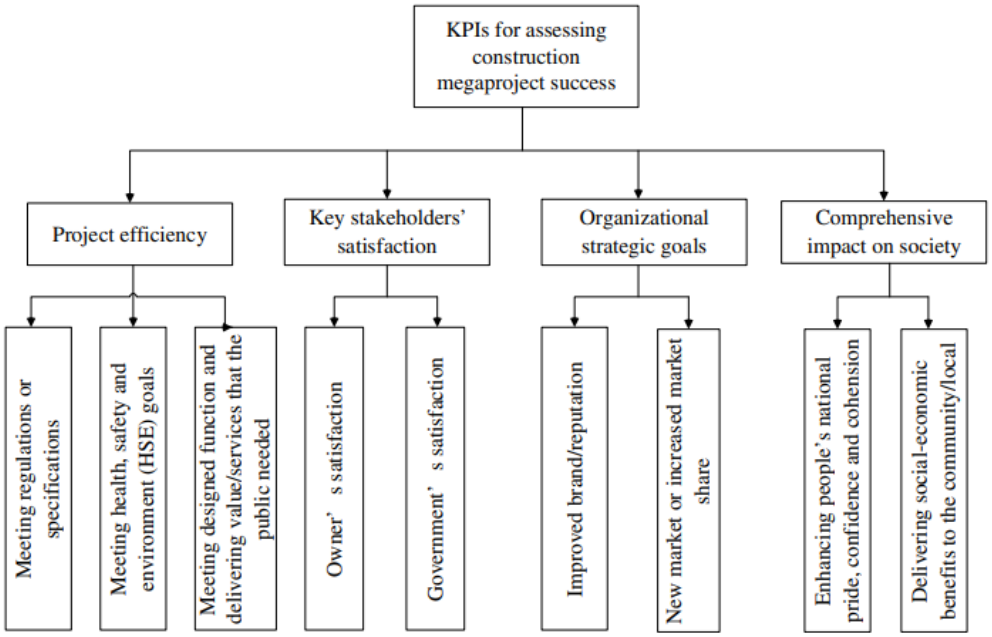


Fig. 5. KPIs for assessing the success of construction megaprojects.

Figure 34: Grouped KPIs (He et al., 2021, p. 8)

Appendix C - Brainstorming

To clarify the KPIs, a purchase order from Company X can be matched with an invoice. Then the invoiced amount matches the expected cost of the purchase order. A purchase order can also be over- or under-invoiced. In that case, more or less is invoiced than expected. So, there are three types of deviations: matched invoice, over-invoiced, and under-invoiced.

Raw list with KPIs

Brainstorm based on the norm

- Absolute amount of deviations.
- Percentage of deviations of the total number of purchase orders.
- Total monetary amount of deviations.
- Amount of deviations per supplier.
    - Absolute amount of deviations per supplier.
    - Percentage of deviations from total purchase orders per supplier.
    - Total monetary amount of deviations added per supplier.
    - Percentage of total deviations caused by a supplier.
    - Percentage of total monetary amount of deviation caused by a supplier
- Amount of deviations per product.
    - Absolute amount of deviations per product.
    - Percentage of deviations from total purchase order per product.
    - Total monetary amount of deviations added per product.
    - Percentage of total deviations caused by a product.
    - Percentage of total monetary amount of deviation caused by a supplier.

Brainstorm based on process flow

- Total amount of deviations let through by Scan and Capture.
    - This way you can find out if you need to change the rules in Scan and Capture that label whether something is a deviation or not.
- Display the KPIs already thought up over time.
- Processing time of a deviation.
    - So how long does it take for the deviation to be resolved from the time that Scan and Capture marks the invoice as a deviation.
- Break down the monetary amounts of the deviations per supplier and product into 'over-invoiced' and 'under-invoiced.
    - Company X wants to know to whom they are paying too much, so that Company X can call the supplier to account or so that Company X can adjust its prices/calculations of the purchase order. The same applies if Company X pay less than they calculated in their purchase order, they also want to know. Company X should then also adjust their purchase order prices/calculations. They might then also adjust their sales price, for example, to be able to face the competition better.

