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Guidelines to Improve the Material Cost Change Forecasting Process in Projects

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Preface

It has been a while since I graduated from my bachelor's studies, and I have to say that so much has changed since those days, yet so many things have remained the same. It still requires long hours to complete needed course assignments, but it has been refreshing to be able to put all the things you learned into practise the very next day. For myself, the most valuable learning is not anything you can study from the books but learning to follow discipline in your way of working. I’m happy to see that the old dog can still learn new tricks.

I want to use this opportunity to thank all my colleagues and stakeholders, who really surprised me with their buy-in on the topic and the brilliant ideas and feedback they provided during the process. I want to extend my thanks also to the unit management team for supporting me in selling the idea to the whole unit and enabling me to take the next steps with a wider audience.

I want to thank my thesis instructor, Dr. Thomas Rohweder, for pointing me in the right direction when needed and for the feedback I received during the process. Thank you, too, M.A. Sonja Holappa, for your comments and heartwarming praise. You helped me pay more attention not only to my academic language but also to my professional language. Special thanks also to other lecturers in the Industrial Management Programme: Dr. Juha Haimala, Dr. James Collins, and Dr. Sami Sainio, for their insightful lectures. Thank you also to all my fellow students for sharing their comments after each gate presentation and bringing humour and light to the greyest days during the autumn and winter.

And my beloved family, thank you for being so patient with me when I needed to focus. My son, thanks for waiting for your favourite sweater from the laundry when the service was on pause; my daughter, thanks for waiting for me with those episodes of our favourite TV series; and my husband, thanks for being there, supporting me.

Tiia Silpo

Hyvinkää, April 30, 2023

Abstract

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In the past years, the unit of the case company that is responsible for delivering the largest projects has suffered unexpected changes in its financial results due to rapid material cost changes. Due to the long lead time of these projects, there could be a significant change in cost between the tender and delivery. There seems to be no clear process for forecasting project material cost changes. The objective of this study is to create guidelines on how to improve the material cost change forecasting process for projects.

The research approach of the study is design research, and it is divided into four stages. The first stage focused on identifying the strengths and weaknesses of the current forecasting process by interviewing the stakeholders involved with the process. The findings from the current state analysis were categorised under three main themes: data processing, forecasting models, and accuracy evaluation. These themes were used in the second stage to collect ideas and best practises from the literature for improving the weaknesses under each theme. Ideas from the literature were summarised as a conceptual framework, which was then used as the basis for co-creation workshops in stage 3. The proposals received in stage 3 workshops were summarised as an initial proposal of guidelines, and they were presented in the fourth stage to the unit management for feedback. Based on the feedback received from the management validation, the initial guidelines were adjusted to become the final guidelines.

The outcome of this study, the final guidelines on how to improve material cost change forecasting for projects, are generated from the summary of proposals and transformed to the operative level using the existing project framework process. It includes a comprehensive set of recommended actions for stakeholders involved to perform in each project framework phase. Following these recommended actions provides an improved forecast for the project result and, therefore, improved visibility for the financial result of the unit to the unit management.

Keywords: Project forecasting, Material cost change, Forecasting process, Forecasting model

Contents

List of Abbreviations

FL:	Frontline
FVA:	Forecast value added
MAD:	Means average error
MAPE:	Mean absolute percentage error
MPCT:	Major projects costing tool
MPE:	Mean percentage error
MSE:	Mean squared error
RFQ:	Request for quotation
SL:	Supply line
VPN:	Variation project notification

1 Introduction

Forecasting means predicting something that could likely happen in the future. People have been making decisions based on forecasts for ages. For example, weather forecasts have been indicating to the farmers when to sow the seeds and when to harvest the grain. Based on the future market forecast, investors are making decisions about when to buy and when to sell. Also, companies need forecasts to make decisions concerning their operations. Good forecasts are key to strategic and tactical decision-making. (Waddell & Sohal, 1994, pp. 41-49)

Due to various global crises, the past few years have been turbulent in the manufacturing industry. Pandemic lockdowns are impacting the availability of components. High and rapid raw material and energy price increases and growing inflation have been increasing product manufacturing costs significantly. The economy and market conditions seem to be changing swiftly and unpredictably.

At the same time, organisations are becoming larger and more complex, which increases the number of factors to be considered during decision-making. Also, the magnitude and importance of individual decisions have grown. This has increased the interest of organisations in moving towards more systematic decision-making and requesting better forecasts. (Waddell & Sohal, 1994, pp. 41-49)

1.1 Business Context of the Case Company

The case company is a global leader in its own industry. It provides products, services, and solutions for its various customers operating in the building industry. Their mission is to improve the flow of urban life and use their innovative solutions to make the cities a better place to live in. The goal is to add value to their users and customers throughout the full life cycle of the

building. The case company was founded in 1910 in Finland, and today it operates in more than 60 countries globally. The company has over 60 000 employees who serve approximately 55 000 customers around the world.

Major Projects is a business unit that is dedicated to the most ambitious customer projects. They are operating globally and are focused on projects that need careful planning, engineering, and expertise in project management. A major project can be major either by size, meaning that the project contains a large number of products, or by complexity, which means a customer project that requires special, tailor-made, or unique solutions.

1.2 Business Challenge, Objective, and Outcome

Major projects are usually high-value projects, and their revenue is tightly linked to unit financial reporting. Changes in the project result will also have an impact on the unit result. The major project transfer price is determined during the tendering phase when the quotation is provided to the customer. If the tender is accepted during the validity period, no changes are made to the prices, and the project transfer price is based on the costs valid at the time of the tender. The major project lead time in the supply unit is, on average, two years from the date of the order being received to the date when materials are shipped to the installation site. The purchase orders are placed with the suppliers a few months before the materials are delivered to the construction site. After the materials have been shipped, projects are able to report the actual material costs. There seems to be no clear process for indicating possible changes in material costs between the time of tender and actual material purchases.

Rapid material price increases in the past years have caused unpleasant surprises to the unit when the project forecasted result has been based on material prices from tendering time two years ago while actual costs today have been much higher. This has affected the financial result of the unit, and therefore the unit leadership team has requested improving the visibility of material cost changes in projects.

The objective of this study is to develop guidelines on how to improve the material cost change forecasting process in projects, and the outcome of the study is the guidelines on how to improve the material cost change forecasting process in projects. The guidelines will help the projects improve their financial result forecast, which will also improve the visibility of changes to the financial result of the unit.

1.3 Scope and Outline of the Thesis Report on Hand

This thesis focuses on the direct material costs assigned to the project from external supply sources. However, internal material costs and engineering costs are outside the scope of this study.

This study contains seven sections. The first section introduces the topic of the study. The introduction is followed by Section 2, which describes the selected research approach and presents the project plan and data collection. Section 3 describes and illustrates the current state of the process at the case company and summarises the findings from the analysis. The current state analysis is followed by the literature review and the conceptual framework of the study in Section 4. In Section 5, the outcomes from Sections 3 and 4 are introduced as the initial guidelines on how to improve the material cost forecasting process in projects. These guidelines are validated in Section 6 based on feedback from the leadership team. The final section provides the conclusions with an executive summary and proposals for the next steps, along with the self-evaluation and final words from the author.

2 Project Plan

In the previous section, the context, the business challenge, the objective, and the outcome of this study were introduced. Section 2 of this thesis presents the project plan and the data collection methods. It first explains the chosen research approach and why that approach was selected to carry out this study. Next, this section describes the Research Design for this study and shows visually the different stages of how the study was conducted. Finally, Section 2 focuses on explaining the data collection methods. It analyses the significance of the data and explains how and why it was collected.

2.1 Research Approach

There are many different research methods for different purposes. According to Saunders et al., a suitable method can be selected based on the context and the expected result of the study. While the basic, pure, or fundamental research approach aims to increase the theoretical understanding of business and management processes by developing a new or improved theory, applied research aims to improve the understanding of a specific business or management problem and try to find a solution for it. (Saunders, et al., 2019, pp. 45-46)

According to Kananen, applied action research is suitable for a project that is a development project in an organisation that aims to produce a practical solution by combining development and research. The objectives of these projects are often found in areas of processes or activities, products, services, or situations that need improvement. Although the development is linked to practical business problems, it is still based on a theory or theories in the background. (Kananen, 2013, pp. 20-21)

For this study, applied action research with qualitative data collection methods was selected as a research approach because the study focuses on finding a solution for an actual business problem. The objective is to look for

improvements to the business process, and the development of the final solution is based on best practises found in the literature.

2.2 Research Design

The objective of this study is to develop guidelines on how to improve the material cost change forecasting process in projects. In order to achieve the objective, strict logic is followed in this study. The logic is presented in Figure 2-1 the Research Design of this study.

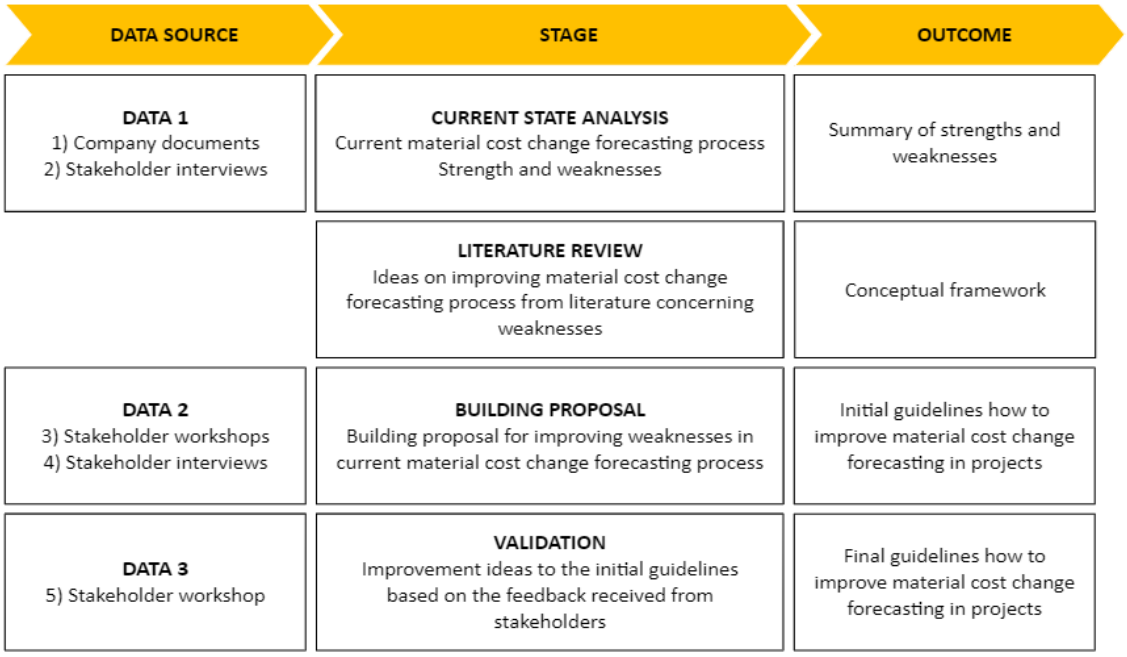


Figure 2-1. the Research Design of this study

As shown in Figure 2-1, the study is divided into four stages. Each stage aims to increase knowledge in the process and is based on the findings from the previous stage. The objective of the study will be achieved as an outcome of the fourth stage.

The first stage of this study was the current state analysis. Since the objective of the study is to develop guidelines on how to improve the material cost forecasting process in projects, it is important to first understand the strengths

and weaknesses of the current process before looking for ideas for improvements.

Data 1 for the current state analysis was collected from two data sources: the company documentation and the stakeholder interviews. Findings from the Data 1 collection round were analysed and then collected as a summary of strengths and weaknesses, which was the outcome for stage one.

As presented in Figure 2-1, the second stage of the study was the literature review. The literature review focused on finding ideas and best practises in the relevant literature, using the summary of strengths and weaknesses collected from the current state analysis as a base. The findings from the literature were compiled into the conceptual framework of the study.

As seen in Figure 2-1, the third stage of this study was building the initial proposal. In this stage, the collection of Data 2 was conducted through stakeholder workshops and stakeholder interviews. Stakeholder interviews were done before the stakeholder workshops, where the information from the interviews and the conceptual framework were used to build the initial proposals. As an outcome of the workshops, the initial guidelines on how to improve the material change forecasting process in projects were introduced.

In the fourth stage, the initial guidelines were validated with the unit leadership team. Data 3 was collected in one workshop that included the whole leadership team. Feedback and recommendations for the initial guidelines were collected from the workshop. Based on the feedback and recommendations, the initial guidelines were adjusted, and the final guidelines on how to improve the material cost change forecasting process in the projects were released.

2.3 Data Plan

As described in the previous section and shown in Figure 2-1, this thesis utilises triangulated data. The data is collected at three stages of the project, and it

utilises different types of data as well as data from different sources. The data collection rounds are presented in the following tables: Table 1, Table 2, and Table 3. Table 1 shows the data collected for the current state analysis.

Table 1. Data 1 collection for current state analysis

DATA 1 - CURRENT STATE ANALYSIS					
	SOURCE	**DATA TYPE**	**TOPIC**	**TIME**	**DOCUMENT**
1	Internal pricing policy	Document (pdf file)	Rules for c-process transfer price calculation	Accessed 2.1.2023	Policy-0070
2	Internal quality document	Document (pdf file)	Tendering and costing process	Accessed 2.1.2023	QD-01775
3	Internal quality document	Document (pdf file)	MSU Tender Letter	Accessed 2.1.2023	QD-01304
4	Internal quality document	Document (pdf file)	Description of handover meeting	Accessed 2.1.2023	QD-06357
5	Internal working instructions	Document (pdf file)	Project cost reporting tool	Accessed 2.1.2023	KM51203772
6	Internal quality document	Document (pdf file)	Transfer price management process	Accessed 2.1.2023	QD-00899
7	Supply Manager 1	Interview (Teams)	Current state delivery	13.1.2023 14:00-14:53	field notes
8	Supply Area Head 1	Interview (Teams)	Current state delivery	13.1.2023 15:30-15:53	field notes
9	Supply Engineer 1	Interview (Teams)	Current state delivery	16.1.2023 14:00-14:45	field notes
10	Senior Supply Manager 1	Interview (Teams)	Current state delivery	16.1.2023 15:00-15:45	field notes
11	Supply Manager 2	Interview (Teams)	Current state delivery	17.1.2023 9:00-9:45	field notes
12	Supply Engineer 2	Interview (Teams)	Current state delivery	17.1.2023 10:00-10:45	field notes
13	Supply Area Head 2	Interview (Teams)	Current state delivery	17.1.2023 13:00-13:45	field notes
14	Supply Manager 3	Interview (Teams)	Current state delivery	17.1.2023 14:00-14:45	field notes
15	Supply Engineer 3	Interview (Teams)	Current state delivery	17.1.2023 15:00-15:45	field notes
16	Senior Tender Engineer 1	Interview (Teams)	Current state tendering and pricing tools	19.1.2023 10:00-10:45	field notes
17	Senior Tender Engineer 2	Interview (Teams)	Current state tendering and pricing tools	18.1.2023 14:00-14:45	field notes
18	Supply Manager 4	Interview (Teams)	Current state delivery	18.1.2023 15:00-15:45	field notes
19	Senior Tender Engineer 3	Interview (Teams)	Current state tendering and pricing tools	19.1.2023 9:00-9:45	field notes

As shown in Table 1, the first round included two data collection methods: the review of existing process documentation and stakeholder interviews.

Interviewed stakeholders represented the tendering and delivery functions, which are providing the project forecast. Selected interviewees represented different levels of expertise in their roles to ensure as much comprehensive data as possible. The stakeholder interviews were conducted as individual interviews to enable the diverse data and opinions from non-senior-level experts to be recorded. The following Table 2 shows the data collection round 2 that was performed after the literature review and was used to create the initial proposal.

Table 2. Data 2 collection for the initial proposal

DATA 2 - BUILDING INITIAL PROPOSAL					
	SOURCE	**DATA TYPE**	**TOPIC**	**TIME**	**DOCUMENT**
1	Head of Continental Supply Line Sourcing	Interview (Teams)	Forecasting index to use in reporting	2.3.2023 10:00-10:30	field notes
2	Project Manager, Source process	Interview (Teams)	Forecasting index to use in reporting	6.3.2023 14:18–14:40	field notes
3	Senior Supply Manager 4 x Supply Manager 2 x Supply Engineer 2 x Tender Engineer Sourcing Manager Sourcing Specialist	Workshop (face-to-face)	Co-creation of the forecasting process	16.3.2023 14:00-15:26	field notes
4	3 x Supply Manager 2 x Supply Engineer 2 x Tender Engineer Sourcing Manager Sourcing Specialist	Workshop (face-to-face)	Co-creation of the forecasting process	22.3.2023 14:30-16:30	field notes

As shown in Table 2, Data 2 for the initial proposal was collected from the interviews and workshops with the stakeholders. Two interviews were conducted before the workshops to collect data to be used in the co-creation process. Workshop participants represented the tendering team, the supply team, and the sourcing team. Participants selected in the workshops were otherwise the same as those who were interviewed earlier in the first data collection round, but for this round, sourcing team members were also added to the co-creation process. The workshops were conducted face-to-face to improve participation in the discussions and avoid possible multitasking. Table 3 presents how Data 3 for the validation round was collected.

Table 3. Data 3 collection for validation of the initial proposal

DATA 3 - VALIDATION OF THE INITIAL PROPOSAL					
	SOURCE	**DATA TYPE**	**TOPIC**	**TIME**	**DOCUMENT**
1	MP Unit director Supply Area Head 1 Supply Area Head 2 Tendering Manager Engineering Manager	Workshop (face-to-face)	Initial guidelines on how to improve material cost change forecasting process in projects	26.3.2023 9:30-10:35	recording

As presented in Table 3, the initial proposal was validated in a workshop. The initial proposal from the previous stage was presented to the whole group, and feedback was collected based on discussion. The stakeholders for Data 3 to validate the initial proposal were selected based on their role as a part of the unit leadership team, which initiated the original request to improve the visibility of material cost changes in projects.

The next section of this study concentrates on the current state of the material cost forecasting process in the case company and analyses the findings from data collection round 1.

3 Current State Analysis of Material Cost Change Forecasting Process

This section introduces the current state and how material cost changes are forecasted at the case company. Findings from the data collection are analysed and summarised as strengths and weaknesses of the current process. The collection of the data was described in the previous section.

First, the section gives an overview of the current state analysis, followed by a deeper description with illustrative pictures of the four selected process steps. The strengths and weaknesses of the selected process steps are analysed, and in the final chapter, the findings are summarised as a list of strengths and weaknesses.

3.1 Overview of the Current State Analysis

The current state analysis started with data collection to create an overview of how the process is described in the case-company documentation. For this purpose, the project work process documentation and working instructions were reviewed. Based on the documentation, the first version of the process flow chart was created. Since the documentation did not include a clear process description of the full project transfer price and cost reporting process but the different steps were included as part of other processes, the initial process flow chart was also validated as part of the stakeholder interviews.

The Major Projects Unit operates in the supply line; therefore, the current state analysis focused on the supply unit part of the project. Figure 3-1 shows the full-chain project framework process in the case company. The supply line is involved in the following phases, marked in yellow: prepare a tender, plan a delivery project, perform order engineering, and purchase, manufacture, and deliver the material.

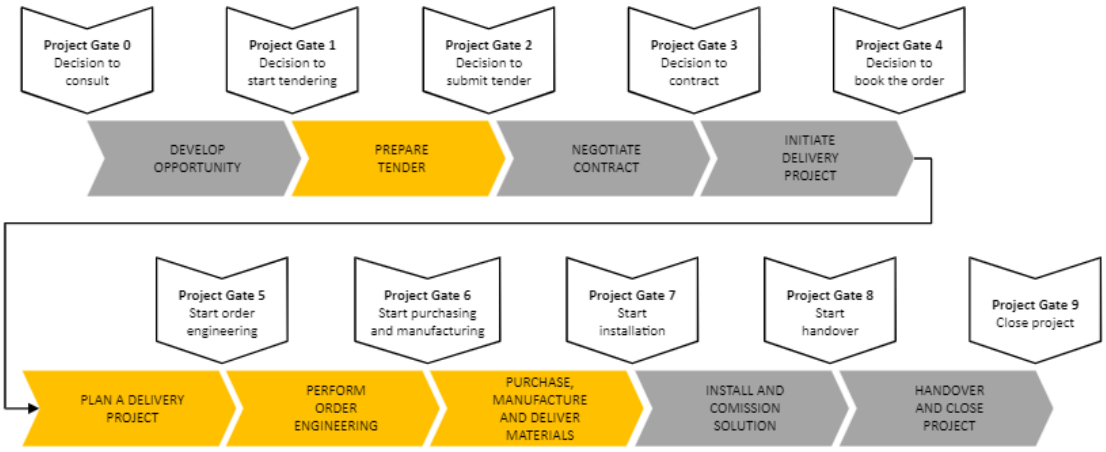


Figure 3-1. Full-chain project framework process

The target was to fully cover the supply line part of the project framework process presented in Figure 3-1 from Project Gate 1, the decision to start tendering, until Project Gate 7, when the materials are delivered to the installation site.

The stakeholders were selected for the current state analysis interviews based on their roles in the Major Projects Supply Unit. Figure 3-2 presents the roles and tasks analysed in the current state interviews.