Brainstorm based on data tables

- Making a top 5 list of customers who cause the most deviating invoices.
- Percentage of deviations from purchase orders of API customers.
- Percentage of deviations from purchase orders of non-API customers.
- Deviations on product composition / product options.
- Top 5 suppliers with the highest percentage of deviations in terms of over and under invoicing.
- Top 5 largest deviations in monetary amounts.
- Deviations per product category, same as per supplier and per product.

- Deviations per market, same as per supplier and per product.
- Percentage of deviations from purchase orders that have had a manual file check.
- Percentage of deviations from purchase orders that have not had a manual file check.
- Percentage of complaints from customers whose purchase invoices deviate.
- Percentage of deviations per urgency type.
- Percentage of margin lost due to deviations per supplier, product.
- Average monetary amount of deviation per supplier.
- Average monetary amount of deviation per product.

Structured list with KPIs

Global deviation KPIs

- Amount of deviations per deviation type over time.
- Amount of deviations per deviation type as a percentage of the total number of purchase orders over time.
- Monetary amount of deviations per deviation type over time.
- Monetary amount of deviations per deviation type as a percentage of total product costs over time.
- Top *n* list of purchase orders with largest deviations in monetary amounts by deviation type.
- Top *n* list of purchase orders where most margin was lost.

KPIs related to the markets

- Amount of deviations per deviation type per market over time.
- Amount of deviations per deviation type in a market as a percentage of the total amount of deviations per deviation type over time.
- Amount of deviations per deviation type in a market as a percentage of total purchase orders in a market over time.
- Monetary amount of deviations per deviation type in a market over time.
- Monetary amount of deviations per deviation type in a market as a percentage of the total monetary amount per deviation type over time.
- Average monetary amount of deviations in a market per deviation type over time.

KPIs related to suppliers

- Amount of deviations per deviation type per supplier over time.
- Amount of deviations per deviation type of a supplier as a percentage of the total amount of deviations per deviation type over time.
- Amount of deviations per deviation type of a supplier as a percentage of the total purchase orders of a supplier over time.
- Monetary amount of deviations per deviation type of a supplier over time.
- Monetary amount of deviations per deviation type of a supplier as a percentage of the total monetary amount per deviation type over time.
- Average monetary amount of supplier deviations per deviation type over time.
- Top *n* suppliers causing most deviations per deviation type over time.
- Top *n* suppliers causing the largest monetary amounts of deviation per deviation type over time.

KPIs relating to product category

- Amount of deviations per deviation type per product category over time.
- Amount of deviations per deviation type of a product category as a percentage of the total amount of deviations per deviation type over time.
- Amount of deviations per deviation type in a product category as a percentage of the total purchase order in a product category over time.

- Monetary amount of deviations per deviation type in a product category over time.
- Monetary amount of deviations per deviation type in a product category as a percentage of the total monetary amount per deviation type over time.
- Average monetary amount of deviations in a product category per deviation type over time.

KPIs related to Stock Keeping Units (SKUs)

- Amount of deviations per deviation type per SKU over time.
- Amount of deviations per deviation type of a SKU as a percentage of the total amount of deviations per deviation type over time.
- Amount of deviations by deviation type of a SKU as a percentage of total purchase orders of a SKU over time.
- Monetary amount of deviations per deviation type of a SKU over time.
- Monetary amount of deviations per deviation type of a SKU as a percentage of the total monetary amount per deviation type over time.
- Average monetary amount of deviations of SKUs by deviation type over time.
- Top *n* SKUs causing the most deviations by deviation type over time.
- Top *n* SKUs causing the largest monetary amounts of deviations by deviation type over time.

KPIs related to the customers

- Percentage of the amount of deviations per deviation type of customers with and without complaints.
- Top *n* list of customers causing most deviations by deviation type over time.
- Top n list of customers causing the largest sums of money in deviations by deviation type over time.