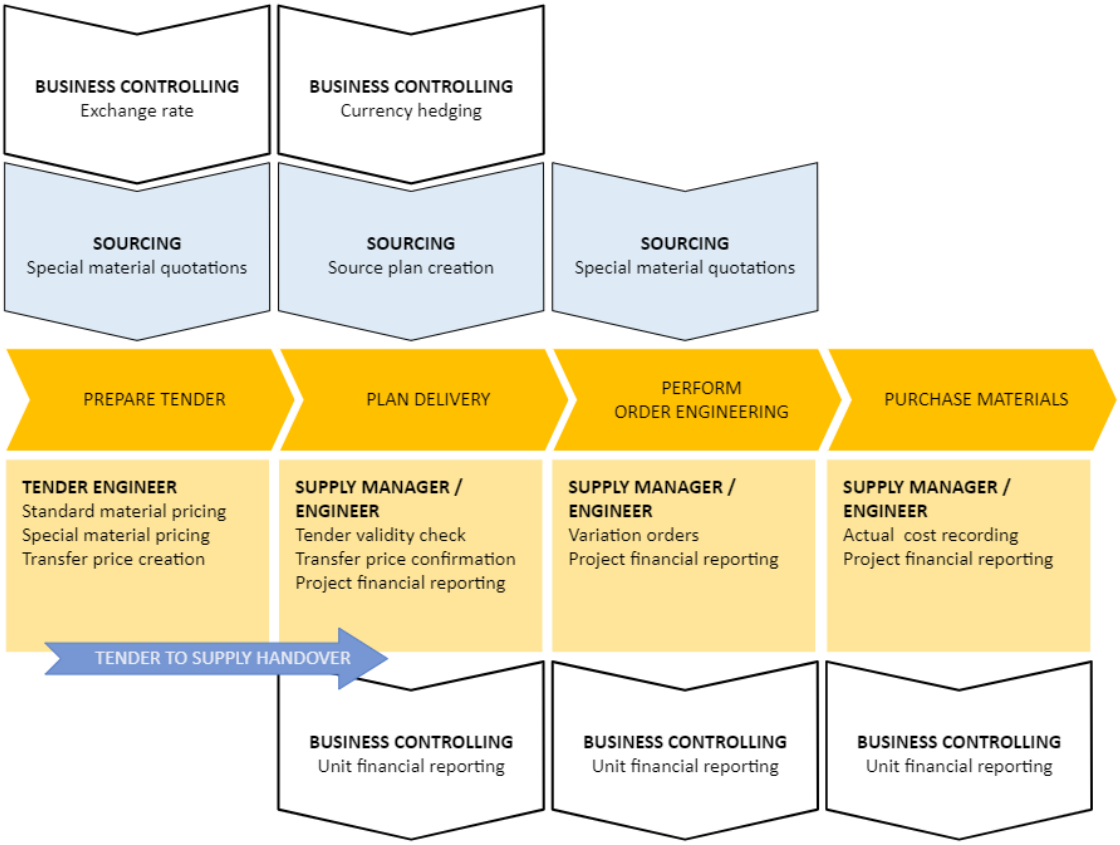


Figure 3-2. Stakeholder roles and price-related tasks in the supply line

As shown in Figure 3-2, the tender engineers are responsible for the initial creation of the project transfer price, and they act as the main contact point for the project during the tender preparation phase. The supply managers and supply engineers are steering the project in the delivery phase. Sourcing and business controlling are support functions for both tendering and supply. Each interviewed stakeholder contributes to the project price at different stages of the project; however, only the supply managers and engineers are responsible for reporting the project profitability.

The stakeholder interviews were conducted as individual interviews via Teams. The interviews focused on the areas of expertise for each role. For example, in the supply manager and supply engineer interviews, the main focus was to understand the flow in the delivery planning, order engineering, and material purchase phases, while tender engineers were interviewed mainly for topics related to the tender preparation phase. Each stakeholder was also asked to

comment on the interfaces with other stakeholders. Pre-prepared questions for the interviews can be seen in Appendix 1.

3.2 Current Forecasting Process and Its Strengths and Weaknesses

The existing project transfer price and cost reporting process flow is divided into four sections based on the supply line project framework process phases presented in Figure 3-1. Each section is illustrated in more detail in the following subchapters.

3.2.1 Prepare Tender Phase

When the decision to start tendering is made, the supply line receives a specification from the sales organisation. The tender preparation phase is the first phase of the full-chain project framework process where the supply line is involved. In the tender preparation phase, the tendering team is calculating the tender price for the project. The workflow and data movement in the tender preparation phase are presented in Figure 3-3.

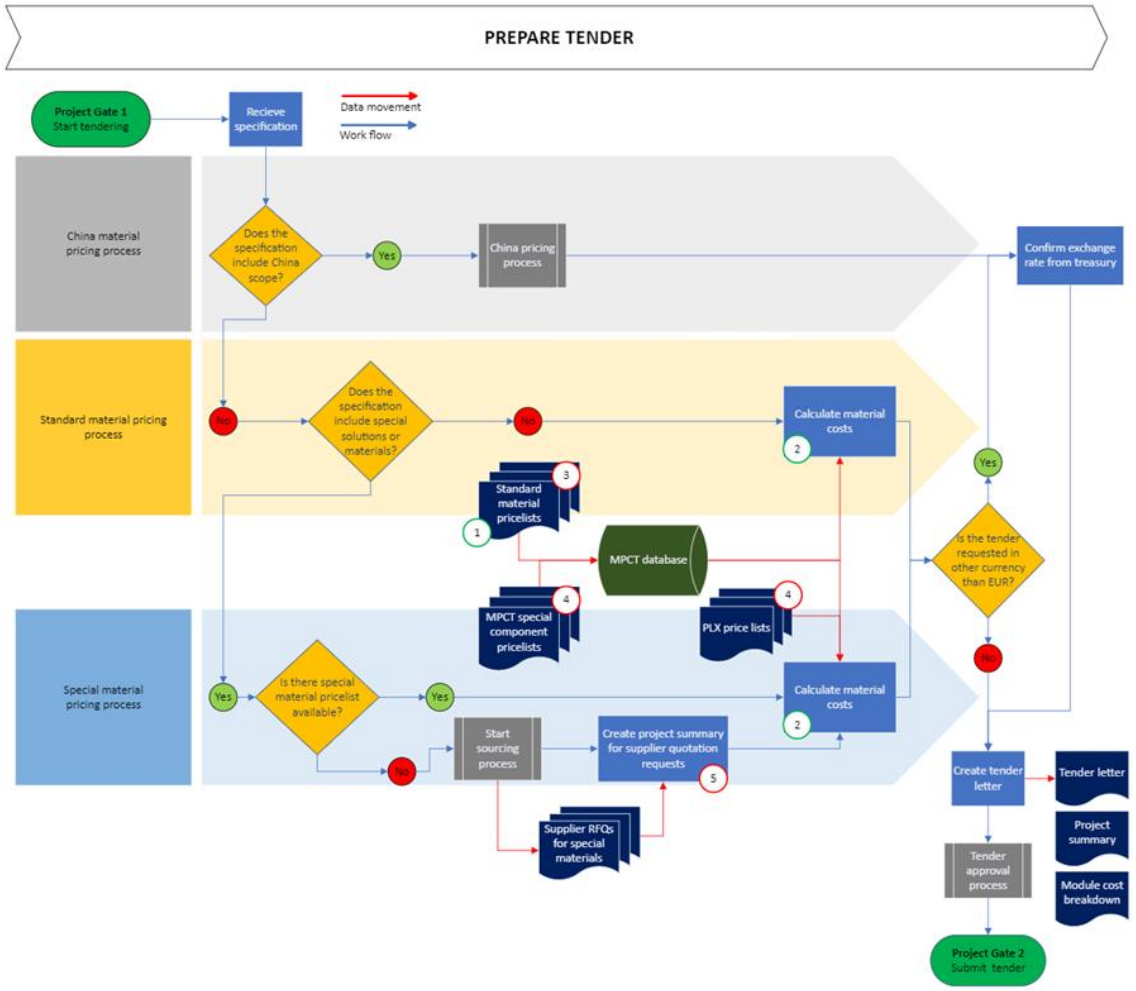


Figure 3-3 Flow chart for the prepare tender phase

As presented in Figure 3-3, the price calculation process can be divided into three sub-processes depending on the material needed. If the specification includes material from China, the tendering team is requesting help from the China tendering team. Standard materials are priced using the pricing tools that use the actual supplier price lists for the standard materials. However, the finding from the interviewees was that the price lists are not uploaded immediately to the tool when the supplier price lists are updated. Updates are done according to the regular update cycle, once or twice a year. Also, the updating process can take up to two months until the new prices are effective. Therefore, the first findings shown in Figure 3-3 are:

- Strength 1: Pricing tools are based on actual price lists.
- Weakness 3: The price list update to the pricing tool is slow.

Special material pricing depends on whether the special material needed is available in the special material price lists or not. If there is a price or price list available, then those are used for the pricing. According to the informant STE2,

> Special material prices that we have in the tool are based on previous delivery prices or special price lists that are updated from time to time. (Data 1: Informant STE2)

Based on this information, it seems that the special material prices in the pricing tools are not updated regularly. Thus, the next finding shown in Figure 3-3 is:

- Weakness 4: The special material price list update is not regular.

If there is no special material price list available for the required special material, the price will be checked with the supplier. In these cases, the price is based on the price level that is valid at the time of the quotation.

The tender price for the project is calculated by using these three subprocesses and their combinations. The tendering team collects the project price for the tender letter and documents in detail how the project price has been calculated. The pricing tool provides the price breakdown for the standard materials, but for the special materials, the common way of working seems to be missing. For example, Informant STE2 commented:

> We should save all quotations to the tender network drive under the tender folder, but not all tender engineers follow these instructions. (Data 1: Informant STE2)

This seems to lead to confusion when the project is handed over to the supply team:

> It is not clear how some special prices are calculated; is it someone's own estimation or is a quotation used? (Data 1: Informant SM1)

Based on this, the last findings shown in Figure 3-3 are:

- Strength 2: The creation of the tender price is documented in detail.
- Weakness 5: Tender documentation content can vary.

The validity time of the tender is currently three months. The sales organisation needs to place the order into the supply line within the validity time; otherwise, the tender will be recalculated. When the tender is recalculated, the tender team calculates all the prices with the latest version of the pricing tool.

3.2.2 Plan Delivery Project Phase

The project delivery phase starts when the tender has been approved and the project notification is received from the sales organisation. The delivery planning phase of the project focuses on understanding the scope of work that has been tendered and confirming the transfer price to the sales organisation. At the beginning of the delivery planning phase, the supervision of the project is handed over from the tendering team to the supply team. Both the workflow and the data movement for the planning phase are presented in Figure 3-4.

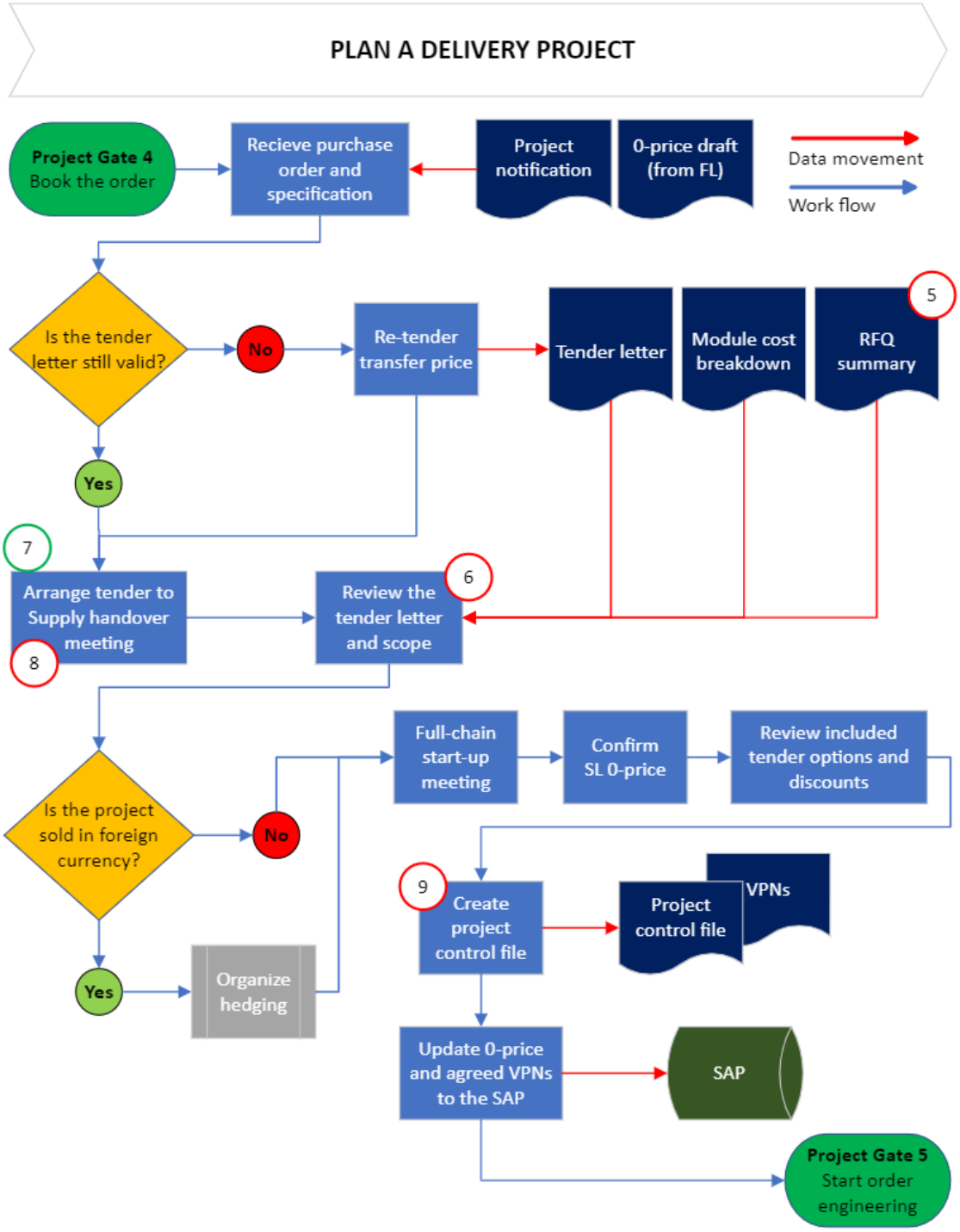


Figure 3-4 Flow chart for planning a delivery project phase

As shown in Figure 3-4, the first checkpoint is to verify the validity of the tender. If the tender is not valid, it will be recalculated with the latest version of the pricing tool. When the validity of the tender has been confirmed, the tender engineer and supply manager arrange a handover meeting where the tender

and project scope are reviewed. A tender-to-supply handover meeting was generally seen as good practise for transferring information from one team to another, but the meeting content could vary depending on the people participating in the meeting. While some interviewees were very happy about the meeting content:

> The tender-to-supply handover meeting has worked nicely. A handover meeting template has been used, and it includes all the right things. (Data 1: Informant SE2)

Others were more conservative:

> It depends on the participants how much you can get out of these meetings. (Data 1: Informant SSM1)

It seems that either the handover meeting template is too broad and allows too much room for variation or some team members do not follow the template for the meeting agenda. The first findings shown in Figure 3-4 are:

- Strength 7: The tender-to-supply handover meeting is mandatory to pass the project gate.
- Weakness 8: The content of the tender-to-supply handover meeting can vary.

Another finding in the project handover from tender to supply was the communication of the tender documentation. During the tender team interviews, all tender engineers explained in detail how the tender price calculation is documented. It seems to be very clear for the tendering team, but when the project is handed over to the supply team, many of the interviewees are not sure about the documentation they received from the tendering team.

One of the most commented-on documents was the RFQ summary. The tendering team collects the supplier quotations in multiple ways, but no one creates a separate summary of the quotations. Also, the content of the tender documentation did not always seem to be what was needed. Informant SM2, for example, described it as follows:

> The module cost breakdown does not include any details automatically, only module level prices. I need to ask about it separately. (Data 1: Informant SM2)

It seems that the tender documentation preparation is not unanimous; it depends on the person who is calculating the tender what kind of documentation package is created for the handover. Therefore, the next finding shown in Figure 3-4 is:

- Weakness 5: Tender documentation content can vary.

When the tender review is ready, the supply line will confirm the 0-price to the sales organisation, create the project control file, and update the 0-price in the SAP system. When the project control file is created, the first project forecast is also created at the same time. Quite often, this seems to be based on the tender price, and only exceptional cases are added to the forecast. Informant SM3 explained it as follows:

> I'm a bit conservative when it comes to forecasting. There could be some issues, like pricing mistakes, etc., that would make sense to forecast at the very beginning. (Data 1: Informant SM3)

Since the price list update cycle for tendering tools is quite long and, due to the short validity time, sometimes the tender price has been agreed to remain at the same level, it is difficult for the supply manager or supply engineer to see what the project profitability level is when there is no information available about the current cost level. Many of the informants commented on the issue in different ways, but informant SM2 summed up the problem very clearly:

> There is nothing that tells me if the standard material prices have changed; a project can take several years, and there is nothing that indicates to me in what direction the material prices have changed. (Data 1: Informant SM2)

It seems that there is a lack of visibility of standard material cost changes, and therefore the project forecast is based on the tendering price level and does not reflect possible future material cost changes. Therefore, the last findings shown in Figure 3-4 are:

- Weakness 6: The visibility of standard material cost changes is missing.
- Weakness 9: The project is forecasted with the tender price.

3.2.3 Perform Order Engineering Phase

When the order has been successfully booked in the supply line order book, the supply manager or supply engineer will start the order engineering phase. During the order engineering phase, the supply line defines the bill of materials for the standard materials and performs engineering for the special materials.

Before the no-return point in Project Gate 6, a customer can request changes to the specification. These changes are handled in the variation management process, and the price changes are recorded in the project control file as VPN. Data movement and workflow for the order engineering phase are presented in Figure 3-5.

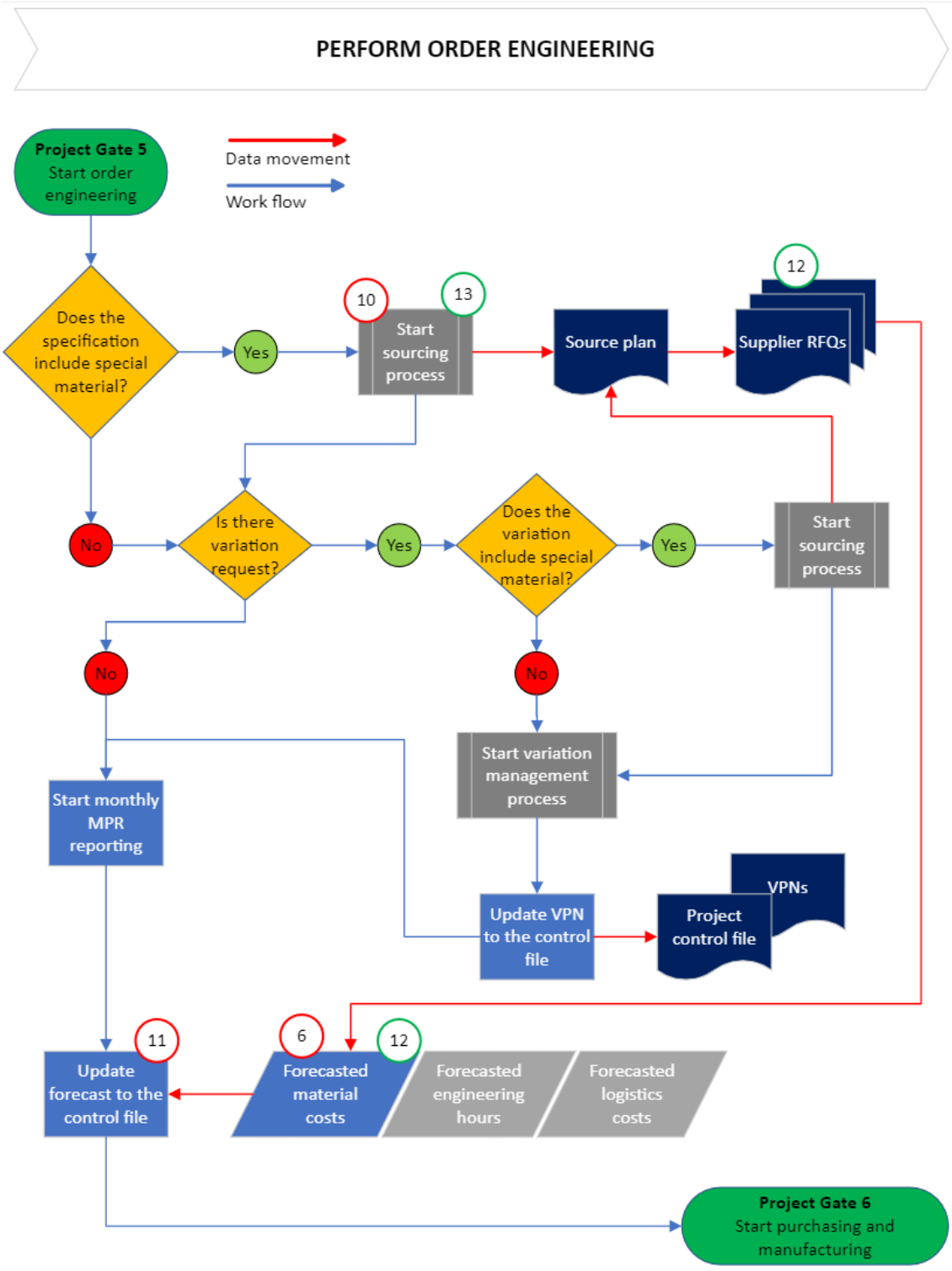


Figure 3-5 Flow chart for performing order engineering phase

As shown in Figure 3-5, the supply manager or supply engineer is contacting the sourcing team to get support for the special material purchases. The sourcing team will help define the source plan for the project and contact

suppliers to get quotations for special materials and components. According to the informants, the sourcing support received was seen as sufficient, and the weekly meeting with sourcing was seen as a good communication channel.

> It is important to have weekly meetings with sourcing, not just some files that the sourcing team is sending, but to check everything together. I see that as a very important way of communicating. (Data 1: Informant SM3)

Supplier quotations were considered to provide information about the actual prices, and special component price differences were included in the project forecasts if the difference between the tender price and the new quoted price was significant enough.

> Only those cases are forecasted where there is a clear difference between tendered and RFQ prices. (Data 1: Informant SAH1)

Based on this, the first findings shown in Figure 3-5 are:

- Strength 12: Special materials can be forecasted with supplier RFQs.
- Strength 13: Weekly meetings with sourcing improve information sharing.

Even though the supplier quotations were checked in the weekly meetings and price differences forecasted, it was recognised that standard materials were not discussed in the weekly meetings with sourcing. It seems that the sourcing process is providing price input only for the special materials, while there is also a need to understand the price level of the standard materials. Therefore, the next finding shown in Figure 3-5 is:

- Weakness 10: The sourcing process provides input only for the special materials.

Monthly project reporting is started at the beginning of the project when the control file is created after the full-chain start-up meeting. The reporting continues until the last delivery group has been shipped out from the terminal and the project is closed in the supply line order book.

When the project has not yet received permission to start manufacturing from the customer, the monthly forecast is based on the tender price plus any possible pricing mistakes found during tender handover, special material price differences compared to the tender price, and variation requests. There is no visibility into the standard material cost changes. There seems to be no process to forecast material cost changes before the material purchases are sent to the suppliers. One of the interviewees said it very clearly:

> There are no clear instructions on how to do the forecast, and I have not been trained to do it. (Data 1: Informant SE3)

The project can stay in the order engineering phase for several months or even a couple of years. There is a significant time when the project cost forecast is based purely on the understanding of the price level at the time of tender. Thus, the final findings shown in Figure 3-5 are:

- Weakness 6: The visibility of standard material cost changes is missing.
- Weakness 11: Instructions for forecasting are missing.

3.2.4 Purchase, Manufacture and Deliver Materials Phase

The material purchase phase starts when the customer gives permission to start manufacturing. Purchase orders are released to the suppliers, and final materials are shipped to the installation site. In this phase, the actual price data is input into the system. Data movement and workflow for the order engineering phase are presented in Figure 3-6.

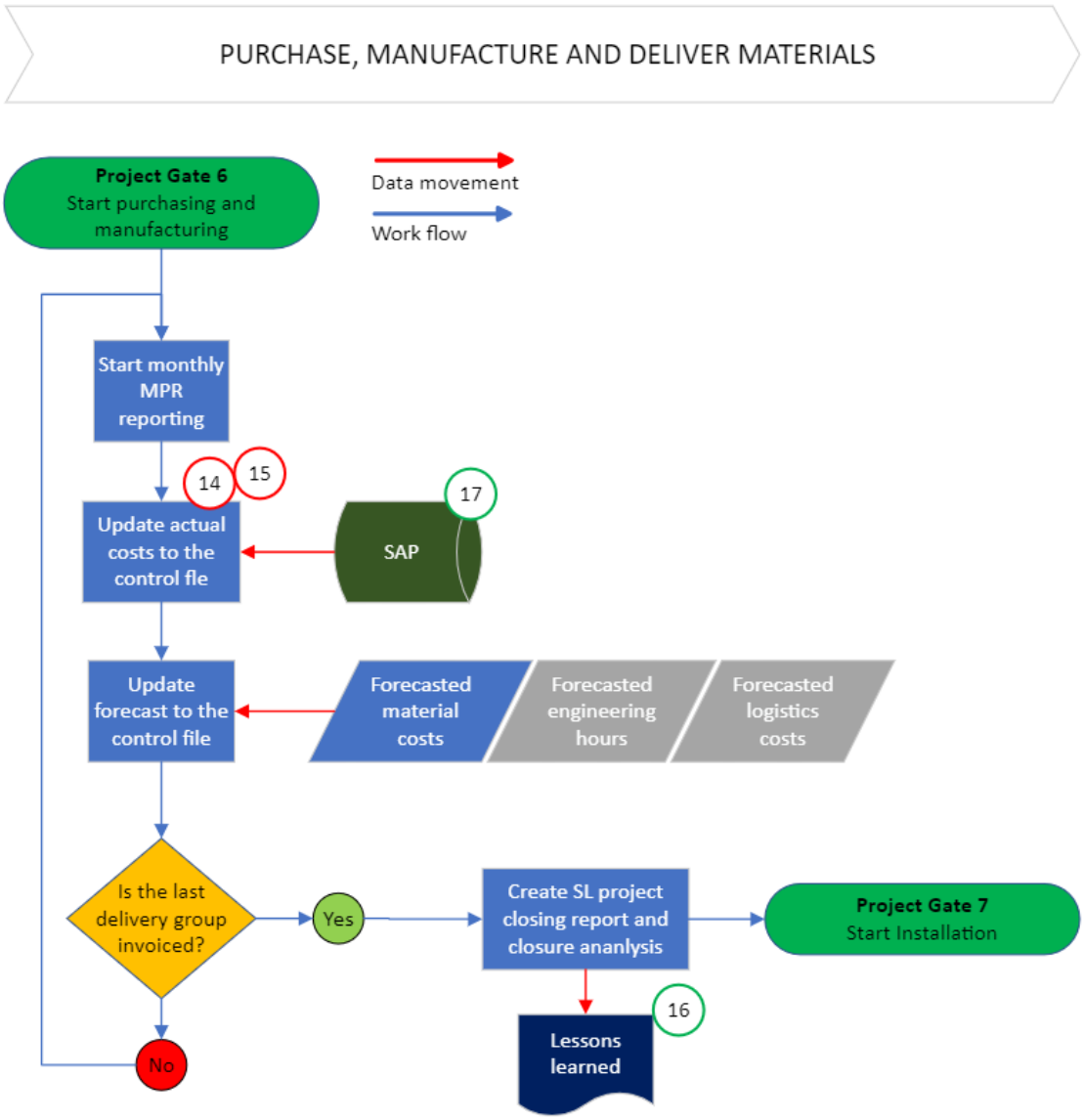


Figure 3-6. Flow chart for the purchase, manufacture, and deliver materials phase

As shown in Figure 3-6, this phase of the project is focused on monitoring the deliveries, finally closing the project, and collecting the lessons learned from the project. Suppliers confirm the prices within a few working days after the purchase orders have been released, and the actual prices for the purchased materials will be visible in the system after the confirmation.

Although the actual prices are available within a short lead time after the purchase order creation, the data is not captured in the project control file until the materials have left the terminal and the material invoice has been sent. The

informants commented that in order to extract the actual prices earlier, it would require an enormous amount of manual work since each component would need to be checked separately. Therefore, it is not a standard way of working unless it is, for some other reason, mandatory to do so. It seems that there are no proper tools or working instructions on how to extract the actual pricing data from the system. Thus, the findings shown in Figure 3-6 are:

- Strength 17: Actual material costs are available in SAP after the suppliers have confirmed purchase orders.
- Weakness 14: Actual cost collection from SAP is manual and laborious.
- Weakness 15: There are no proper tools for extracting actual material costs from the system.

When the project invoices the final delivery group, the project can be closed in the supply line order book. The Supply Manager or Supply Engineer creates a project closing report, including the lessons learned document and the pricing learnings, and presents that in the closing review meeting. This was generally seen as good practise, and for example, Informant SE3 described the usage of the data as follows:

> This is really useful practise. I use the data collected from these meetings to see if there is anything related to my new project to which I need to pay attention. (Data 1: Informant SE3)

Therefore, the last finding shown in Figure 3-6 is:

- Strength 16: Pricing learnings are collected systematically.

During the interviews with the stakeholders, other types of findings were also discovered from the project framework process. Since those findings were not related to the project cost forecasting, they are outside the scope of this thesis and therefore not included as findings in the flow charts or the summaries.

3.3 Summary of Current Process Strengths and Weaknesses

The findings from the current state analysis interviews are divided into tables based on the supply line project framework process. Each table includes strengths presented in green and weaknesses presented in red for the corresponding process phase.

The first process phase, presented in subsection 3.2.1, focused on tender preparation. Table 4 summarises the strengths and weaknesses identified for the tender preparation phase from the Data 1 collection round.

Table 4. Strengths and weaknesses from the tender preparation phase

#	Strength or Weakness for Tender Preparation	
1	S	Pricing tools are based on actual price lists.
2	S	The creation of the tender price is documented in detail.
3	W	The price list update to the pricing tool is slow.
4	W	The special material price list update is not regular.
5	W	Tender documentation content can vary.

As shown in Table 5, the main findings from this phase are related to the frequency of price list updates in the pricing tool and the tender documentation shared with the supply team. The tender price defines the base line for the project, and the project material forecast is based on the understanding of the price level received from the tendering team. The more comprehensive the handover data is, the better the starting point for the project forecast will be.

The second process phase, presented in subsection 3.2.2, described the project delivery planning phase. The strengths and weaknesses identified for this phase are presented in Table 5.

Table 5. Strengths and weaknesses of the project delivery planning phase

#	Strength or Weakness of Project Delivery Planning	
7	S	The tender-to-supply handover meeting is mandatory to pass the project gate.
5	W	Tender documentation content can vary.
6	W	The visibility of standard material cost changes is missing.
8	W	The content of the tender-to-supply handover meeting can vary.
9	W	The project is forecasted with the tender price.

The findings from planning the project delivery phase, presented in Table 5, also highlight the importance of the tender-to-supply handover meeting and tender documentation quality. Another major finding from this process phase was the insufficient visibility of the material cost changes. The project profitability forecast at this process phase is based on the prices calculated in the tendering phase. The supply team does not have the knowledge to estimate the project cost level at the time of delivery.

The next process phase was the order engineering phase. This phase is presented in more detail in subsection 3.2.3, and the main findings are summarised in .

Table 6.

Table 6. Strengths and weaknesses from the order engineering phase

#	Strength or Weakness for Order Engineering	
12	S	Special materials can be forecasted with supplier RFQs.
13	S	Weekly meetings with sourcing improve information sharing.
6	W	The visibility of standard material cost changes is missing.
10	W	The sourcing process provides input only for the special materials.
11	W	Instructions for forecasting are missing.

As shown in Table 6, the main findings from this process phase are related to the visibility of material prices; for standard materials, visibility is still insufficient, but for special materials, the sourcing process can provide a better view via supplier quotations. The project profitability forecast is based on the tender prices enhanced with the cost received from the special material quotation.

Finally, the last project phase analysed, presented in subsection 3.2.4, focused on the "material purchasing and manufacturing" phase. This phase is the last process phase for the supply line. The findings from this phase are summarised in Table 7.

Table 7. Strengths and weaknesses of the purchase, manufacture, and deliver phase

#	Strength or Weakness for Purchase and manufacture of materials	
16	S	Pricing learnings are collected systematically.
17	S	Actual material costs are available in SAP after the suppliers have confirmed purchase orders.
14	W	Actual cost collection from SAP is manual and laborious.
15	W	There are no proper tools for extracting actual material costs from the system.

As seen in Table 7, the main findings from this process phase are related to extracting the actual cost from the system. Suppliers confirm actual costs in the system within a couple of days after they have received the purchase order, but the supply team is not able to retrieve this information effectively from the system. The profitability of the project is forecasted in the same way as in the previous phase, unless there is a special requirement to extract the actual costs from the system manually.

3.4 Key Findings to Elaborate

The objective of this study is to develop guidelines on how to improve the material cost change forecasting process in projects; therefore, the strengths and weaknesses are divided into four themes that require focus when improving

the forecast. Ideas and best practises for these themes are then searched for in the literature in Stage 2. Four themes and the division of strengths and weaknesses are presented in Table 8.

Table 8. Key findings divided into themes for the literature review

Theme	#	Strength or weakness
Forecasting process	7	The tender-to-supply handover meeting is mandatory to pass the project gate.
	11	Instructions for forecasting are missing.
Data processing	1	Pricing tools are based on actual price lists.
	2	The creation of the tender price is documented in detail.
	5	Tender documentation content can vary.
	8	The content of the tender-to-supply handover meeting can vary.
	12	Special materials can be forecasted with supplier RFQs.
	14	Actual cost collection from SAP is manual and laborious.
	15	There are no proper tools for extracting actual material costs from the system.
	17	Actual material costs are available in SAP after the suppliers have confirmed purchase orders.
Forecasting model	3	The price list update to the pricing tool is slow.
	4	Special material price list update is not regular.
	6	The visibility of standard material cost changes is missing.
	10	The sourcing process provides input only for the special materials.
	13	Weekly meetings with sourcing improve information sharing.
Accuracy evaluation	9	The project is forecasted with the tender price.
	16	Pricing learnings are collected systematically.

The themes presented in Table 8 are forecasting process, data processing, forecasting model, and accuracy evaluation. Weaknesses 3 and 4 are related to the pricing tool that is used in the tendering phase. The tool is old and includes multiple layers of formulas, which is causing the slow updating process. To improve the data upload to the pricing tool, it would require developing a new

pricing tool, which is outside the scope of this thesis, but both of these weaknesses could be overcome with a proper forecasting model.

Weaknesses 14 and 15, then again, are related to extracting the actual material cost data out of the SAP system. Currently, there is no tool to import the data from SAP. Also, this tool development is outside the scope of this thesis.

Even though the tender-to-supply handover meeting practise will remain a strength under the forecasting process theme, the content of the meeting as well as the content of the tender documentation, weaknesses 5 and 8, will be left outside this study.

This completes Stage 1, the current state analysis, of this study. The following Section 4 presents the improvement ideas found in the literature for the selected weaknesses presented in this section.

4 Improvement Ideas for Material Cost Change Forecasting Process from Literature

This section introduces the ideas collected from the literature and summarises them as the conceptual framework for this study. The literature review focuses on the selected themes identified in the current state analysis in Section 3.

At the beginning, this section introduces the main principles of forecasting and the forecasting process. Other ideas from the literature are introduced under sub-sections that follow the same order as the forecasting process.

4.1 Ideas on the Forecasting Process

Forecasting is an important process for decision-making in business. In fact, all business decisions are based on forecasts: how much to produce, which markets to invest in, how to define prices and what kind of new products should be designed, for example. While long-term forecasts support strategic planning, short-term forecasts are needed for tactical decision-making. Improving forecast accuracy reduces costs and improves customer service. (Sanders, 2015, pp. 5-6)

According to Sanders, there are three main principles that need to be understood before starting to create a forecast. These principles set the limits for what can and cannot be expected from the forecast. (Sanders, 2015, p. 18)

The first principle states that forecasts are rarely perfect. This is especially true in a business environment, where there are many factors that cannot be forecast with certainty. Therefore, the forecasts always include uncertainty, thus the target should not be to create a perfect forecast but to aim for good overall forecast accuracy. (Sanders, 2015, p. 18); (Gilliland, et al., 2015, p. 22)

The second principle states that forecasts are more accurate for groups than for individual items. Individual items might have a higher variety of data, but when those items are grouped together, the values cancel each other out, and the

data for the group is more stable. When the items are grouped together, the overall forecast accuracy improves, and vice versa; the more detailed the forecast, the lower the level of forecast accuracy that can be obtained. (Sanders, 2015, pp. 18-19)

The third principle states that shorter-term forecasts are more accurate than long-term forecasts. There are fewer changes in the data in the short run, but when the time horizon increases, so does the likelihood of changes. (Sanders, 2015, p. 19) Keeping in mind these three principles, the expectations for forecasting can be defined on a more realistic level.

To be able to generate a proper forecast, a clear forecasting process is needed. In Figure 4-1 five steps of the forecasting process are presented.

Figure 4-1 Forecasting process (Sanders, 2015, p. 20)

All steps presented in Figure 4-1 are equally important when generating the forecast. Even though there might be a temptation to jump directly to the part of generating the forecast, it is not recommended to overlook the previous steps to save time. Following the process will ensure the credibility of the forecast (Sanders, 2015, p. 20). The five steps of the forecasting process are presented in more detail in the following sections.

4.2 Ideas on Defining the Scope of Forecasting

The forecasting process starts by defining the scope of the forecast. When defining the scope, there are a few issues that need to be considered. The first issue is to understand how detailed a forecast is needed (Hyndman & Athanasopoulos, 2021). Should the forecast be created at the component level

or for a group of components? The level of forecast also impacts the final forecast accuracy; according to the second forecasting principle, the forecast is more accurate for groups than for individual components (Sanders, 2015, pp. 19-20).

The second issue is related to defining the preferred forecasting horizon (Sanders, 2015, p. 21). Is the forecast needed for a couple of months or for a longer period? Forecasting horizon impacts forecasting model selection because some forecasting models provide better long-term forecasts, but it is also good to remember the third forecasting principle: short-term forecasts are more accurate than long-term forecasts (Sanders, 2015, p. 19).

The third issue to consider is: how frequently should the forecast data be updated- once a quarter or less? Forecasts needed with high frequency might be better done with an automated system (Hyndman & Athanasopoulos, 2021), but when the interval between the forecasts is short, the changes in the data also become visible faster.

The fourth issue is to decide what the forecasted unit is. Whether it is items or money, it should be naturally linked to the forecasted variable. (Sanders, 2015, p. 21)

4.3 Ideas on Data Processing

When the forecast scope has been defined, it is necessary to find out what kind of data can be used to create the forecast. Forecast model selection depends largely on what kind of data is available, and the forecast can only be as good as the data used. A credible forecast requires credible data (Sanders, 2015, p. 21).

Understanding the scope of the forecast will help define the needed sources. For example, needed information can be quite often found in historical data like internal records of old purchase prices or information and experience from

earlier projects. It is also possible to gather information from internal or external experts by interviewing them or asking for cost estimates from suppliers. Data, such as economic indicators of unemployment rates or inflation, is available from public sources, or data could be obtained from consulting companies. (Triantis, 2018) (Wilson, 2014)

4.3.1 Data Cleaning

Before the data can be used for forecasting, it needs to be checked and cleaned to ensure accuracy. One of the most common problems in forecasting is missing data. Data might have been lost or not recorded in the first place for some reason. These holes in the data should be filled; otherwise, they might be interpreted incorrectly as zero values. One way of replacing the missing data is by using a moving average from past data. (Sanders, 2015, p. 22)

Another common issue with data is outliers. Outliers are unusually high or low data points compared to the expected level. These spikes in the data could be due to a seasonal peak, special promotions, or disruptive events like strikes or catastrophes. Sometimes the reason for the peaks is not known. These peaks should be adjusted from the data, but depending on the reason, whether it is known or not, there are different approaches to adjusting the data. The first and simplest way is to replace the outliers with a more typical value. However, with outliers that are not severe, smoothing the values might result in a less accurate forecast. Outlier correction is a suitable approach when the cause of the outlier is unknown, but when the cause is known, other approaches should be considered. The second way to correct the outliers is to separate the demand streams. This approach is suitable if the sources of demand are understood and can be separated. The third option is to use the forecasting model that models outliers. Especially for events that are likely to happen again in the future, including these in the forecasting model often improves the accuracy of the forecast and provides an understanding of the impact of the event. (Gilliland, et al., 2015)

Depending on the data used, it might also be a good idea to review possible trading day adjustments and exchange rate impacts on the data. Trading day differences can impact, for example, the results of the same month in different years. The reason is that the number of working days can change because weekends and holidays change from year to year. If the exchange rate impact is not reviewed, the possible monetary value fluctuation in the data can be due to changes in currencies. (Sanders, 2015, p. 22)

4.3.2 Identifying Data Patterns

When the data is cleaned, it can be analysed. The purpose of the analysis is to try to identify possible patterns from the data, which can then help select the correct forecasting model. The most common data patterns are the horizontal pattern, trend pattern, seasonal pattern, and cyclic pattern. (Sanders, 2015, p. 23)

The horizontal pattern is the simplest data pattern and the easiest to forecast. An example of a horizontal data pattern is shown in Figure 4-2.

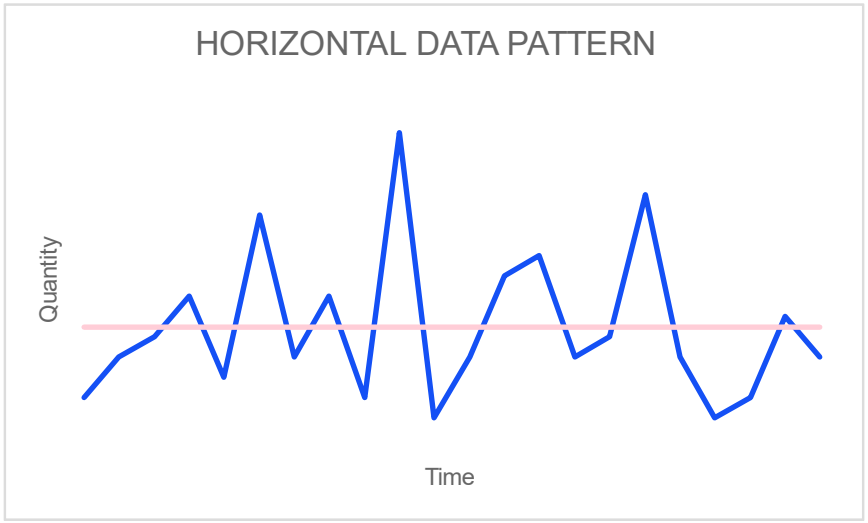


Figure 4-2 A horizontal data pattern

As presented in Figure 4-2, the horizontal pattern can be shown as a straight line, the mean value, where the data points fluctuate randomly around it. This

kind of data pattern is typical for mature commodity products. (Sanders, 2015, p. 23)

The trend data pattern shows an increase or decrease in the mean value within the long-term time horizon. An example of a trend data pattern is shown in Figure 4-3.