KPIs related to product compositions/options

- Amount of deviations per deviation type as a percentage of the total purchase orders per API customer.
- Amount of deviations per deviation type as percentage of the total purchase orders per urgency type.
- Amount of deviations per deviation type as a percentage of the total purchase orders per manual check.

Other KPIs

- Processing time of a deviation.
- Monetary amount that Scan and Capture let through per deviation type.

Appendix D – Dashboard

Data input for dashboard

ORDERITEM_NUMBER	apiCustomers	CUSTOMER_ID	ORDER_DATE	SUPPLIER_CODE	SKU	CATEGORY	MARKET	PRODUCT_COST	PRODUCT_INVOICED	…
6000152155-1	False	175	26-2-2020	[redacted]	bounded-magazines	magazines	small format	[redacted]	10.033,34	
6000158966-1	False	3401	9-3-2020		hockers	interior	large format		6.450	
6000180532-1	False	1759	30-4-2020		facemasks	facemasks	clothing and apparel		6.000	
6000180530-1	False	1759	30-4-2020		facemasks	facemasks	clothing and apparel		5.318,60	
6000180528-1	False	1759	30-4-2020		facemasks	facemasks	clothing and apparel		6.000	
6000180523-1	False	1759	30-4-2020		facemasks	facemasks	clothing and apparel		6.315,13	
6000204310-1	False	1167	10-6-2020		click-frame-desinfection-column	displays	large format		5.898,50	
6000182010-1	False	886	4-5-2020		bounded-magazines	magazines	small format		7.326,70	
6000149785-2	False	175	21-2-2020		bounded-magazines	magazines	small format		4.827,29	
6000213814-2	False	2522	25-6-2020		ring-binders	ring-binders	small format		5.590	
6000185794-1	False	2462	11-5-2020		facemasks	facemasks	clothing and apparel		7.167,30	
6000182840-2	False	241	5-5-2020		signing	signing	large format		4.843,92	
6000189268-1	False	1431	15-5-2020		floor-decal	stickers	large format		4.451,03	
6000176606-1	False	2292	22-4-2020		signing	signing	large format		4.150,17	
6000133591-1	False	2298	22-1-2020		stapled-magazines	magazines	small format		4019,35	
6000133634-1	False	2298	22-1-2020		stapled-magazines	magazines	small format		4628,00	
6000190689-1	False	4389	19-5-2020		flyers	flyers	small format		5137,00	
6000176385-1	False	2254	22-4-2020		flyers	flyers	small format		5266,00	
…										

Figure 35: Part of data for the dashboard

Calculated fields in Tableau for the made figures in the dashboard

General calculated fields

Deviation type

```
if [PRODUCT_INVOICED]-[PRODUCT_COST] > 0
then "Over-invoiced"
ELSEIF [PRODUCT_INVOICED]- [PRODUCT_COST] < 0
then "Under-invoiced"
ELSE "Matched invoice"
END
```

Euros deviations ABS

```
ABS([PRODUCT_INVOICED]-[PRODUCT_COST])
```

and Euros deviations per month

Fixed # deviations per date

```
{ FIXED [ORDER_DATE]: COUNT([Deviation type])}
```

Deviation types as % of total POs per date

```
(COUNT ([Deviation type] )) / SUM ([Fixed # deviations per date] )
```

Fixed # Euros product costs per date

```
{ FIXED [ORDER_DATE]: SUM([PRODUCT_COST])}
```

Euros deviation type as % of product costs per date

```
SUM([# Euros deviation ABS])/SUM([Fixed # Euros product costs per date])
```

Deviation info. per supplier

Fixed # Euros per type per month

```
{ FIXED [Deviation type], MONTH([ORDER_DATE]): SUM([# Euros deviation ABS])}
```

Fixed # deviations per supplier per month

```
{ FIXED [SUPPLIER_CODE], MONTH([ORDER_DATE]) : COUNT([Deviation type])}
```

Fixed # Euros per supplier per type per month

```
{ FIXED [SUPPLIER_CODE], [Deviation type], MONTH([ORDER_DATE]): SUM([# Euros deviation ABS])}
```