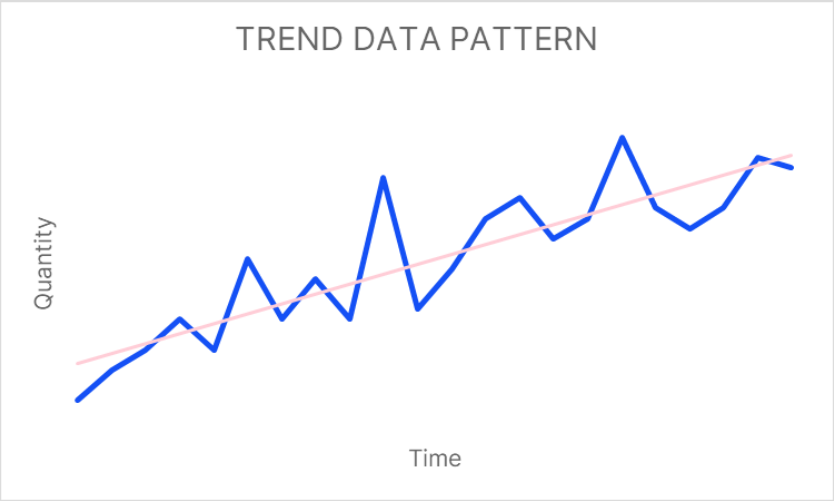


Figure 4-3 A trend data pattern

Figure 4-3 shows an upward trend, but the trend data pattern can also be downward. It is also possible that the data pattern changes direction, from an increasing to a decreasing trend, but the change happens over a long time period. (Hyndman & Athanasopoulos, 2021)

The seasonal and cyclic patterns can be easily mixed since both include rises and falls in the data. A seasonal pattern example is shown in Figure 4-4.

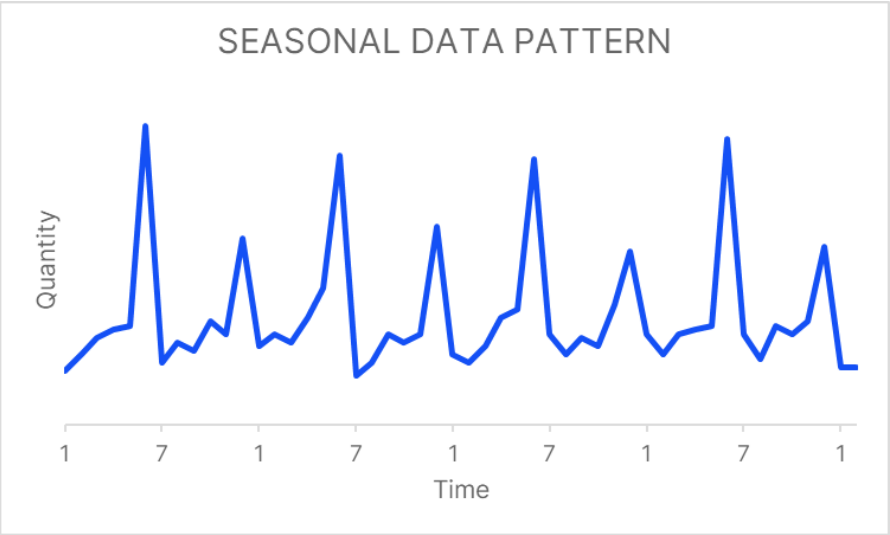


Figure 4-4 A seasonal data pattern

The seasonal pattern is tied into seasonal factors like the month of the year, for example, Christmas sales in December, or the day of the week, for example, summertime Friday afternoon traffic peaks on highways. The frequency of the seasonal pattern is fixed; therefore, the beginning and duration of the seasonal peak can be easily forecasted. (Hyndman & Athanasopoulos, 2021)

An example of a cyclic pattern is shown in Figure 4-5.

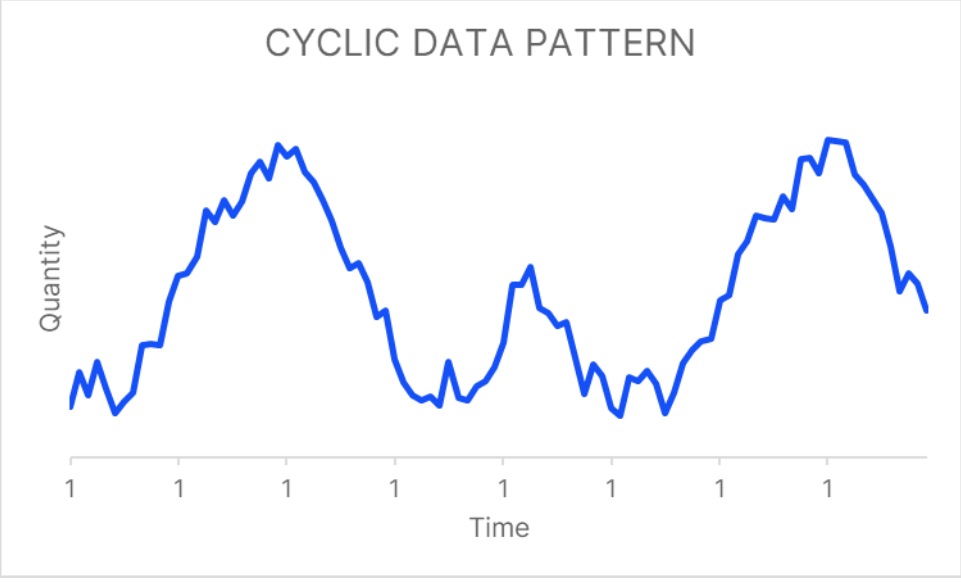


Figure 4-5 A cyclic data pattern

While the seasonal pattern frequency is fixed to the known period, the cyclic pattern is not. The duration of cyclic patterns is longer, usually at least 2 years, and the magnitude of cycles can vary. Cyclical data patterns are often due to economic conditions like regression or inflation. Unlike the seasonal pattern, the beginning and length of the cyclic pattern are more difficult to predict. (Sanders, 2015, p. 23) (Hyndman & Athanasopoulos, 2021)

In addition to the known data patterns, there is also some unexplained variance in the data that cannot be predicted. If the data includes much random variation, it is difficult to forecast. When analysing the data, the focus should be on identifying as many patterns as possible and minimising the random variation. (Sanders, 2015, p. 24) (Chase Jr., 2013)

4.4 Ideas on Selecting a Forecasting Model

The selection of the most suitable forecasting model can be narrowed down using the parameters defined earlier. For example, the amount of available data can limit the selection of some quantitative models that require a large amount of data. Some models are better for short-term forecasting, while others work better for long-term forecasts. Understanding the needed forecasting horizon will guide the selection of the forecasting model. Moreover, it is important to select a forecasting model that is suitable for the data patterns identified during the data analysis. Some quantitative models may generate quite accurate forecasts, but developing such a model can be expensive. Thus, it is important to understand what the needed forecast accuracy is compared to the importance of the forecast. (Sanders, 2015, pp. 24-25)

4.4.1 Qualitative Forecasting Models

Forecasting models can be divided into two categories: qualitative and quantitative models. Qualitative models, also known as judgmental models, are based on the opinion or judgment of a person or a group. Judgmental forecasting models are suitable when there is no historical data available or

there is a disruption that changes the market conditions. Judgmental forecasts utilize soft information or domain knowledge and can react quickly to changes in the environment. However, judgmental forecasts are based on opinions and therefore subject to human biases like optimism, wishful thinking, and political manipulation. (Sanders, 2015, pp. 66-68)

The most commonly used qualitative techniques are independent judgment or the judgment of a group, market research, and the Delphi method. A summary of these models can be seen in Table 9.

Table 9. Qualitative techniques (Sanders, 2015, p. 71)

Technique	Description	Strengths	Weaknesses
Judgment of group	A group of experts creates the forecast together	Able to utilise the latest information	One person can dominate the judgment
		Have wide access to soft information	
Market research	Survey or interview to identify customer preferences	A good tool to understand customer preferences	It is difficult to develop a quality questionnaire
Delphi method	Seek to form a consensus among a group of experts	Structured process and anonymity	Time consuming

As shown in Table 9, judgment of group is a technique where a group of experts, like managers or salespeople, meet and create a forecast together. The group quite often has strong domain knowledge and wide access to soft information, and they are able to include the latest information when creating the forecast. The downside to this technique is that the opinion of one person can dominate the judgment of the group. (Sanders, 2015, p. 70)

Market research is a good tool to collect an understanding of customers' likes and dislikes and identify new product ideas. The downside to this technique is that it is difficult to develop a good questionnaire that does not lead to

misinterpretations; it requires knowledge of how to conduct a reliable survey. (Sanders, 2015, p. 72)

The third technique presented in Table 9 is the Delphi method. This technique aims to form a consensus forecast from a group of experts. Experts are selected for the panel based on their expertise in the field of the forecasted topic. In the first round, each expert provides an individual forecast. All forecasts are collected and summarised, and based on the summary, feedback is shared with the experts. In the second round, the experts are reviewing their initial forecast based on the feedback they received. Iteration rounds are continued until a satisfactory level of consensus is reached. The strength of this technique is that each expert remains anonymous, which decreases the social and political pressure on their forecasts. Also, this prevents one-person dominance in the forecast. The downside of this technique is that it is time-consuming, thus it is not suitable for short-term forecasting but is excellent for forecasting, for example, long-term product demand or technological change. (Hyndman & Athanasopoulos, 2021)

4.4.2 Quantitative Forecasting Models

Quantitative models use historical data and mathematics to create the forecast, and they tend to be more accurate than qualitative models. The advantages of quantitative forecasting models can be considered to be that they are objective and consistent, capable of processing a large amount of data as well as many variables and complex relationships. However, quantitative forecasting models are slow to react to environmental changes, and the accuracy of the forecast is highly dependent on the quality of the data they are based on. The most sophisticated quantitative forecasting models require technical understanding and money to build. (Sanders, 2015, p. 55)

Statistical forecasts can be divided into two categories: time series and causal models. These models are summarised in Table 10.

Table 10. Quantitative models (Summarised by the author based on Chase Jr., 2013)

Technique	Description	Strengths	Weaknesses
Time series models • Naïve • Moving average • Exponential smoothing	The forecast is based on analysed patterns from the data.	Provide excellent results	Require a large amount of historical data
		Easy to use and understand	React slowly to changes
		Easy to automate, thus suitable for a large number of forecasted items	Big fluctuations in data can lead to big forecast error
Causal models • Linear regression • Multiple regression	The variable being forecasted is related to other variables in the environment	Able to handle multiple variables	Require time to develop
		Capable of supporting what-if analysis	Require large data storage
		More accurate short and mid-term forecast	Expensive to build and maintain

As shown in Table 10, time series model forecasts are based on the patterns found in the historical data. They are easy to automate, making them excellent models for creating multiple forecasts within a short timeframe. However, time series models react slowly to changes in the environment, and big differences in the data might lead to big forecast errors. (Chase Jr., 2013).

The simplest time-series forecasting model is the naïve model. The naïve forecast can be done with the minimum effort, and that is why the naïve forecast is often used as a benchmark when the accuracy of the selected forecast model is evaluated. A naïve model can be a random walk, which is just taking the last known actual as a forecast, or a seasonal random walk, which is utilising the actuals from the last seasonal peak as a forecast or simple moving average. (Gilliland & Platt, 2010, p. 84).

Another time series forecasting technique is moving averages, including the simple moving average and the weighted moving average. Moving average techniques utilise the latest actual data to create the forecast. The simple

moving average calculates an average from the defined number of previous data points, and when new data becomes available, the oldest data point is left out of the calculation. A weighted moving average is otherwise the same, but the forecaster can assign more weight to the selected data points. (Sanders, 2015, pp. 81-82)

Perhaps the most commonly used time series models use different exponential smoothing techniques. Exponential smoothing is comparing the actual numbers to the forecasted numbers for the same data points to create the forecast for the next period. Another way of interpreting exponential smoothing is the weighted average for all data, where more weight is given to the latest data points. Single exponential smoothing uses one smoothing parameter and an equation that cannot take trend or seasonality into account. Holt's technique is a more advanced exponential smoothing technique that uses two smoothing parameters and thus also considers trend patterns in the data. Similarly, if seasonality also needs to be taken into account when forming the data, three smoothing parameters can be used. Three smoothing parameter techniques are also known as the Holt-Winters method. (Kolassa & Simensen, 2016, pp. 51-58)

As presented in Table 10, causal model forecasts are based on the assumption that the forecasted variable, a dependent variable, can be associated with another variable, an independent variable, or variables. Causal models are able to handle more complex relationships between the variables than time series models, and quite often they improve the forecast accuracy compared to the time series forecast alone, especially on short- and mid-term forecasts. However, causal models require much data analysis before the relationships between the variables can be defined. (Chase Jr., 2013)

The most basic causal model is called linear regression, where the forecasted variable has a linear relationship to another variable. This relationship can be presented as a straight-line equation. Multiple regression in turn presents the forecast in a relationship between a dependent forecasted variable and multiple independent variables. The selection of variables should be based on logic:

there should be a relationship between the dependent and independent variables, and the variable should be forecastable. The correlation coefficient can be used to define the weight of each variable. (Sanders, 2015, pp. 85-87)

Selecting the appropriate forecasting model requires first understanding what value the requested forecast will bring to the company. The more important the forecast is for the company, the more sophisticated the forecasting model that should be used. The second area to understand is the forecastability of the item. Figure 4-6 shows the four quadrants where the forecasting models are divided based on the focus areas.

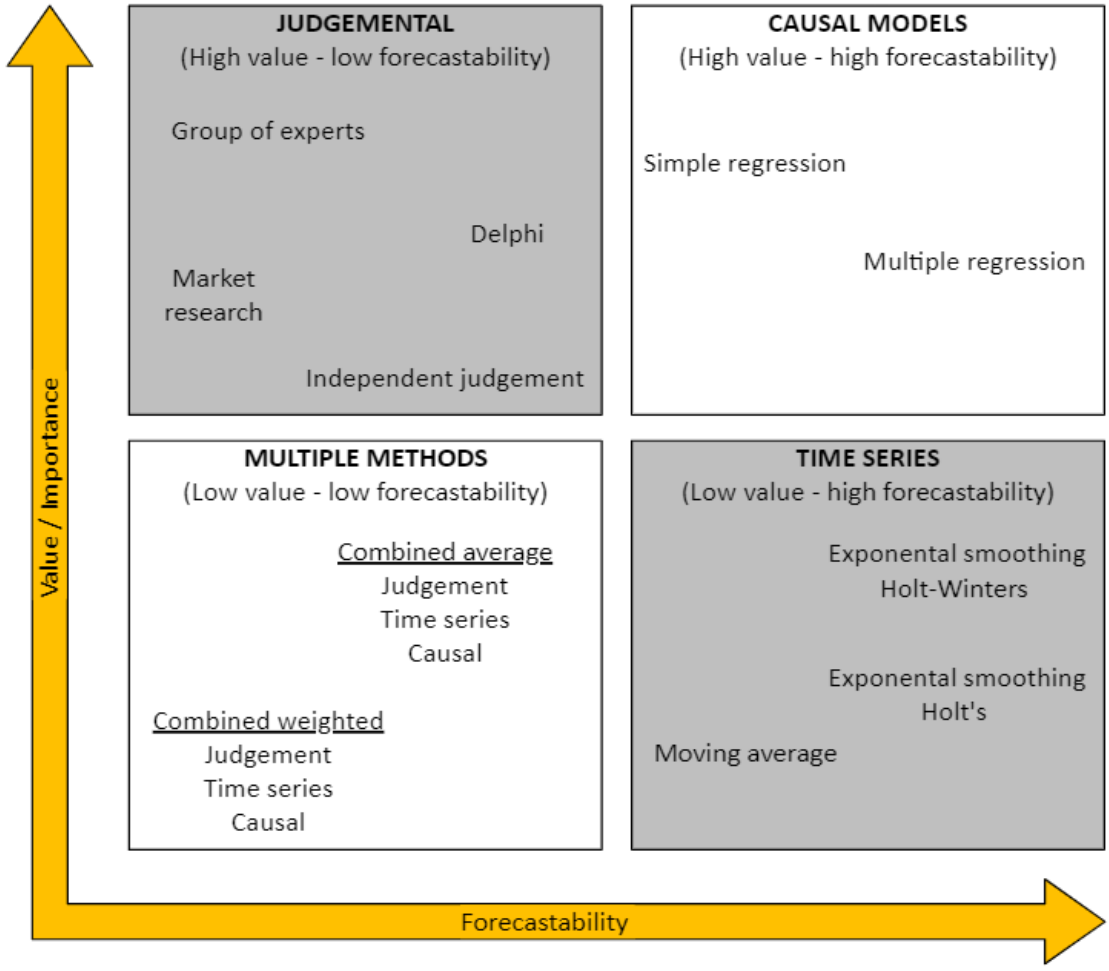


Figure 4-6 Forecasting model selection quadrants (Chase Jr., 2013)

As shown in Figure 4-6, with low-forecastability items, the qualitative models work better, and vice versa, when the forecastability is high, the quantitative models are better suited for forecasting. Also, when the forecast is important to the company and forecast errors can be costly, there is a need for higher forecast accuracy. From the qualitative models, the group of experts and the Delphi method can provide a more accurate forecast when the forecastability is low, and from the quantitative models, the regression techniques can provide better accuracy compared to pure time series techniques.

As presented in Table 9 and Table 10, each forecasting method has its strengths and weaknesses. Combining different methods might help overcome some of these weaknesses, improve forecast accuracy, and avoid biases. The most commonly used combined method is managerial adjustment, where the quantitative forecast generated is adjusted based on managerial judgment. Another possibility is to use combined judgemental and quantitative forecasting, where the statistical forecast and managerial judgement are mechanically combined. The third option of combined methods is where managerial opinion is used as an input for the forecasting model. (Sanders, 2015, pp. 58-60)

In order to improve the forecast accuracy with the combined method, some general criteria need to be considered: first of all, the combined forecasts should be generated independently; secondly, they should be based on different data or information; and thirdly, there should be actual domain knowledge present in the judgmental forecasts. (Sanders, 2015, p. 57)

4.5 Ideas on Evaluating the Accuracy of the Forecast

Based on the first forecasting principle from Sanders, who states that forecasts are rarely perfect (Sanders, 2015, p. 18), it can be assumed that there is almost always an error in the forecast. The aim of the forecast is not to create a forecast without error but to achieve overall good forecast performance over time. Only by measuring the forecast accuracy can it be determined if the overall performance is, in fact, at a good level.

Selection between the forecasting models can be done by evaluating their accuracy and then picking the one that provides the best accuracy. This validation can be done based on the historical data and by evaluating how well the selected model fits that data. However, it is important to understand that the fit of the model to the historical data does not provide a reliable indication of future forecast accuracy. (Gilliland & Platt, 2010, p. 30)

A forecast model can also be validated by taking the out-of-sample measure from the historical data. This is done by dividing the historical data into two data sets. One data set is used to create the forecasting model, and another is used to evaluate the performance. There are some general rules for dividing the data: usually, the data set used for testing is much shorter than the data set used for creating the forecasting model; the most recent data should be used for the testing; and the data used for creating the forecasting model should cover at least two seasonal cycles to enable the capture of possible seasonality from the data. (Sanders, 2015, p. 37)

Forecasting models can also be compared by using forecast error measures to provide information on the accuracy of the forecasting model. At its simplest, forecast error measures can be divided into standard error measures and relative error measures. Different forecast error measures are summarised in Table 11.

Table 11. Forecast error measures (Summarised by the author based on Sanders, 2015, pp. 38-47)

Standard error measures		• Dependent on the metrics of the data • Useful when comparing different forecast models from the same data	
Measure	**Description**	**Strengths / weaknesses**	**Instructions to use**
MAD	Mean absolute deviation	• Opposite signs don't cancel each other • Provides average forecasting error • Is not able to separate under and over forecast	Select a model with the lowest MAD
MSE	Mean squared error	Magnifies large errors	Select a model with the lowest MSE
Relative error measures		• Based on percentages • Cannot deal zero values	
Measure	**Description**	**Strengths / weaknesses**	**Instructions to use**
MPE	Mean percentage error	Provides a measure of forecast bias	• Positive MPE means under forecasting • Negative MPE means over forecasting
MAPE	Mean absolute percentage error	Similar to MAD but is not scale-dependent	Select a model with the lowest MAPE

As presented in Table 11, standard error measures are dependent on the metrics of the data, while relative error measures are not. Both MAD and MAPE are using the absolute error value, meaning that the positive and negative errors are not cancelling each other. On the other hand, they are not able to tell whether the forecast is too much or too little. MPE, then again, is the only measure that provides visibility into the forecast bias. MSE is highlighting the large errors in the data. This is a useful metric if large forecasting errors are considered disastrous. (Sanders, 2015, p. 42).

Forecast error measure metrics provide information about forecasting errors, but they do not provide information on whether the changes in the forecasting model are making the forecast better or worse. This can be measured with the

forecast value added (FVA) analysis. For example, if the forecast received from the forecasting model is manually adjusted afterwards, the FVA analysis will compare the forecast before and after the manual adjustment to understand whether the manual adjustment is adding value to the forecast. FVA analysis identifies waste and inefficiency in the forecasting process. (Gilliland & Platt, 2010, pp. 82-83)

When making the comparison of forecasts, the FVA analysis should also compare the forecast received with the naïve model. The naïve model acts as a benchmark forecast because the naïve model is created with minimum effort, and any formal forecasting model should generate a better result (Sanders, 2015, p. 45). Otherwise, it will not make sense to create a formal forecasting model. A naïve forecast used as a benchmark should nevertheless be created so that it would be possible to use it as a forecast (Gilliland & Platt, 2010, p. 87).

To perform the FVA analysis, any traditional performance metric can be used since the FVA is measuring the change in that metric. If the FVA is negative, the evaluated activity is making the forecast worse and should be eliminated from the process, but if the FVA is positive, the activity is improving the forecast. In this case, it should be evaluated to see what the cost of that activity is versus the improvement it brings and make the decision to keep or remove it based on that. (Gilliland & Platt, 2010, pp. 83, 95)

4.6 Conceptual Framework

The ideas found in the literature and described in the last sections are summarised as a conceptual framework for this thesis. The conceptual framework is presented in Figure 4-7.

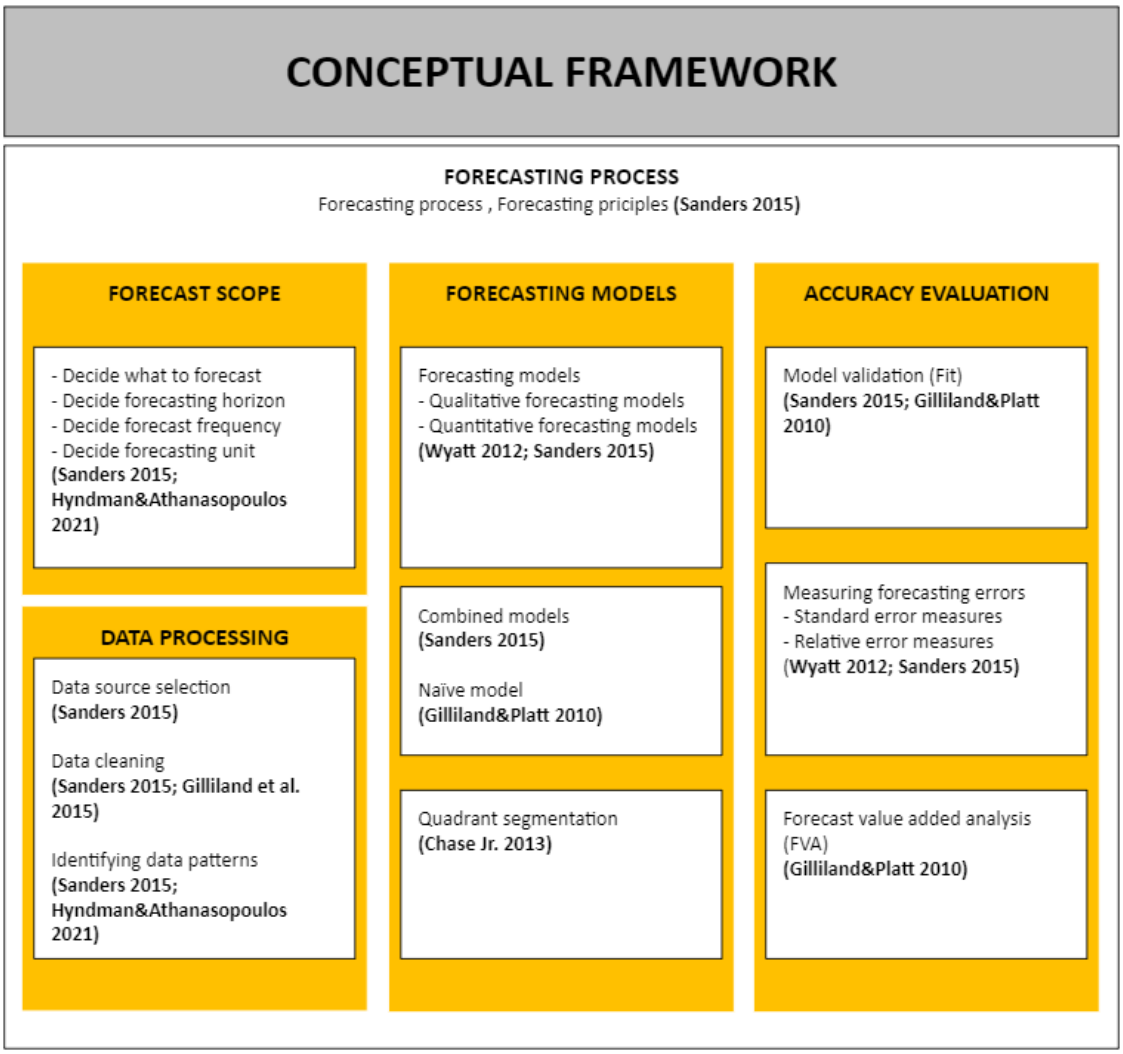


Figure 4-7 Conceptual framework of this study

As shown in Figure 4-7, the conceptual framework is divided into four steps following the forecasting process logic presented in Section 4.1. The first step presents the key issues to consider when defining the forecasting scope. The second step identifies the phases that need to be performed during data processing, including data source selection, data cleaning, and identifying patterns in the data. The third step introduces the most common qualitative and quantitative forecasting models and explains how they are used. The third step also shows the quadrant segmentations as a tool for selecting the proper forecasting model. The fourth step provides methods for evaluating the accuracy of the forecast model. This includes evaluating the historical data,

measuring forecasting errors, and analysing the forecasting process LEAN by using the forecast value-added analysis.

In Section 5, the conceptual framework is utilised to build the initial proposal as guidelines on how to improve material cost change forecasting in projects together with the stakeholders. Building the guidelines on top of the conceptual framework and embedding the strengths of the current process will provide the solution to the original business problem.

5 Building Proposal for Improving Current Material Cost Change Forecasting Process

Section 5 presents the co-creation process for improving weaknesses in the current material cost change forecasting process. At first, the section describes how the creation process was carried out and then presents the received proposals summarised as the initial proposal of guidelines on how to improve material cost change forecasting in projects.

5.1 Overview of the Proposal Building

The objective of this study is to develop guidelines on how to improve material cost change forecasting in projects. From the operative project work perspective, the guidelines are presented as a task list that follows the project framework phases presented in Section 3. The full final guidelines are presented in Appendix 4. Since the project framework phases contain the same tasks in multiple phases, the initial proposal building follows the conceptual framework process steps for forecasting.

Proposals for each step were co-created in two workshops with the tendering, supply, and sourcing stakeholders. In addition to the workshops, which were the main source of the proposals, there were two discussions with sourcing stakeholders from the global unit to clarify the availability of existing data. Participants for the Data 2 workshops were the same as those for the Data 1 current state analysis interviews, plus two new stakeholders from the sourcing team. The business problem was already familiar to most of the participants from the previous round, and the new stakeholders received a short introduction to the topic before the workshop meeting. Since data 1 was collected from individual interviews and analysed afterwards by the author, the workshop started with a short review of the findings from the current state analysis to validate whether the stakeholders agreed with the common findings or not. No changes were proposed to the findings, and the workshop continued with co-

creating improvement ideas. Preparation questions shared with the participants of the workshops are presented in Appendix 2.

5.2 Building Proposal Concerning the Forecasting Scope

The discussion of improving the forecasting process started with defining the forecasting scope. Proposals for the forecasting scope are presented in Figure 5-1.

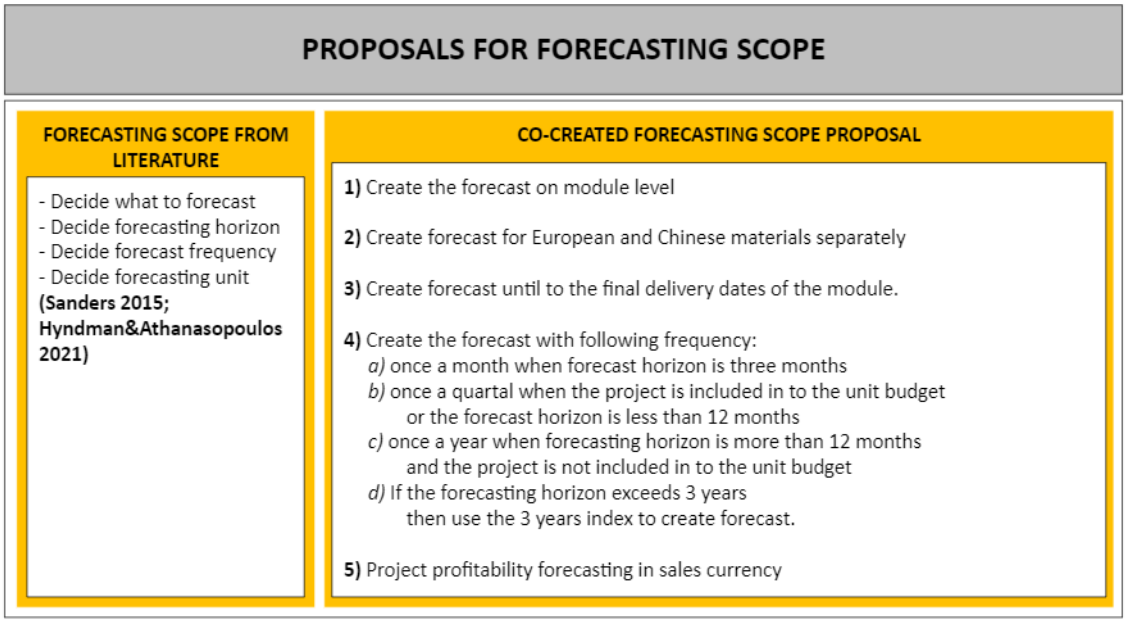


Figure 5-1 Proposals for forecasting scope

As shown in Figure 5-1, the stakeholders proposed creating the forecast at the module level. As a preliminary question before the workshop, alternatives, which included project level, equipment level, module level, and component level, were shared with the participants. All these alternatives are possible to forecast, but the project- or equipment-level forecasts were not considered real alternatives. The main reason for this was the current reporting tool, the project control file, which requires financial reporting at the module level; therefore, it was considered logical to provide forecasts at the module level. An alternative to module-level forecasting was component-level forecasting. Tender documentation provides the possibility for this, and the benefit of component-

level forecasting would be the possibility to gradually include actual supplier pricing data in the forecast. Although this possibility seems tempting, the second principle of forecasting, stating that forecasts are more accurate for groups than for individual items, guided the team to select the module-level forecast as the final proposal.

The stakeholders also highlighted the importance of forecasting European and Chinese materials separately. Modules including materials from China should be forecasted based on price level changes in China, and modules including materials from Europe should be forecasted based on European price level changes.

> If I have understood correctly, the raw material price changes are different in Europe than in China, so we should forecast these separately. (Data 2: Informant SM5)

Stakeholders proposed three different forecasting frequencies, depending on the proximity of the delivery date. Figure 5-1 presents the three steps for forecasting frequency. The first forecast should be created when the project is opened in the order book and a control file is created. According to the stakeholders, it doesn't add additional value to forecast more often than once a year at the beginning of the project when the scope and schedule are not yet finalised; therefore, the proposed forecasting frequency at the beginning of the project is once a year. When the project is included in the budget or the delivery will be within 12 months, the proposed forecasting frequency is increased to the quarterly level, and when the expected delivery is within 3 months, the proposed forecasting frequency is increased to the monthly level.

Depending on the project, the forecasting horizon may vary from less than one year to several years. The forecast should be made until the estimated final delivery of the project, but it was pointed out to the team that the further into the future the horizon is, the flatter the forecast looks, so therefore, it was decided that the maximum forecasting horizon is three years, and every project exceeding the three-year limit will be forecast with a three-year forecasting horizon index.

5.3 Building Proposal Concerning Data Processing

After the forecasting scope was defined, the discussion moved to the data processing area. Proposals from the workshop for the data processing are shown in Figure 5-2.

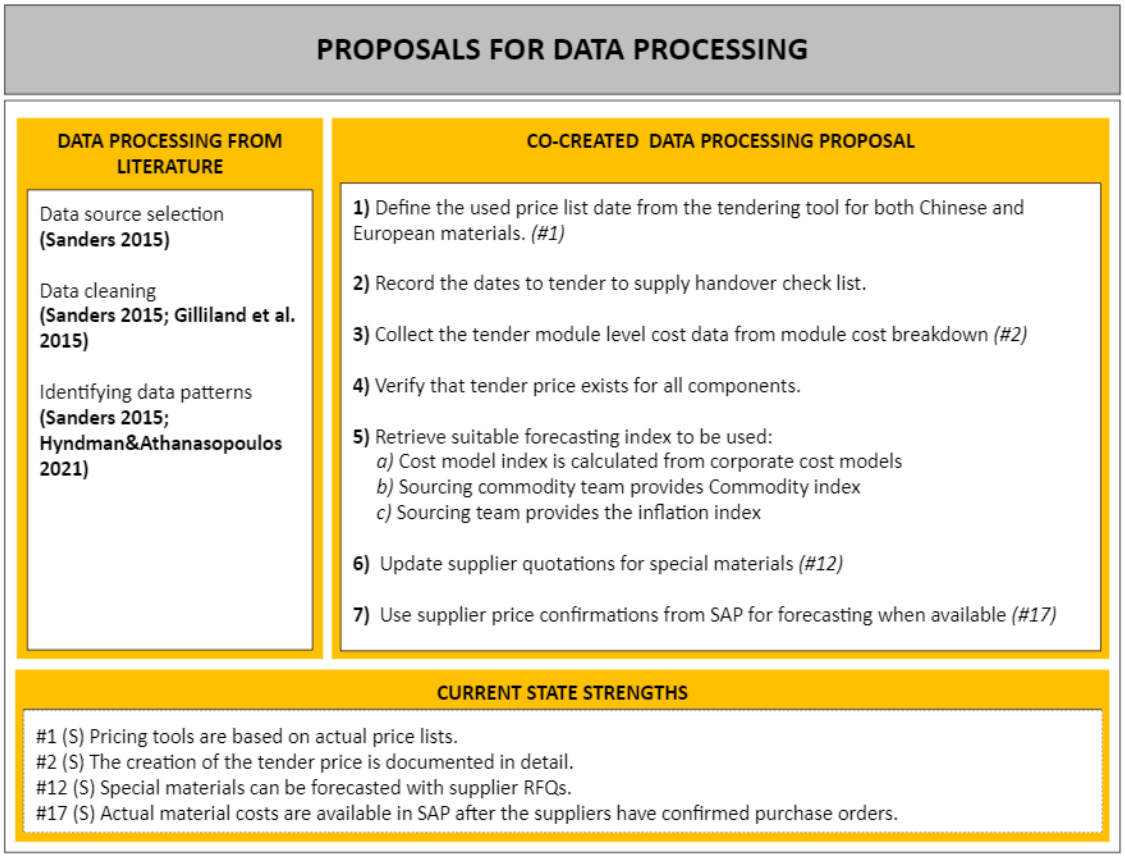


Figure 5-2 Proposals for data processing

As shown in Figure 5-2, the discussion started with defining the baseline for the forecast. To be able to forecast the change, it requires understanding the price level that was used to create the tender price. The first strength found during the current state analysis was that the pricing tool is based on actual price lists. The stakeholders felt that even though the pricing tool prices do not follow price level changes with the same frequency as the actual price lists, they can be used as a baseline for forecast calculation as long as the actual date when the price lists were updated in the tendering tool is known.

> It would be enough if we would just check what the price list date was in the tendering tool at tendering time and use that as the base line. (Data 2: Informant SM1)

The proposal from the stakeholders was to define the latest date when the price lists have been updated in the tendering tool during the project tender-to-supply handover meeting and record the date on the tender-to-supply handover meeting checklist. This data can then be used as a forecast index baseline when calculating the change.

The second strength found during the current state analysis, which is also shown in Figure 5-2, was related to the detailed tender price documentation. The tendering team prepares a cost breakdown at the module level for the project that is used for financial reporting in the project control file. The proposal is to use the same file for forecasting as well. Based on the discussions with stakeholders in workshops and during the current state interviews, the tender data should be reviewed in case of missing prices or pricing mistakes. Possible holes in tender data should be filled before the first forecast to ensure that the starting level for the forecast is as accurate as possible.

Before the co-creation workshops, there were discussions with the Commodity Team Project Manager and the Sourcing Head of Continental Supply Chain to understand potential existing data that could be utilised for forecasting. Based on the discussion with the Commodity Team Project Manager, existing commodity data could be utilised for forecasting. It is updated monthly in the system and is available for the main raw materials. The commodity data has historical data available from the past 10 years, and it includes a rolling 15-month forecast for the future. Therefore, it can be used for projects that have a longer forecasting horizon than one year.

Based on the discussion with the Sourcing Head of Continental Supply Chain, the proposal was to use the general inflation rate, which reflects the general level of price increases while also considering, for example, material price increases, energy costs, transportation costs, and labour costs. The European

Central Bank prepares macroeconomic projections four times a year, which can be used for project forecasting purposes. These macroeconomic projections from the European Central Bank have historical data from the past seven years, and they provide the forecast for the current year plus two years ahead. Therefore, it can be used for projects with a forecasting horizon longer than two years.

The third forecasting index option shown in Figure 5-2 was proposed by the stakeholders in the workshop. Since the case company is already using cost models to understand general price changes for the products, the same reports could be used for project forecasting purposes. Cost models provide the forecast until the end of the year, and when the budgeting period starts, the cost models are also updated for the next year to support the budgeting. Therefore, the cost models can be used for projects with a forecasting horizon of less than 15 months.

During the current state analysis, two more strengths were identified that can be utilised to obtain the data for forecasting. As shown in Figure 5-2, strength number twelve was identifying supplier RFQs as sources for forecasting special materials, and according to strength number seventeen, actual material costs can be retrieved from the SAP when the suppliers have confirmed the purchase orders. Both were considered valuable sources when available, and thus they were added as tasks to the guidelines.

5.4 Building Proposal Concerning Selecting the Forecasting Model

To identify potential forecasting models for the workshop, project pricing data from the past four years was pre-analysed. Based on the analysis, suitable quantitative forecasting models were selected for the workshop discussions.

The impact of the raw material price change on the material cost can vary depending on the module, and there is also variation between the modules as to which raw material is the most dominant in terms of price. The historical raw

material price data follows a cyclic pattern, but the same pattern is not as clearly visible in the actual project cost data. This is due to other dependencies coming from the project. For example, the number of units in one module is not the same for all projects; it varies case by case; consequently, finding a pattern from the available past data is difficult. Then again, the dependency between raw material price change and module cost change is clear, and since the forecast for the raw material exists, the linear regression model from casual models was selected for workshop discussions. The proposal from the workshop for the forecasting model is presented in Figure 5-3.

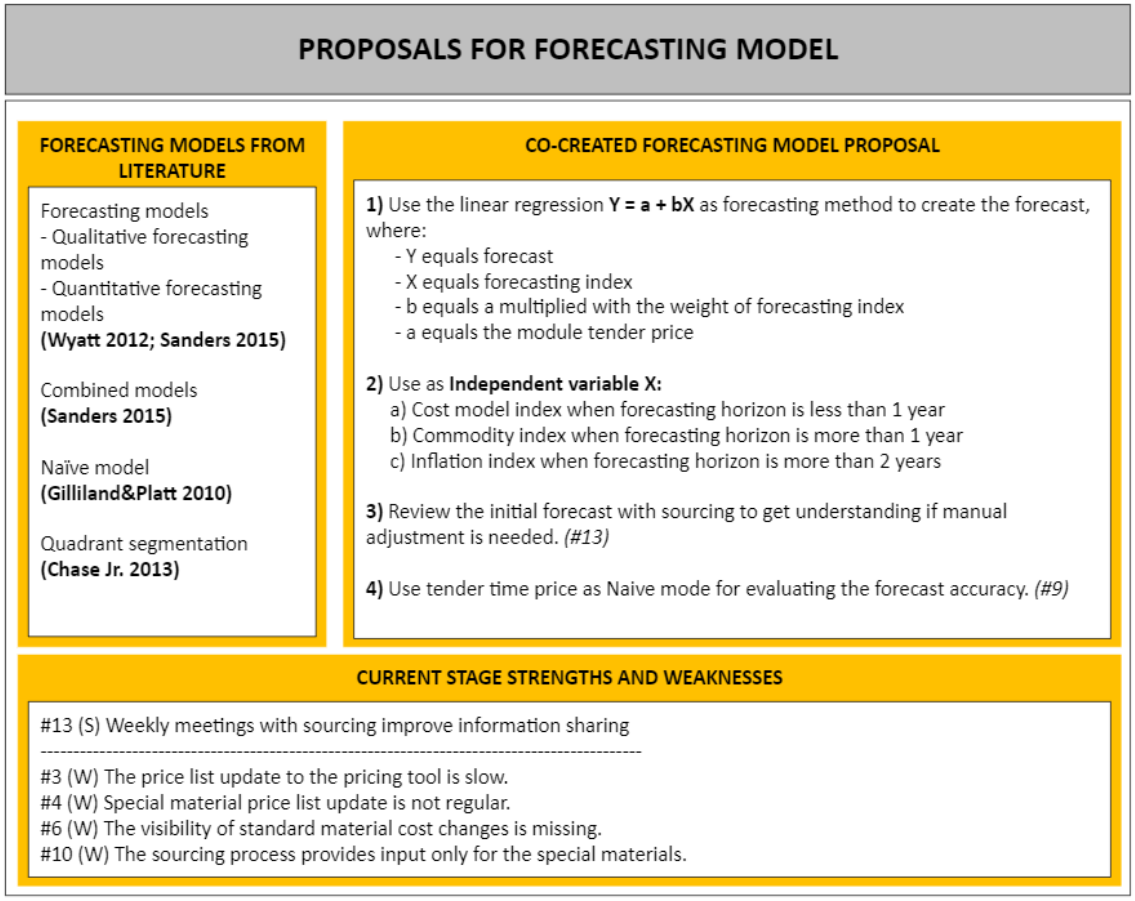


Figure 5-3 Proposals for the forecasting model

As shown in Figure 5-3, a linear regression model is a simple model to be used for forecasting when an independent variable has been defined. For project forecasting purposes, there are three independent variable options—the cost

model index, the commodity index, and the inflation index—that are selected based on the needed forecasting horizon.