Fixed # deviations per type and month

```
{ FIXED [Deviation type], MONTH([ORDER_DATE]): COUNT([Deviation type])}
```

Deviation types supplier as % of total POs per month

```
COUNT ([Deviation type] )/ SUM ([Fixed # deviations per type and month])
```

Deviation types supplier as % of total POs supplier per month

```
COUNT ([Deviation type] )/ SUM ([Fixed # deviations per supplier per month])
```

Euro deviation types supplier as % of total Euros per type per month

```
IFNULL(SUM([Fixed # Euros per supplier per type per month])/SUM([Fixed # Euros per type per month]),0)
```

Index (supplier)

```
INDEX()
```

Deviation info. per SKU

Fixed # Euros per type per month

```
{ FIXED [Deviation type], MONTH([ORDER_DATE]): SUM([# Euros deviation ABS])}
```

Fixed # deviations per SKU and month

```
{ FIXED [SKU], MONTH([ORDER_DATE]) : COUNT([Deviation type])}
```

Fixed # Euros per SKU per type per month

```
{ FIXED [SKU], [Deviation type], MONTH([ORDER_DATE]): SUM([# Euros deviation ABS])}
```

Fixed # deviations per type and month

```
{ FIXED [Deviation type], MONTH([ORDER_DATE]): COUNT([Deviation type])}
```

Deviation types SKUs as % of total POs per month

```
COUNT([Deviation type])/SUM([Fixed # deviations per type and month])
```

Deviation types SKU as % of total POs per SKU and month

```
COUNT([Deviation type])/ SUM([Fixed # deviations per SKU and month])
```

Euros deviation types SKUs as % of total Euros per type per month

```
IFNULL(SUM([Fixed # Euros per SKU per type per month])/SUM([Fixed # Euros per type per month]),0)
```

Index (SKU)

```
INDEX()
```

€ top *n* SKUs over suppliers per time unit

Fixed # Euros per SKU per type per month per supplier

```
{ FIXED [SKU], [Deviation type], MONTH([ORDER_DATE]), [SUPPLIER_CODE]:SUM([# Euros deviation ABS])}
```

Index (SKU)

```
INDEX()
```

Top *n* SKUs greatest margin losses over time

Margin

```
[PRODUCT_PRICE]-[PRODUCT_COST]
```

% lost from margin

```
[# Euros deviation ABS]/[Margin]
```

Index SKU margin

```
INDEX()
```

Top *n* greatest € deviations over time

Index (orderitem_number)

```
INDEX()
```

% deviation type per apiCustomer over time

Fixed # apiCustomers

```
{ FIXED [apiCustomers], [ORDER_DATE]: COUNT([Deviation type])}
```

Deviations as % of apiCustomers

```
COUNT([Deviation type])/SUM([Fixed # apiCustomers])
```

% deviation type per manual check over time

Fixed # manual checks

```
{ FIXED [MANUAL_CHECK], [ORDER_DATE]: COUNT([Deviation type])}
```

Deviations as % of manual checks

```
COUNT([Deviation type])/SUM([Fixed # manual checks])
```

% deviation type per urgency over time

Fixed # urgency

```
{ FIXED [OPTION_URGENCY], [ORDER_DATE]: COUNT([Deviation type])}
```

Deviations as % of urgency

```
COUNT([Deviation type])/SUM([Fixed # urgency])
```

Deviation rule

Deviation type 2

```
if [PRODUCT_INVOICED]-[PRODUCT_COST] >= [PRODUCT_COST]* [Deviation rule]
then "Over-invoiced"
ELSEIF [PRODUCT_INVOICED]-[PRODUCT_COST] <= ([PRODUCT_COST] * [Deviation rule]* -1)
then "Under-invoiced"
ELSEIF [PRODUCT_INVOICED]-[PRODUCT_COST] > [PRODUCT_COST] * [Deviation rule]* -1
AND [PRODUCT_INVOICED]-[PRODUCT_COST] < 0
then "Matched under-invoiced"
ELSEIF [PRODUCT_INVOICED]-[PRODUCT_COST] >= 0
AND [PRODUCT_INVOICED]-[PRODUCT_COST] < [PRODUCT_COST] * [Deviation rule]
THEN "Matched over-invoiced"
END
```