Elements for the linear regression equation can be defined as follows:

- Dependent variable Y represents the forecast.
- Independent variable X represents the forecasting index.
- The constant "a" represents the starting point of the forecast and equals the tender price.
- The constant "b" is the tender price multiplied by the forecasting index weight; if only one index is used, the weight is 1; if multiple indexes are used, the weight is divided between the indexes.

One of the strengths identified during the current state analysis was the weekly meetings with sourcing, which were considered important sources of information sharing. During the workshop with stakeholders, it was also recognised that sourcing has strong domain knowledge about price changes. Thus, the proposal was to review with sourcing whether the initial forecast received from the forecasting model is reasonable or if some adjustment is needed.

Based on the findings of the current state analysis, the tender price is currently used as a project forecast; thus, this can be used as a naive model to benchmark the forecast accuracy improvement evaluation.

5.5 Building Proposal Concerning Evaluating the Forecast Accuracy

Before the forecasting model is implemented, it needs to be validated to see if it improves forecasting accuracy or not. Proposals for evaluating the forecasting model are presented in Figure 5-4.

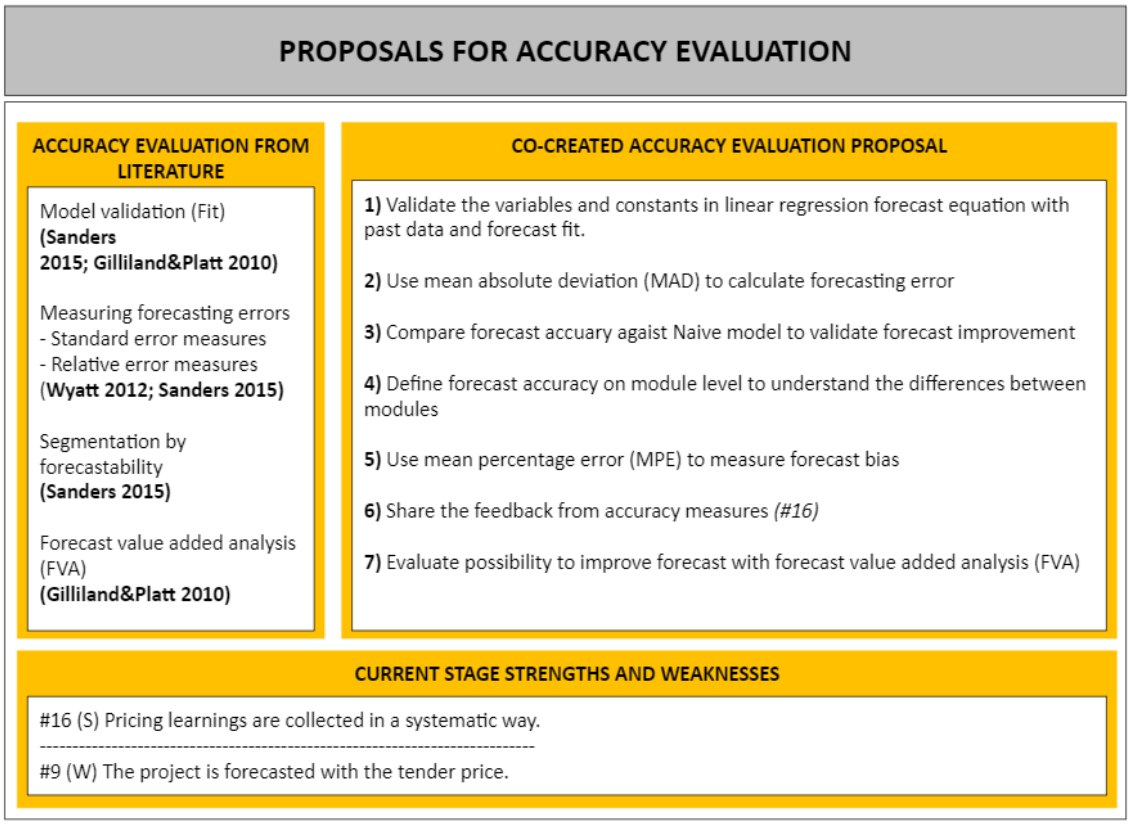


Figure 5-4 Proposals for accuracy evaluation

To avoid unnecessary work, it is important to understand whether the selected forecasting model improves forecast accuracy compared to the current way of forecasting. As shown in Figure 5-4, the accuracy of the forecasting model can be validated by creating a simulated forecast from past project pricing data and comparing it to the actual prices. Since the proposal from the stakeholders was to utilise all three forecasting indexes, the simulation should be done with three scenarios: forecasting horizons longer than two years, forecasting horizons longer than one year, and forecasting horizons less than one year. All the forecasting indexes should improve the forecast compared to the naive model.

Evaluation of the different forecasts can be done using the mean absolute deviation (MAD). The mean absolute deviation is calculated for both the forecast received with the new forecasting model and the naive forecast. A forecast with a lower MAD provides better accuracy. MAD is not able to separate under- or over-forecasting, but it does not cancel opposite errors. In

project forecasting, deviation in either direction, over or under forecasting, is not preferred; therefore, MAD can be used for comparison.

Based on the stakeholder comments, products from the in-house factories are the most difficult to forecast. The cost structures have multiple layers, and products usually include multiple raw materials and a lot of labour. Stakeholders felt that forecasting price changes for the in-house factories might be difficult. Factory products are located under their own module; therefore, forecasting accuracy calculated at the module level will help to understand whether the forecasting of in-house factory price changes is reasonable or not.

After the material purchases, suppliers confirm the prices in the system. Projects take, on average, two to three years until they are fully delivered, and the material purchases and deliveries are divided into several delivery groups. According to the stakeholders, the first material price confirmations are sometimes used for forecasting costs for the rest of the project. The proposal from the stakeholders was to use this initial actual data to review the forecast accuracy and adjust the forecast if needed.

> When I receive actual prices from the first project phase, I can use them to adjust the forecast for the rest of the project phases. (Data 2: Informant SM3)

The initial accuracy data can also be used to validate the forecasting index accuracy by following the forecast bias. The mean percentage error (MPE) measures if the model provides an under- or over-forecast.

To identify the possibility of improving forecasting accuracy, forecast value added analysis (FVA) can be used to identify the tipping point after which adding additional layers or multipliers to the forecast will not improve the accuracy anymore.

5.6 Summary of Initial Guidelines on How to Improve the Material Cost Change Forecasting Process in Projects

The co-created proposals from the workshops were presented in more detail in previous sections. The summary of all proposals from the workshops is presented in Figure 5-5.

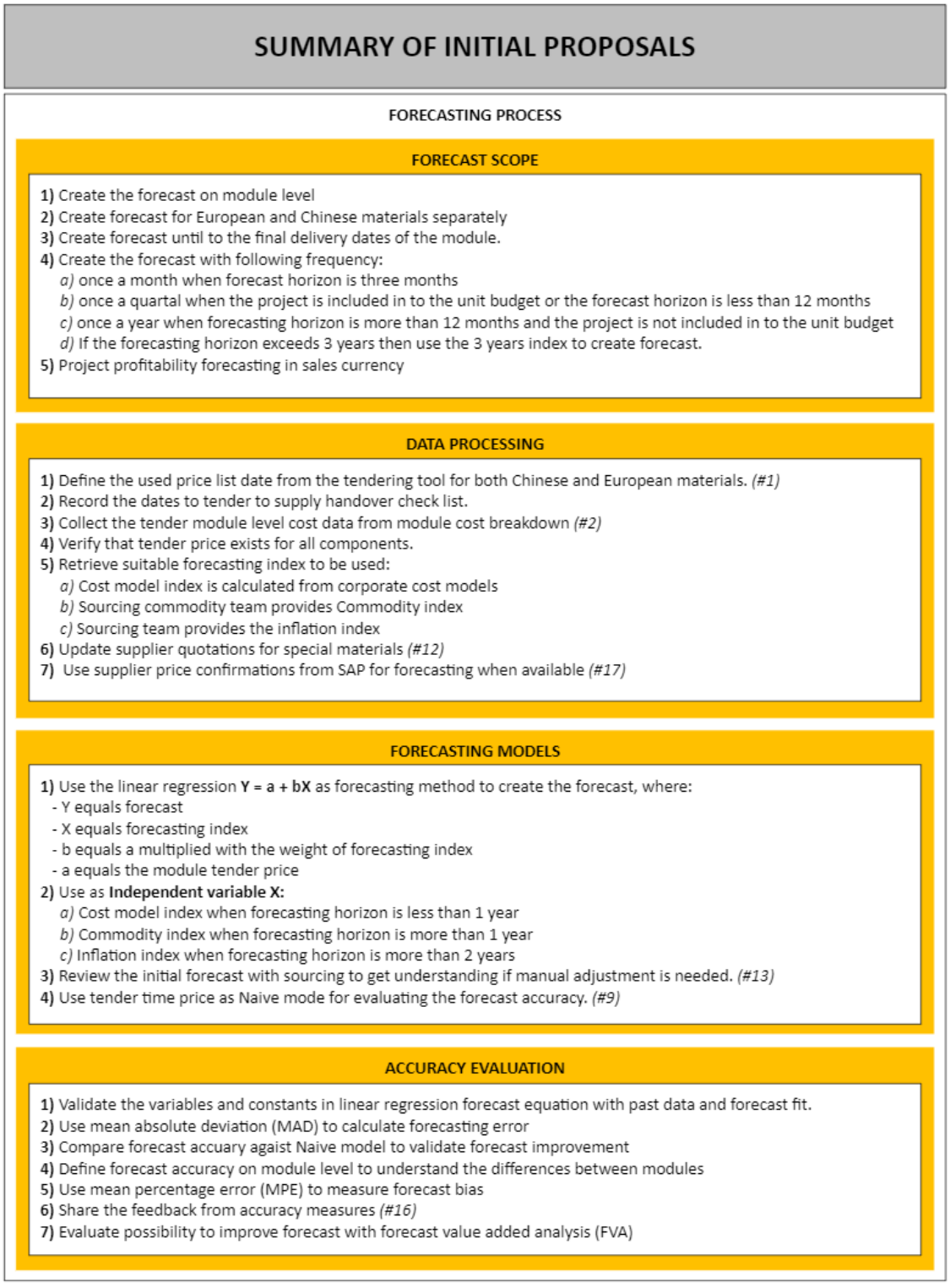


Figure 5-5 Summary of initial proposals from the workshops

As shown in Figure 5-5 Summary of initial proposals from the workshopsfour process steps from the forecasting process were gone through, and multiple task proposals were identified for each step. Based on the summary, the tasks

were transferred to the more operative format, which follows the phases of the project framework process. Project framework phases are linked to the project gates, which will also link the forecasting tasks as part of the project gates, form a timeline, and provide reminders about when each task should be performed. Full guidelines are presented in Appendix 4.

6 Improvement Ideas for the Initial Guidelines on How to Improve the Material Cost Change Forecasting Process in Projects

Section 6 presents the improvement ideas for the initial guidelines on how to improve the material cost change forecasting process in projects. At first, the section describes how the improvement ideas were collected and then presents the received improvement proposals. Finally, improvement proposals are embedded in the initial proposals and summarised as the final guidelines on how to improve material cost change forecasting in projects.

6.1 Overview of the Initial Proposal Validation

The validation was carried out in one meeting, where the initial proposals were presented to the unit leadership team. At the beginning of the meeting, the business problem and the objective were presented, and then the findings from the current state analysis were reviewed, followed by ideas from the literature and initial proposals. The leadership team participants in the validation meeting were Supply Area Heads, Tender Manager, Engineering Manager, Planning Manager and Supply Unit Director. The initial proposals were first presented as summarised proposals under each forecasting process step to get an understanding of the big picture and record the first feedback. After the comments to the summary of initial proposals, more operative-level full initial guidelines were reviewed and discussed, and improvement proposals were recorded. Based on the comments from the leadership team, the initial guidelines were adjusted to the final guidelines on how to improve the material cost change forecasting process in projects.

6.2 Feedback Received and Corrections to the Initial Guidelines

The general feedback from the leadership team was positive, and it was recognised that the business problem presented at the beginning of the meeting

has not disappeared, but the demand for improving the visibility of the project profitability had increased.

> We have had quite recently some cases where the expectations of the result were high, but finally the outcome turned out to be something totally different. It is a big hit to our result. (Supply Unit Director)

The topic had faced a lot of resistance earlier, so the leadership team was especially happy to hear that the initial proposals were the result of active group work by the people involved in the project forecast reporting.

The team provided only a couple of comments on the summary of the initial proposal. These changes are presented in Figure 6-1.

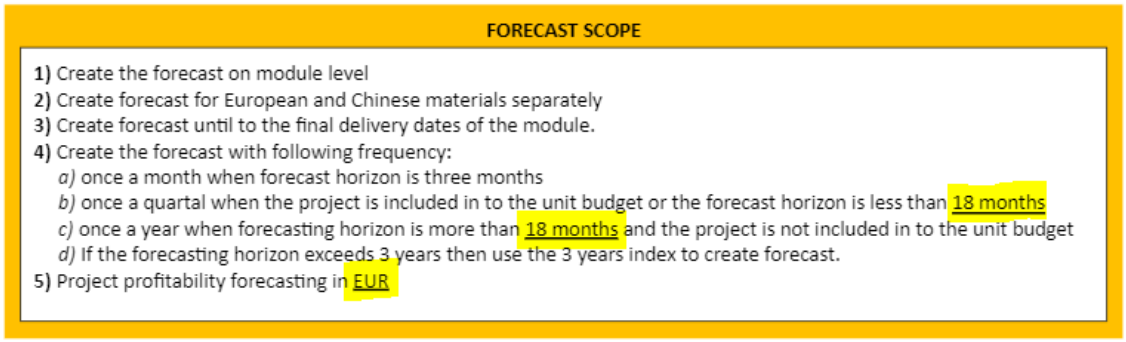


Figure 6-1 Changes proposed to the forecasting scope

As shown in Figure 6-1, the first point commented on was the forecasting frequency and especially how much earlier the quarterly level forecasting should start. Since the quarterly level forecasting is linked to unit budgeting, the team proposed increasing the forecasting horizon from 12 months to 18 months to support early budgeting rounds that start 18 months prior. Another observation made during the validation was that the forecasting unit should be in euros instead of the sales currency since the unit reporting currency is euros.

Other improvement proposals from the leadership team were linked to the full guidelines and mainly to the instructions. Since forecasting has not been an

easy topic and there have been no instructions, the leadership team wanted to ensure that the instructions would be as clear and easy to follow as possible.

> This area has not been easy, so I think it is good that we will get clear instructions on how to do this in the future. (Supply Area Head 1)

The full Guidelines for Material Cost Change Forecasting in Projects are available in Appendix 4. Below are only the parts where the leadership team proposed improvements. The first proposal was for task number one, which instructed identifying the date when the price lists were updated last time in the tendering tool. The improvements for the first task instructions are presented in Figure 6-2.

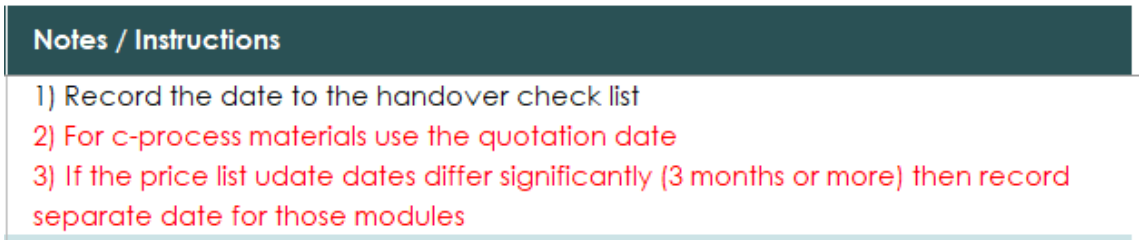


Figure 6-2 Improvements for task one instructions

In Figure 6-2, the red parts are the two additional instructions that were included in the guidelines. The initial proposal included only the instruction to record the dates on the handover checklist, but the leadership team proposed to also add instructions for c-process materials and instructions in case all price lists were not updated at the same time.

The second adjustment was for task number seven, which instructed creating the project forecast. The improvements for the seventh task instructions are presented in Figure 6-3.

Notes / Instructions
Forecast = Tender price x forecasting index (EUR) 1) Forecast to be created on module level 2) Forecast European and Chinese materials separately 3) For the modules divided in different delivery groups use the full module forecast divided according to the delivery group split

Figure 6-3 Improvements for task seven instructions

As shown in Figure 6-3, one instruction was added to this task. The initial proposal already included instructions to calculate the forecast separately at the module level and for European and Chinese materials. The leadership team also proposed including instructions on how to handle divided modules.

Following improvements were proposed for task number eleven, which instructs to review the forecast on a regular basis. The improvements for the eleventh task instruction and timing are presented in Figure 6-4.

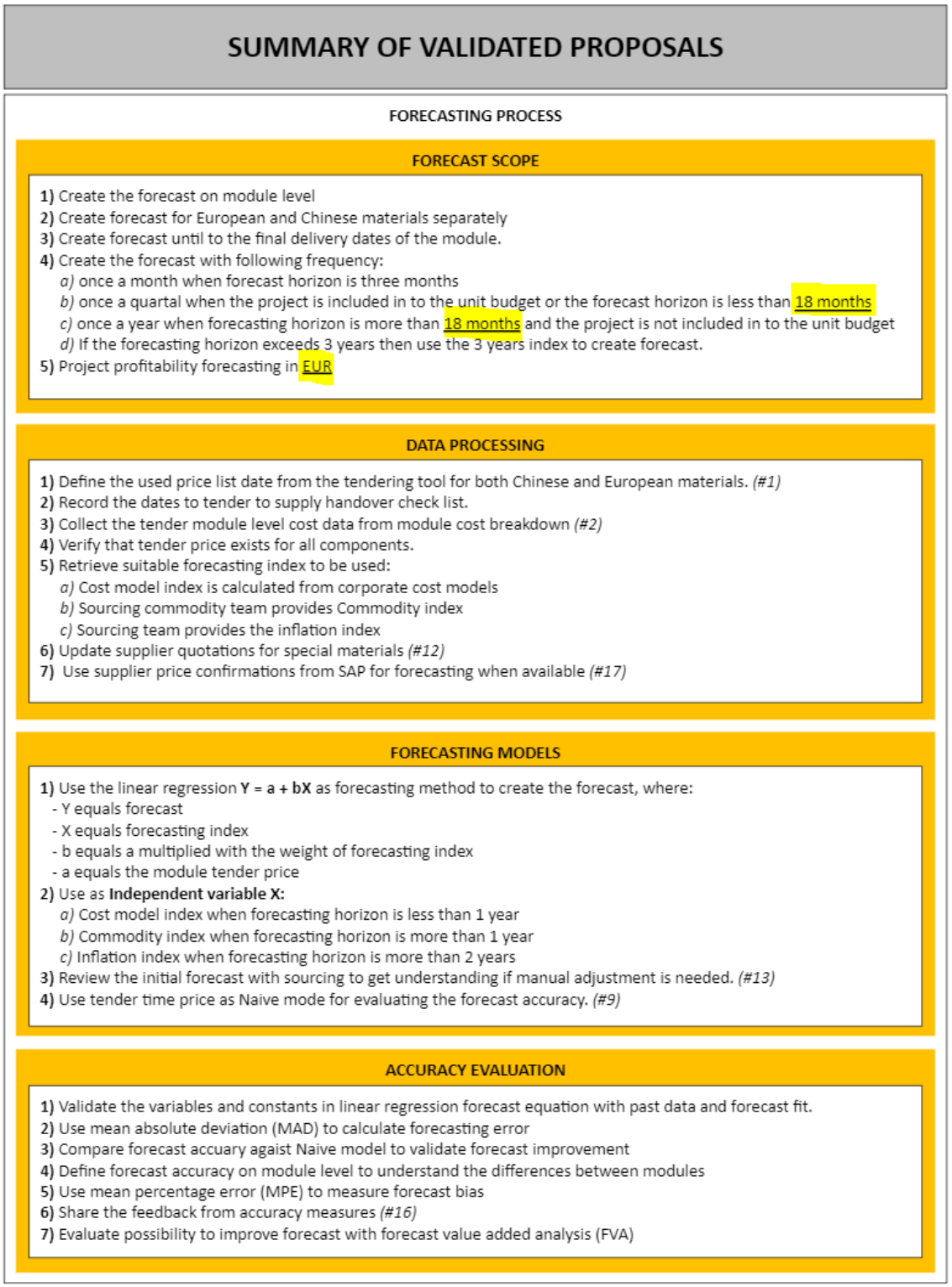
When	Notes / Instructions
1) For the monthly sales forecast 2) For the quarterly RUSH reporting 3) According to the project calendar when FL index is reviewed	1) Once a month if delivery is within three months or less 2) Once a quartal if project is included into the unit budget or if the delivery will be within 18 months or less 3) Once a year if the delivery will be more than 18 months and the project is not included into the unit budget

Figure 6-4 Improvements for task eleven instructions and timing

As shown in Figure 6-4, the leadership team proposed linking the forecasting frequency to the existing process phases and reporting cycles. When the expected delivery is within 3 months and the forecasting frequency is at the monthly level, forecasting should be synchronised with the existing sales forecast update cycle. When the project is included in the budget or the delivery will be within 12 months, the frequency of quarterly level forecasting should be synchronised with the existing RUSH reporting cycle, and when the forecast is updated once a year, it should be synchronised with the project annual index update discussions.

6.3 Summary of Final Guidelines on How to Improve the Material Cost Change Forecasting Process in Projects

A total of two adjustments to the initial summary of proposals and three adjustments to the instructions in the full guidelines were made. The summary of the validated proposals is presented in Figure 6-5 and the full guidelines on how to improve the material cost change forecasting process in projects are available in Appendix 4.



SUMMARY OF VALIDATED PROPOSALS

FORECASTING PROCESS

FORECAST SCOPE

1) Create the forecast on module level
2) Create forecast for European and Chinese materials separately
3) Create forecast until to the final delivery dates of the module.
4) Create the forecast with following frequency:
a) once a month when forecast horizon is three months
b) once a quartal when the project is included in to the unit budget or the forecast horizon is less than 18 months
c) once a year when forecasting horizon is more than 18 months and the project is not included in to the unit budget
d) If the forecasting horizon exceeds 3 years then use the 3 years index to create forecast.
5) Project profitability forecasting in EUR

DATA PROCESSING

1) Define the used price list date from the tendering tool for both Chinese and European materials. *(#1)*
2) Record the dates to tender to supply handover check list.
3) Collect the tender module level cost data from module cost breakdown *(#2)*
4) Verify that tender price exists for all components.
5) Retrieve suitable forecasting index to be used:
a) Cost model index is calculated from corporate cost models
b) Sourcing commodity team provides Commodity index
c) Sourcing team provides the inflation index
6) Update supplier quotations for special materials *(#12)*
7) Use supplier price confirmations from SAP for forecasting when available *(#17)*

FORECASTING MODELS

1) Use the linear regression **Y = a + bX** as forecasting method to create the forecast, where:
- Y equals forecast
- X equals forecasting index
- b equals a multiplied with the weight of forecasting index
- a equals the module tender price

2) Use as **Independent variable X:**
a) Cost model index when forecasting horizon is less than 1 year
b) Commodity index when forecasting horizon is more than 1 year
c) Inflation index when forecasting horizon is more than 2 years
3) Review the initial forecast with sourcing to get understanding if manual adjustment is needed. *(#13)*
4) Use tender time price as Naive mode for evaluating the forecast accuracy. *(#9)*

ACCURACY EVALUATION

1) Validate the variables and constants in linear regression forecast equation with past data and forecast fit.
2) Use mean absolute deviation (MAD) to calculate forecasting error
3) Compare forecast accuary agaist Naive model to validate forecast improvement
4) Define forecast accuracy on module level to understand the differences between modules
5) Use mean percentage error (MPE) to measure forecast bias
6) Share the feedback from accuracy measures *(#16)*
7) Evaluate possibility to improve forecast with forecast value added analysis (FVA)

Figure 6-5 Summary of validated proposals

As shown in Figure 6-5, no other adjustments were proposed for the summary, but the other forecasting process steps were validated without changes.

7 Discussions and Conclusions

This is the final section of this study, and it includes the executive summary, recommendations for the next steps, a self-evaluation of the study and the results, and finally the closing words.

7.1 Executive Summary

The rapid material cost changes have caused a lot of problems for the Major Projects unit financial reporting because the forecasted project financial results have been unreliable. Projects generally have a long lead time from the time of tendering to the last material delivery. Material costs can change significantly during the long lead time from the initial tender prices, and it seems that the material cost change forecasting process in projects is not working currently. The objective of this study was to develop guidelines on how to improve the material cost change forecasting process for the project. The outcome of this study, the guidelines on how to improve the material cost change forecasting process, will help projects improve their financial forecasts and, thus, improve the visibility of unit financial reporting.

The study followed the research design approach, which included four stages. The first stage focused on analysing the current state of the project material cost change forecasting process and identifying the strengths and weaknesses of the current process. This stage was conducted as individual interviews with the stakeholders that are involved with the operational work of project reporting. Interviews followed the flow of the project framework process, and findings were recorded under each project framework phase. The identified strengths and weaknesses were then reorganised and classified under three themes: data processing, forecasting models, and accuracy evaluation.

Themes identified in the first stage were utilised in the second stage, where ideas and best practises for improving the weaknesses under each theme were collected from the literature. Ideas from the literature were summarised as a

conceptual framework. During the literature review, the set of themes was supplemented with forecasting scope; therefore, the conceptual framework included four themes: forecasting scope, data processing, forecasting models, and accuracy evaluation.

The third stage used the conceptual framework and ideas from the literature as bases for the co-creation discussions in workshops. The workshops were conducted with the same stakeholders that were involved in the current state interviews. At the beginning of the workshops, the summary of strengths and weaknesses identified during the current state analysis was reviewed together, after which the conceptual framework themes were presented. Proposals were gathered under the conceptual framework themes as a summary of initial proposals.

Under the forecasting scope theme, the initial proposals defined the forecasting scope, horizon, frequency, and unit. The data processing theme included the initial instructions for what data should be used to create the forecast for the project, where to collect it, and how to validate the data. Initial proposals under the forecasting models theme then again defined the forecasting models to be used for forecasting and the naïve model to be used for comparison. Under the accuracy evaluation theme, the initial proposals included instructions on how to measure forecasting accuracy and how to validate improvements in forecasting.

In addition to the summary, more operative-level guidelines were created. In these operative-level guidelines, the initial proposals from the summary were divided into the project framework phases to help identify what steps needed to be taken in each project phase. Both documents, the summary of initial proposals and the full set of guidelines, were presented to the unit leadership team in stage four.

The initial proposals were validated with the unit leadership team in a group discussion. At the beginning of the meeting, the original business problem, objective, and outcome were reviewed, followed by a summary of the current

state analysis and conceptual framework. After that, the summary of the initial proposal and operative-level guidelines were reviewed. The leadership team provided feedback for two proposals under the forecasting scope theme and asked to enhance some of the instructions given in the operative guidelines. Otherwise, the initial proposal was accepted, and the leadership team gave recognition to the team for its enthusiastic collaboration and thorough work on all proposals. Based on the feedback received from the leadership team, the initial guidelines were adjusted, and the final guidelines were finalised.

The final guidelines are provided as a comprehensive operational-level task list that follows the project framework process timeline. This will help Supply Managers and Supply Engineers adapt the new tasks as part of their current project framework tasks and schedule these forecasting tasks to follow the project gates. Following the tasks defined in the guidelines will improve the project forecast, which will lead to improved visibility of the unit forecasted result. Improved visibility also makes it possible to focus more resources on the areas of projects where there seem to be more difficulties and create preventive actions to try to avoid unnecessary profitability losses.

7.2 Recommendations for Next Steps

To ensure a smooth forecasting process, there are still weaknesses that need to be addressed. During the current state analysis, it was discovered that the content of the tender-to-supplier handover meeting as well as tender documentation can vary. Therefore, the first recommendation is to define the content of the tender-to-supply handover meeting and the tender documentation package to ensure a smooth handover between the teams and the availability of the needed information for forecasting. The content of the meeting and documentation package should be standardised and documented clearly to ensure that all projects receive the same information at the beginning, apart from the participants.

Another finding during the current state analysis was that there are no proper tools for extracting the actual material cost from SAP; it is manual and laborious. Because one step in the guidelines includes the usage of actual material data from SAP, the second recommendation is to build the reporting tool to retrieve the supplier-confirmed pricing data from SAP. The easier the data is to retrieve from SAP, the more probable it is that it will also be used for forecasting. This will ultimately lead to better forecasting accuracy and improved visibility of unit monthly results.

In the validation round, the leadership team proposed investigating how the forecasting process could be extended to support future organisational structures. It was seen as important to harmonise the way of working to ensure that, in the future, forecasting is not exclusively performed in one unit but for all projects that could be considered major. The presentation of the final version of the process has already been agreed upon with stakeholders in other departments, and the next steps will be determined based on the feedback received from them.

The leadership team also proposed extending the forecast process to the tender preparation phase. It was discussed that this could support and bring more control to the discussions of strategic discounts.

The third proposal from the leadership team was to review the proposal with tool developers to verify that future tendering tools will also provide sufficient data to support the forecasting process. The tool development team should consider the needs of project forecasting when preparing the updates for the tendering and reporting tool base.

Recommendations for the next steps are summarised in Table 12.

Table 12. Recommendations for the next steps

	Recommendations for the next steps
1	Refresh and harmonise the supply-to-tender handover meeting content.
2	Harmonise the tender handover documentation content.
3	Reawaken the Click Cloud report development to retrieve confirmed prices from SAP.
4	Review the process with tool developers to ensure adequate output data for the process in the future.
5	Investigate possibilities to extend the process to other units to support future organisational structures.
6	Investigate the possibilities of utilising a similar process in tendering to support price negotiations.

The recommendations shown in Table 12 are not in priority order. All the recommended steps can be done in any order. Recommendations 1, 2, and 3 are related to improving other processes linked to the forecasting process and are in the hands of the unit leadership team to decide. Recommendations 4 and 5 are focused on ensuring that the knowledge gained with this thesis is not lost and can be utilised in the future despite changes in the tools or organisational structures. These actions require support from other units. The sixth recommendation is an additional benefit that could increase the visibility of material cost prices already in the tendering process and therefore help the unit consider different scenarios in price negotiations.

7.3 Self-Evaluation of Thesis Project Credibility

Reliability and validity are considered important criteria to evaluate the quality of business research. However, since these terms characterise more quantitative research, the researchers have different opinions about their relevance for qualitative research. The author of this study has decided to evaluate the study through the four aspects of trustworthiness that Bell et al. (2019) describe in their book and which are based on the suggestions of Lincoln and Guba. (Bell, et al., 2019, p. 48)

Trustworthiness can be described with four terms that have similarities with the quantitative criteria of validity and reliability: Credibility aligns with the quantitative measurement of internal validity and transferability, which then corresponds to external validity and dependability. Parallel reliability and confirmability can be transferred to objectivity. (Bell, et al., 2019, p. 48)

According to Aityan (2021), in order to define a thesis as a credible research project, it needs to have a clear, meaningful business problem and a clearly stated objective. Research phases need to follow appropriate methods that are clearly defined and followed accurately. Data needs to be collected from reliable sources or with reliable and accurate methods and then properly analysed. Relevant knowledge from the literature must be included in the thesis, and it needs to form a link to the research conclusions. The conclusions must clearly answer the business problem and be logically derived from the data collection and literature. Finally, the research phases are reported in a logical and structured way in the research report. (Aityan, 2021, pp. 19-21)

Dependability can be demonstrated in a study by following an auditing approach. It ensures that a complete record of all phases, including methods, data sources, collection of data, analysis, and decisions, is kept and accessible. (Bell, et al., 2019, p. 365)

In this thesis, these criteria were taken into consideration as follows: the business problem was identified by the case company, and a clear objective was set to improve the situation. The business problem and objective of this study are described in more detail in Section 1. Based on the objective, the research approach was selected, and a research design was created. Research design includes four stages, including three data collection rounds and a review of existing knowledge from the literature. The study strictly followed the research design established for the project at the beginning. The research approach and research design are presented in more detail in Section 2, including the reasoning for selections. The execution of the research design is described in Sections 3, 4, 5, and 6.

The credibility and quality of the data in this study can be validated by the triangulation and transparency of the data. From the data plan presented in Section 2, it can be seen that multiple data sources were used and data was collected at different stages of the study. The selection of stakeholders and interview methods were carefully considered for each round, and the results of previous data collection rounds were reviewed at the beginning of the following rounds.

Data 1 started with collecting information from existing process document data, followed by individual stakeholder interviews. Stakeholders selected for Data 1 represented a variety of experiences in their roles. Interviews were carried out as individual interviews to ensure that all opinions were recorded. The data collected from the first round was carefully analysed, and the findings were categorised as strengths and weaknesses under different themes.

Although the selection of stakeholders was done carefully, the limited time also limited the selection of the interviewees. Therefore, if the interviews were carried out with those stakeholders that were left out due to a lack of available time, there might be slightly different weights for the findings. The author of this thesis works in sourcing and is a stakeholder for Supply Managers and Supply Engineers; thus, the comments related to sourcing might be biassed. Regardless of the biases presented, Data 1 can be considered valid and usable for this study.

Data collection round 2 included the same stakeholders as in the first data collection round as well as additional stakeholders from the support function to help with the co-creation workshop. At the beginning of the co-creation workshop, the findings from the first data round were reviewed and validated to be correct. The data collected from the second round was formulated as initial proposals to be presented in the validation round.

Validation round Data 3 included stakeholders from the unit leadership team. The team selected to do the validation is the receiver of the current forecast and

the improved forecast. At the beginning of the validation workshop, the findings from the first data round were presented, followed by the initial proposals from Data 2. The raw data collected from each data collection round is saved and can be found as field notes in the appendices of this study.

Relevant knowledge from literature was collected from reliable sources, including multiple perspectives, and summarised in the conceptual framework of the study. The conceptual framework is presented in more detail in Section 3, and a detailed list of sources can be found in the Reference list of this study.

The conceptual framework retrieved from the literature was then successfully utilised in the co-creation process for building the initial proposal. And the final outcome, which followed the logic of the conceptual framework, was transferred into practical instructions and embedded in the existing project framework process.

Transferability, which evaluates the generalizability of the results, is not considered for this study since the study is conducted for the specific business problem identified in the case company and the outcome of the study is built based on the inputs from the case company and therefore is not transferable.

The final term of the four criteria of trustworthiness is confirmability, which evaluates the objectivity of the researcher. Since complete objectivity is impossible to achieve, the impact of the author on this study can be evaluated through transparent documentation. As already mentioned, the author of this study is a stakeholder in the operative personnel executing the current forecasting process. The author is involved only in the sourcing-related parts of the process. For the other parts of the process, the author has no impact. For data collection round 3, the sole impact of the author was tried to minimise by including additional sourcing stakeholders in the co-creation process.

A couple of words about relevance: for this study, relevance is evaluated based on the relevance of the study to the case company. The case company had identified a business challenge where the forecasting process for the projects

was not working properly. Projects were not able to evaluate possible material cost change impacts on their profitability, which made unit financial result forecasting difficult. The objective set for this study was to develop guidelines on how to improve the material cost change forecasting process in projects.

Stakeholders working with the existing process were involved in identifying the weaknesses in the current process as well as creating the initial proposal to improve the weaknesses found. Initial proposals were validated with the unit leadership team that originally initiated the business problem. As an outcome, guidelines with practical instructions on what steps need to be taken in order to improve material forecasting in projects were developed. Guidelines are embedded in the project framework process to help Supply Managers and Supply Engineers find the correct steps in each project phase. Thus, the outcome of this study can be considered relevant to the case company, and therefore the objective of this study is fulfilled.

7.4 Closing Words

Forecasting is an important topic for the case company. This study started with a one-unit observation of an issue with forecasts, but during the study, the topic sparked interest in other units in the case company, and there is a true interest in extending the outcome of this thesis into practise in other units as well. It has been rewarding to build the solution with the team since the practical instructions created will help them perform better and help the unit reach its goals.

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Current state analysis interview questions

Supply Manager / Supply Engineer

Plan a delivery project:

Supply-to-Tender handover meeting:

- What kind of documentation is received from the tender team? (e.g., tender letter, CMB, supplier RFQs)
- How do you verify the validity of the supplier's quotation? (RFQ summary)
- What additional information would you need for forecasting?
- How well do the tender-to-supply handover meetings work? (content of the meeting, information shared)
- How is the validity of the price list checked? (What price list is used for tendering?)
- How are the material cost forecasts for the project checked?
- How are the current price level changes communicated?

Creating a control file:

- How is the forecast defined when the control file is created?
- How do you get the information if the price list has changed?

Perform order engineering

Sourcing process:

- How does communication with sourcing work? (meetings, documents, etc.)
- What phases of the process do you usually contact for sourcing?
- How are the material prices reviewed?
- How are the supplier quotations documented?
- How are the risks of price increases or opportunities for extra savings due to price decreases communicated?

Variations:

- How are the variations forecasted?
- How is the validity documented?

Monthly reporting:

- How is the price forecast updated in the control file?
- In what ways is the special material forecasted?
- In what ways is the standard material cost forecasted?
- Are the forecast costs reviewed with sourcing or any other stakeholder before reporting?

Purchase, manufacture, and deliver materials

Monthly reporting:

- How is the price forecast updated in the control file?
- In what ways is the special material forecasted?
- In what ways is the standard material cost forecasted?
- Are the forecast costs reviewed with sourcing or any other stakeholder before reporting?

Lessons learned:

- How are the lessons learned utilised?

Tender Engineer:

Prepare tender:

Pricing tools:

- How often are the price lists updated in the MPCT tool?
- How is the uploading process done, and how long does it take?
- What indicates when the price lists need to be updated?
- How do you define possible future risks for material increases?
- How is the pricing tool version history documented? Can you see what price list version has been used for tendering?

Tender documentation

- How are the tender price calculations documented?
- How are the supplier quotations documented?

Updating tender:

- How do you make the update to the tender if there is no specification change but only the tender's validity needs to be extended?
- How are the price change risks identified?

Tender supply handover meeting:

- How are cost changes evaluated in tenders?
- How are the price list changes in tenders communicated to the supply team?
- How are the price risks communicated to the supply team?

How well do you get the information from the project closing meetings?

If you have special materials, how much do you rely on sourcing help?

Field notes from current state interviews

Phase	ID	Comment
Prepare tender	#SE3-1	All special solutions have been properly documented and checked carefully with engineering for possible additional costs. The documentation has been so clear that it has been easy to review later on and understand how the pricing has been done.
Prepare tender	#SM3-2	I have understood from tendering and sourcing that the price list that tendering is using might not be the latest one. And this might lead to the situation that even if we re-tender the project, the latest actual price is not used for tendering.
Prepare tender	#SM3-3	I have heard that the price lists are updated in the pricing tools once a year, so there might be a cap between the tendered price and the actual price due to this.
Plan a delivery project	#SM1-3	I have not seen any RFQ summary, but it would be a good idea.
Plan a delivery project	#SM1-4	It is not clear how some special prices are calculated; is it someone's own estimation or is a quotation used?
Plan a delivery project	#SM1-5	It is not clear what specification is used to define the price, like the part number or drawing number.
Plan a delivery project	#SM4-1	I have not received any kind of summary about the RFQs, but sometimes the tender engineer has provided information about the asked prices.
Plan a delivery project	#SM3-5	I have not received any RFQ summaries from tendering.
Plan a delivery project	#SM2-1	There is no general view, list, or summary available of the supplier quotations that have been requested during the tendering or delivery phases. It would make sense to list the RFQ numbers and validity dates somewhere.
Plan a delivery project	#SM2-2	The module cost breakdown does not include any details automatically, only module level prices. I need to ask about it separately. But it has, for instance, revealed to me some pricing mistakes, like prices missing from certain components, etc.

Phase	ID	Comment
Plan a delivery project	#SAH1-3	There might be big price caps if the tender update has been postponed multiple times and finally decided to update.
Plan a delivery project	#SM1-8	Sometimes, when the tender validity has expired, FL asks for an extension of time. The decision is made by management. If the extension is granted, the difference between the time of tender and the present will increase. Impact is not communicated.
Plan a delivery project	#SM3-1	Even though the tender letter is valid, the pricing in the module cost breakdown is not based on the latest price lists. Therefore, it is difficult to get a full understanding of the price level. There is no separate checking process for this.
Plan a delivery project	#SSM1-9	There was once a percentage increase agreed upon for the prices when the latest price lists were not yet updated in the pricing tools.
Plan a delivery project	#SM1-6	It is not clear how old price lists are used to calculate the tender price.
Plan a delivery project	#SM2-3	There is nothing that tells me if the standard material prices have changed, but the same issue occurs during the delivery phase. A project can take several years, and there is nothing that indicates to me in what direction the material prices have changed.
Plan a delivery project	#SM1-7	We are not able to see how the prices have been developing from the time of tender to the current moment. We don't have such a tool. It would require manual investigation, and finding the actual price is not so straight-forward. We would need to know in which order each component is delivered, and it needs to be done component by component.
Perform order engineering	#SM4-8	Standard materials seem to be the most difficult to forecast. If there are no changes to the specification after the tender is approved, these will fall off the follow-up list, and the truth is revealed only after the actual costs are recorded in the control file.
Plan a delivery project	#SM1-9	If the validity has expired, the tender is recalculated with the present-day prices.