Dashboard tabs

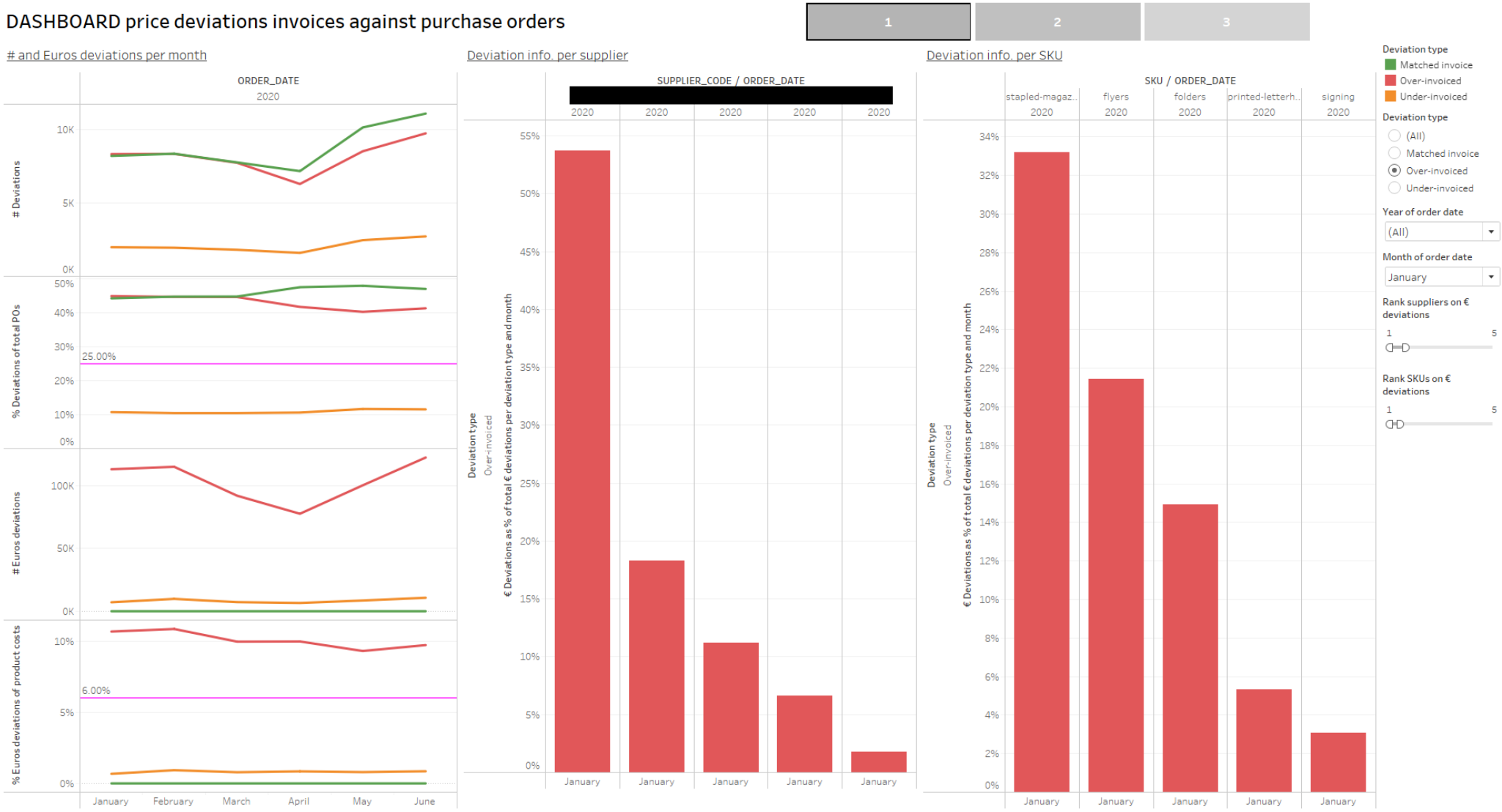


Figure 36: Dashboard tab 1

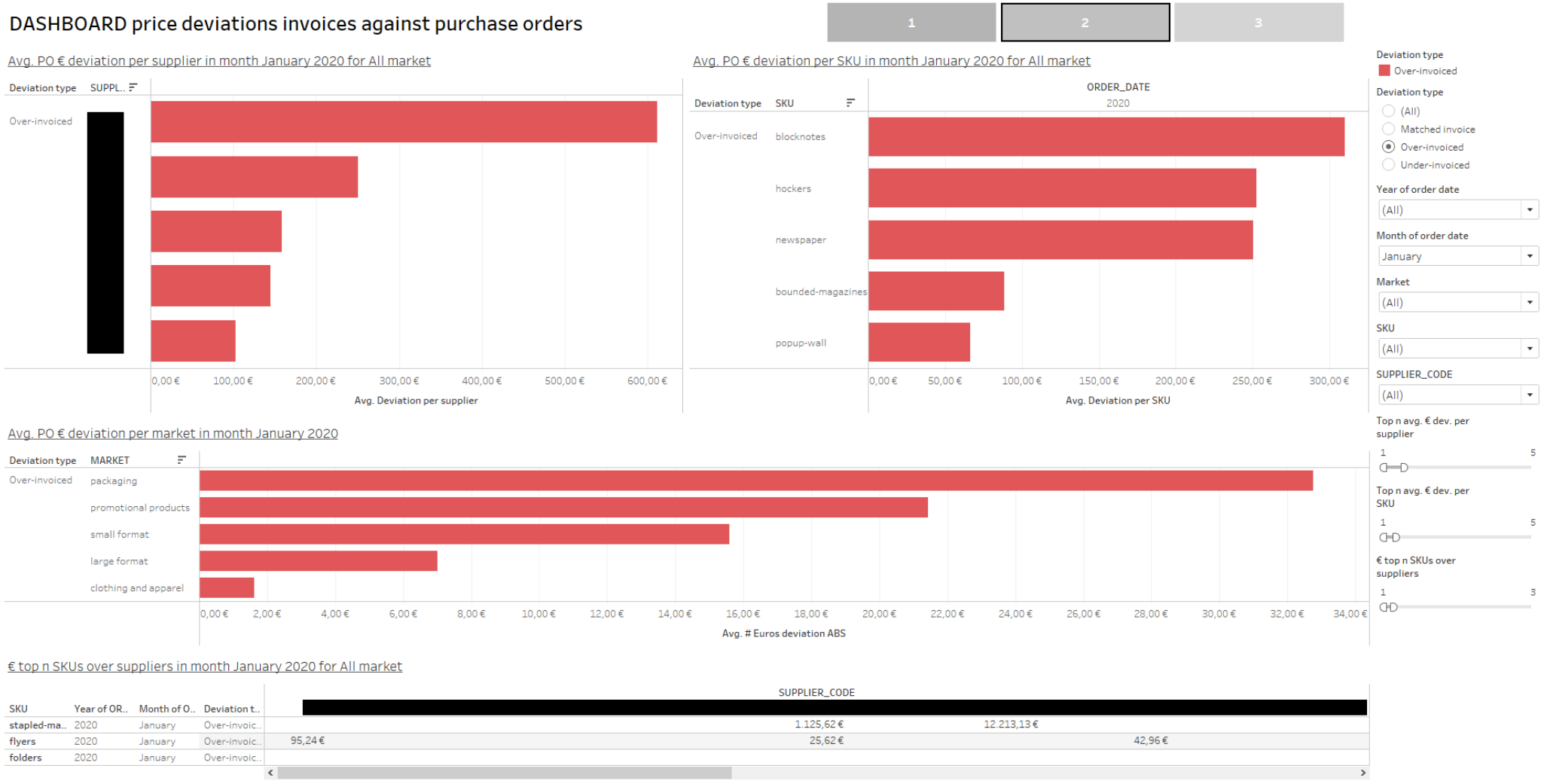


Figure 37: Dashboard tab 2

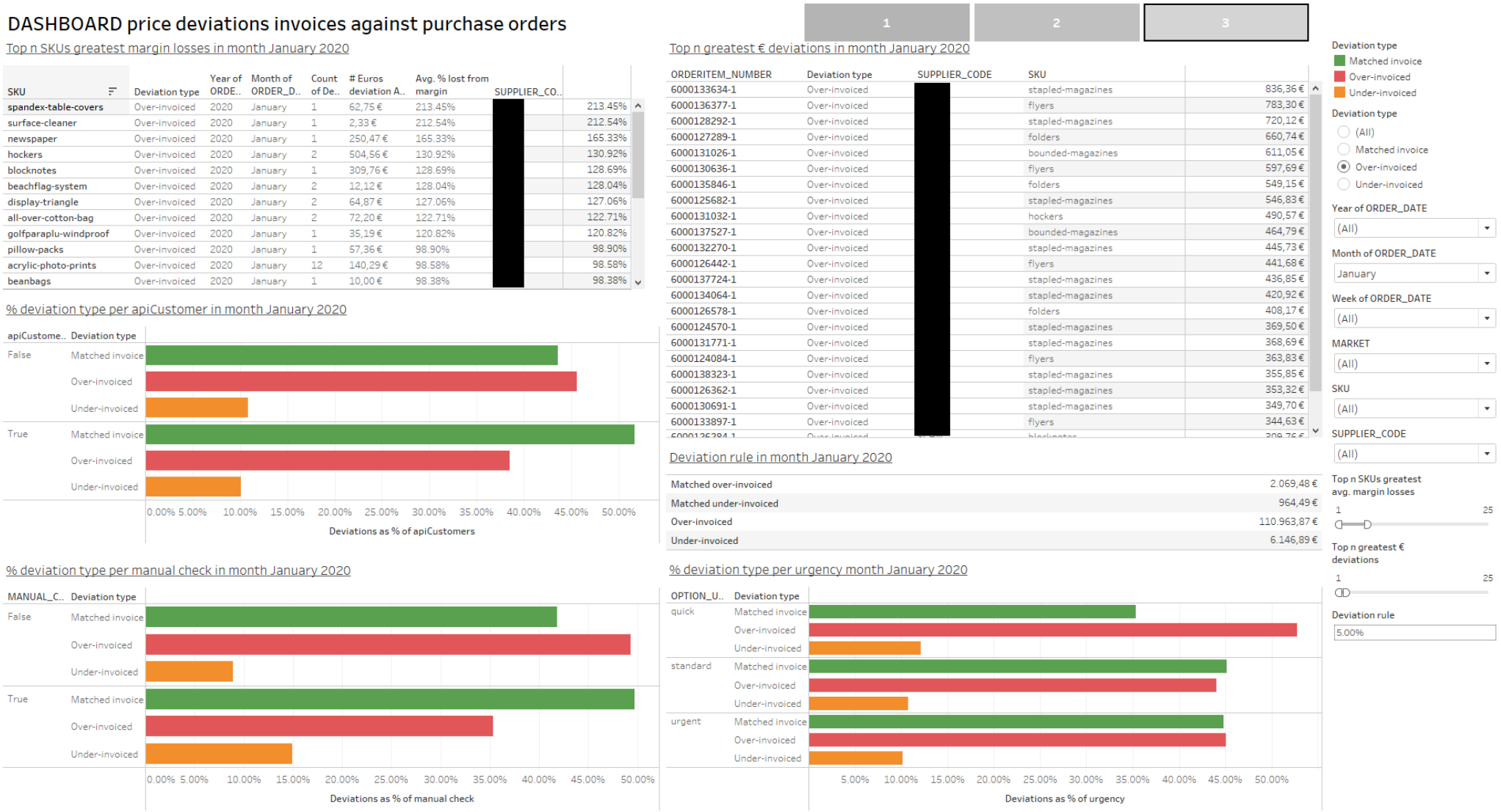


Figure 38: Dashboard tab 3