Phase	ID	Comment
Plan a delivery project	#SE2-1	The tender-to-supply handover meeting has worked nicely. A handover meeting template has been used, and it includes all the right things. Quality and price risks have been raised. Also, information about price increases was shared in the meeting.
Plan a delivery project	#SSM1-8	It depends on the participants how much you can get out of these meetings, and sometimes when the project is new, you might not be able to ask the right questions at that point. But the tender team will also help in later phases if something was not clarified during the meeting.
Plan a delivery project	#SE2-2	The focus on the specification could be a little less because the specification will be checked in the full chain start-up meeting.
Plan a delivery project	#SE3-2	There are not many comments about material costs, but if there is a special solution with a lot of engineering, it has been communicated that it includes a lot of engineering because the solution tendered is complex.
Plan a delivery project	#SM4-2	I'm not sure if the price risks are part of the check list that is used as a template for the handover meeting. Generally, it might be mentioned if there is a risk with certain prices but no increase in percentage or euros.
Plan a delivery project	#SM3-7	If module costs are not okay, it will impact our capability to forecast project results. If the price errors are not corrected, the wrong price will remain the base during the whole project, which will lead to wrong forecasts.
Plan a delivery project	#SM3-8	According to my experience, in standard materials, price errors are mainly due to price list errors at first, and in special materials, pricing errors are due to wrong estimates.
Plan a delivery project	#SE3-3	Only pricing mistakes have been cases that I have forecasted.
Plan a delivery project	#SM4-3	If there have been pricing mistakes in tenders, those I have forecasted. Usually, those are found out during the tender supply handover meeting.
Perform order engineering	#SM3-11	I'm a bit conservative when it comes to forecasting. There could be some issues, like pricing mistakes, etc., that would make sense to forecast at the very beginning.

Phase	ID	Comment
Perform order engineering	#SM2-6	I will add to the forecast numbers if there are any pricing mistakes found during the tender-to-supply handover meeting. This way, the project forecast already includes this possible price difference.
Perform order engineering	#SAH1-4	There is no common way of storing the RFQs and communicating them to SMs. These could also be available for SMs as well as the RFQ summary in the ordering phase.
Perform order engineering	#SSM1-3	There seem to be different kinds of source plan versions available depending on the person. It would be more clear if everyone used the same template.
Perform order engineering	#SSM1-4	The source plan might not be fully utilised.
Perform order engineering	#SM4-4	Usually the sourcing process works fine, and I have received all prices or even more than I asked for, but there is no summary of RFQs and also no input on how they differ from tendered prices. There is also no indication if there are any changes in standard material prices.
Perform order engineering	#SM2-7	I'm not sure if we have access to the source plans; the sourcing person is presenting them in our weekly meetings.
Perform order engineering	#SM3-16	There have been no project budgeting discussions with sourcing, but after the project is finally billed, the results have been reviewed from the sourcing files.
Perform order engineering	#SM3-13	Weekly meetings have no one agenda but depend on the project phase. Like special design details, clarifications, and prices, in the ordering phase if there are some unpriced components in the PO team's lists, and afterwards the project result will be reviewed.
Perform order engineering	#SM2-8	In weekly meetings with sourcing, some bigger quotations are reviewed, but there is no discussion about standard prices.
Perform order engineering	#SSM1-5	It makes it difficult to forecast even special materials if the module contains both standard and special materials. It is difficult to identify what the price estimated for this one special component in the module was during the tender phase to be able to compare with the RFQ.

Phase	ID	Comment
Perform order engineering	#SM1-13	Forecasting process = crystal ball process
Perform order engineering	#SE3-7	I don't have the competence to understand what data is reliable in SAP, so I'm not sure if I can trust the data I receive from SAP.
Perform order engineering	#SE3-13	There are no clear instructions on how to do the forecast, and I have not been trained to do it. I have been asking here and there and then completing those with my own thoughts. Some kind of training would be nice.
Perform order engineering	#SM3-14	I have not very actively searched SAP for any standard material actual prices. I hope that we could get a tool or clicksense report that would give this information automatically.
Perform order engineering	#SM2-11	SAP's actual price data is not always so accurate. It depends on the component and how well and when the costs are recorded in the system. Also, if you have a big project, you still need to go through all the modules.
Perform order engineering	#SSM1-2	We are able to ask the supplier for RFQs quite late in the process because only after the engineering is completed can we get accurate enough prices.
Perform order engineering	#SM4-7	I have used RFQs from sourcing to forecast material changes and, only in very special cases, checked actual prices from earlier deliveries, but it is not common practise. Standard materials are not checked unless there is a very special need.
Perform order engineering	#SM3-15	If I knew that there was price risk, I would have followed the actual prices in SAP and forecasted those. Also, if I get information from the supplier's RFQ that there will be a significant price change compared to the tender, I have forecasted that.
Perform order engineering	#SM2-4	Special materials: yes, we get updated prices via RFQs.
Perform order engineering	#SE3-4	Weekly meetings with sourcing are good practise. During the meetings, the sourcing manager has provided information, for example, about whether some components should be purchased from China or not.

Phase	ID	Comment
Perform order engineering	#SM4-5	RFQs and prices are discussed in weekly meetings with sourcing.
Perform order engineering	#SM3-6	The latest source plan template lists all RFQs recorded.
Perform order engineering	#SM3-12	It is important to have weekly meetings with sourcing, not just some files that the sourcing team is sending, but to check everything together. I see that as a very important way of communicating.
Perform order engineering	#SE2-3	The sourcing process is working well; in weekly meetings, RFQs are discussed and reviewed if there are any changes.
Perform order engineering	#SM4-6	Variation notification validity time should be included, especially if the tendered variation is expensive. I'm not sure if it is common practise since there is no common template that is used when VPNs are sent, only freely formulated e-mail messages.
Perform order engineering	#SM3-18	VPNs that are not yet approved have no clear instructions on whether they should be forecasted or not. One way to communicate would be good.
Perform order engineering	#SM2-10	VPNs could be one way to get input about pricing issues in some modules or components. When calculating the change during the pricing, it is noticed that tender time prices are not the same anymore. For example, extra pieces of the same component are added to the order.
Purchase, manufacture and deliver materials	#SAH1-5	Forecasts are inserted manually into the control file, and if you have a big project, it is laborious to collect all the data at a detailed level.
Purchase, manufacture and deliver materials	#SE3-12	I have heard comments that someone didn't have time to do the forecast because it was additional work. The process or the tools should be so easy and simple that, no matter the size of your project, it wouldn't take you one week to complete it.

Phase	ID	Comment
Purchase, manufacture and deliver materials	#SM2-9	Usually, I don't check the forecast for standard materials because it is really laborious to go through the standard prices component by component. Only if I have received input somewhere that there could be some issue with the prices in some certain component, then I have asked the tender team to recalculate the prices, and from them I got an updated price.
Purchase, manufacture and deliver materials	#SM1-15	Actual material prices are recorded in the project control file only when materials are left at the terminal, which is too late.
Purchase, manufacture and deliver materials	#SM2-12	The control file is collecting the actual data automatically for the project, but the actual costs are recorded only when the materials have left the terminal for the site. Sometimes when the installation schedule is delayed, the materials could wait in the terminal for quite some time, and in those cases, the actual costs are not recorded in the control file.
Purchase, manufacture and deliver materials	#SE3-9	This is really useful practise. I use the data collected from these meetings to see if there is anything related to my new project to which I need to pay attention.
Purchase, manufacture and deliver materials	#SE3-10	We have a lot of super experts in our team, and it would make sense to collect the silent knowledge somewhere where it could be utilised easily so that one wouldn't need to ask the same questions again.
Purchase, manufacture and deliver materials	#SM2-14	One project could take quite a long time until it is closed, so those lessons learned should be shared during the project already. For instance, if we wait with some findings related to tendering until the lessons learned are recorded in the tool, the tendering team has tendered several projects during that time.
Purchase, manufacture and deliver materials	#SM4-9	There is information shared between the projects, and findings are raised in weekly meetings with sourcing for possible actions.
Purchase, manufacture and deliver materials	#SM3-17	Pricing findings are recorded in the Lessons Learned tool, but I don't systematically use them, and I don't know if they are shared with the tender team.

Phase	ID	Comment
Purchase, manufacture and deliver materials	#SM2-13	Lessons learned from the project are recorded in the tool, but the information is not shared in any systematic way with the stakeholders, like with tendering or sourcing. Usually, the people involved are invited, and the assumption is that they will share the information forward in their teams.
Purchase, manufacture and deliver materials	#SM1-16	I think it is a really beneficial meeting. Project costs are reviewed, and learnings, like where to find savings and what to avoid, are shared. You can get really good tips there.
Perform order engineering	#SM1-11	Supplier RFQs provide actual price information, but accurate prices can be received only after engineering is completed and manufacturing drawings are available. Sometimes SM can take the risk and start preliminary engineering to get the manufacturing drawings available earlier.
Perform order engineering	#SAH1-2	Only those cases are forecasted where there is a clear difference between tendered and RFQ prices.
Perform order engineering	#SSM1-6	If I know that there are pricing mistakes in the tender or if, after the layout engineering, it turns out that we need to use different components that were originally tendered, those are usually put into the forecast.
Purchase, manufacture and deliver materials	#SM1-14	Supplier RFQs provide actual prices, but only for some parts of the materials. The rest of the materials you would need to go to SAP or, based on the first elevators delivered to the project, some estimation can be done based on those, but the data collection is purely manual. It is laborious.
Purchase, manufacture and deliver materials	#SE3-6	I have used the data in SAP. When the supplier confirms the purchase order price, it is recorded in SAP, and sometimes I have manually extracted this information from SAP. It is manual work and needs to be done component by component, so some kind of tool for this would be nice.
Plan a delivery project	#SM3-4	I have received some really high-level indications of price changes, but not anything that would have been divided at the module level, not any details. I believe that it is based on one person's own experience and opinion about the situation.

Phase	ID	Comment
Perform order engineering	#SSM1-7	If I found out that prices for some components have increased significantly, I might add these to the forecast. Usually, the information is received from earlier deliveries but also from supplier RFQs.
Plan a delivery project	#SM1-2	The tender is divided into module prices, which are used to fill the project control file.
Perform order engineering	#SSM1-1	Is sourcing able to give a general percentage of raw material increases that could be used in forecasting?
Perform order engineering	#SM1-10	Source plan creation should happen as early as possible to ensure that engineering takes into account possible country of origin limitations.
Perform order engineering	#SM1-12	Full component samples and mock-ups can be used to get the manufacturing drawings and prices earlier.
Perform order engineering	#SE3-5	I'm not sure if variation pricing is a competence that a supply manager or engineer should have.
Perform order engineering	#SE3-8	I have also wondered: if I don't have time to start the sourcing process and ask for RFQs, how can I then forecast specialities?
Purchase, manufacture and deliver materials	#SE3-11	It would be interesting to know if we could utilise pricing tools from tendering to forecast material costs.
Prepare tender	STE1-1	I have used our own unit sourcing quite often for Chinese materials. When we have only components from China, I have asked sourcing to ask for quotations from Chinese suppliers to get an up-to-date price because there could be a big difference in the quoted price depending on who is asking for the quotation. I believe the Chinese tender team is just asking for the price from some supplier, and it might not always be correct.

Phase	ID	Comment
Prepare tender	STE1-2	I save all supplier quotations to the tender folder on the server. Prices are just marked in the project summary file, and the whole email is saved to the tender folder. Then, before the tender to supply handover meeting, I will go through my mailbox and review all e-mail exchanges that are related to the project and save those to the tender folder.
Prepare tender	STE1-3	We don't have any existing process for collecting the tender time quotations.
Prepare tender	STE1-5	I don't use any additional multipliers to compensate for possible material cost changes compared to our standard price lists in our pricing tools. Management can give separate instructions to use multipliers if they see that they are needed. We had this kind of case some time ago when the material prices increased heavily, but the pricing tool price lists were not yet updated. I generally think that the price lists from suppliers should be up-to-date and not that everyone should think for themselves if they need to use an additional multiplier.
Prepare tender	STE1-6	We make the quotations with today's prices and do not consider any risk factors for material price changes during the first 2 years. But I don't have any actual information because I'm not involved in price list creation.
Prepare tender	STE1-7	When the tender is updated, I will check if price lists have been updated in the meantime. If there is an update, then I will calculate the whole project with the new prices, but quite often I check with management if we are going to release the full impact to the tender or if we will adjust the increase.
Prepare tender	STE1-8	It is not very fast to update the prices with the tool because each unit needs to be checked and all components, if not in the pricing tools, have to be imported manually to the new tender.
Prepare tender	STE1-9	When I update the tender, I usually check where the price difference is coming from.

Phase	ID	Comment
Prepare tender	STE1-10	I would like to see more feedback from the supply on whether the pricing has been successful. Now it depends on the supply manager if these are checked together with the tender engineer.
Prepare tender	STE1-11	I have shared the information in the tender to supply handover meeting if the tender has been extended without price increases and if I have rechecked the prices.
Prepare tender	STE3-1	If there is Chinese material needed, I will ask for component prices from the China tendering team. They will provide the tender letter for the materials.
Prepare tender	STE3-2	We have been asking for new quotations from China. We also have some China price lists in our pricing tool that we are not asking for from the China tendering team.
Prepare tender	STE3-3	Chinese price lists are updated once a year. Usually at the beginning of the year, I will send the uploading files to the China team and ask them to download the prices from their tool.
Prepare tender	STE3-4	Prices are transferred manually from price lists to the upload files.
Prepare tender	STE3-5	European materials were updated earlier also once a year, but last year this was changed, and now they are updated twice a year. The rhythm has been in spring and in autumn.
Prepare tender	STE3-6	I will collect all new price lists from sourcing, and it will take approximately two weeks to get the files ready. Then I send those to the data processing team, and it will take approximately 6 weeks to upload the prices to the tool and test it because there are so many manually inserted formulas inside the tool. So the upload of the new price lists takes approximately 2 months until the new prices are in use.
Prepare tender	STE3-8	All quotations that are requested are saved under the tender folder, but there is no summary of the quotations.
Prepare tender	STE3-9	Special material prices that we have in the tool are based on previous delivery prices or special price lists, which are updated from time to time.

Phase	ID	Comment
Prepare tender	STE3-10	MPCT version is visible in the project summary, and it is copied to the project summary. When you enter the MPCT tool, you can see from the version history what the latest updates have been.
Prepare tender	STE3-11	Yes, these are separated in the MPCT file on their own sheet.
Prepare tender	STE3-12	If I know that there is a newer version of the MPCT, I will run the project with the newer version, but it takes quite a lot of time since the file is quite slow. I don't have any multipliers in use.
Prepare tender	STE2-1	If we have approved suppliers, the tender team can ask for quotations directly and keep sourcing in the loop, but there could be more junior-level tender engineers who might need more sourcing assistance.
Prepare tender	STE2-2	In my opinion, when ever we are asking for prices outside our company, sourcing should be involved at least as a copy on email.
Prepare tender	STE2-3	We should save all quotations to the tender network drive under the tender folder, but not all tender engineers follow these instructions.
Prepare tender	STE2-4	I will add the screenshot of the quotation email to my calculation files. It is easier for anyone to continue the tender.
Prepare tender	STE2-5	Yes, it is very important that we provide the cost breakdown.
Prepare tender	STE2-6	Chinese materials once a year, but European components more often. European components are not updated all at the same time, but there could be update rounds that include only part of the components.
Prepare tender	STE2-7	I think it is linked to the calendar so that the updates are always done in a certain month.
Prepare tender	STE2-8	We have indexes in the tender letters that will be added after the first two years, but for the first two years we don't add anything.
Prepare tender	STE2-9	On some big projects, we have sometimes used a multiplier to extend the tender validity, but that multiplier has been defined by the management.

Phase	ID	Comment
Prepare tender	STE2-10	We don't have, for example, a proper price list for some special components, so in those cases, I have told the project that these prices are based on some old estimations.
Prepare tender	STE2-12	In our special material price lists, we have some materials that are really old if they have not been delivered for a while. In those cases, we have to utilise some multipliers to get an understanding of today's price level.
Prepare tender	STE2-13	Yes, we have sometimes participated in these meetings and shared the information within our team. But these are quite rare, and there could be more of this kind of information sharing between supply and tendering.

Preparation questions for initial proposal building workshops

PLAN	ENGINEER	DELIVER
STAKEHOLDERS: Tender Supply Sourcing	**STAKEHOLDERS:** Supply Sourcing	**STAKEHOLDERS:** Supply Sourcing

SCOPE: (same scope for all phases or not?)
On what level should the forecast be created?
(Component / module / product / project level, or something else...)
How far should we be able to forecast? (next month / quarter / half a year / year / more...)
How often should the forecast be updated? (Once a month / quarter / half a year / year / less...)

DATA: (same data for all phases or not?)
What data can be used for forecasting? (SAP, sourcing data, tender data...)
What data is available for each process step?
Who can provide that data?
Is it usable as such, or does it require polishing?

FORECAST: (same model for all phases or not?)
Can we use COST x MULTIPLIER = FORECAST?
How should the starting level for cost be defined?
What multiplier should be used? Is it suitable for all phases?
What are the main challenges?

FEEDBACK:
How do we get feedback during and after the process about the accuracy?
(Lessons learned shared from other projects; adjust own forecasting)

Tasks:	Resposibilities:
Concrete ideas for what should be done	Who should be doing it?

Field notes from initial proposal building workshops and interviews

TOPIC	COMMENTS	TIME
	Tender price baseline: What is the price list version used for tendering? (date when the price list was updated last time)	
DATA	a. Can be checked from the MPCT tool version history	(00:15:10)
DATA	b. To be recorded in the handover meeting check list	(00:21:51)
SCOPE	c. For EU and CHN materials separately	(00:33:35) (00:37:09)
SCOPE	A forecast should be created at the module level for each elevator.	
	a. Easier to split in DGs	(00:30:43)
	b. Project control file supports	(00:31:37)
	Component-level forecasting possibility in the same cost breakdown file	(00:35:17)
	a. Actual prices are easy to include in the forecast	(00:35:30)
	b. Single-item forecasts are less accurate (Sanders II principle)	(00:36:06)
SCOPE	Forecast needed on project currency	
	a. Supports the finance department with hedging	(01:08:54)
DATA	Own price forecast index needed for both EU and CHN materials	(00:37:57)
DATA	a. Include different scenarios depending on the tender price baseline (e.g., 2020 vs. 2023, 2021 vs. 2023, 2022 vs. 2023, etc.)	(00:23:00)
	b. Add the data to the comparison tool (Power app.)	(00:25:17)
	c. Raw material changes are different in China and Europe	(00:37:09)
SCOPE	Forecast frequency:	
	First forecast when the order is received and the updates:	(00:04:16)
	a. Once a month when there are 3 months or less until the delivery	(01:03:47)
	b. Once a quarter when the project is budgeted (12 months)	(00:21:24)
	c. Once a year before budgeting	(00:21:11)
	Forecast horizon:	

TOPIC	COMMENTS	TIME
	a. The project should be forecasted up to the final delivery date	(00:31:56)
	b. Some projects might exceed a 3-year horizon i. Forecast starts to get flat after the third year; use the 3rd year index	(00:32:31)
	"Short-term" forecast (today's price level):	
DATA	a. Forecast based on actual purchase prices from SAP i. Available shortly after the creation of the PO ii. Actuals are available at the component level iii. The price is valid only for one PO iv. How to fill missing prices (gaps): 1. Ask the supplier 2. Use the standard price from the price list 3. Check the non-standard price in the RFQ 4. Use the component-level forecast	(00:26:50) (00:35:17) (01:33:46) (01:39:09) (01:52:33) (01:35:26)
	a. "Cost models" could be created for the tendering tool to compare changes between price list changes i. Prices are available at the module level ii. The future of the MPCT tool is not clear iii. Can this be used with the new KTOC tool?	(01:01:22) (01:01:47) (01:02:10) (01:02:37) (01:02:53)
	"Mid-term" forecast (3-12 months)	
	a. The forecast is based on the index extracted for standard price list changes i. Prices are on the supplier level only; they are difficult to use ii. Validity time can vary	(00:39:54) (00:40:21)
DATA/ MODEL	a. The forecast is based on forecasting indexes from existing cost models i. Prices are available at the module level ii. Does it include EU and CHN products? iii. It includes labour cost changes, raw material changes, sourcing, and R&D actions iv. Visibility is approximately 12 months ahead	(01:12:52) (01:12:52) (01:16:11) (01:13:48) (01:14:36)
	"Long-term" forecast (> 12 months)	

TOPIC	COMMENTS	TIME
DATA/ MODEL	a. The forecast is based on a commodity price index i. It is updated monthly ii. It is available for the main raw materials iii. It includes a rolling 15-month forecast	Project Manager Interview
DATA/ MODEL	a. The forecast is based on the inflation index i. One index can be applied to the full project ii. It reflects general price level changes iii. It includes a forecast for the current year plus two years ahead	Sourcing Head Interview
MODEL	Creating forecast	
	a. Price indexes are defined for each module (raw material type/CHN/EU) b. Module cost breakdowns from the tender can be used	(00:37:57) (00:37:55)
	How to forecast special materials	
ACC	a. Special components are difficult to forecast; can they be forecast separately? b. Use reference prices c. Use supplier RFQs	(00:56:27)
	Adjustments to the forecast	
ACC	a. Review if price level information is available from other sources or projects with sourcing b. Review the forecast when the first actuals became available for the first deliveries for the project c. Review the forecasting possibilities for difficult modules separately	(00:59:02) (01:11:11) (01:49:36) (00:59:29)
	Comments (for later consideration): a. It is not known what the future of the MPCT tool will be or if it will be used in future tenders anymore (no updates to the tool?) b. How can the price list version used in KTOC tenders be checked?	

Workshop 1: 16.3.2023 (1 hour 26 min)

Workshop 2: 22.3.2023 (2 hours)

Interview 1 and 2: 2.3.2023 and 6.3.2023 (20-30 min)

Whiteboards from initial proposal building workshops and interviews

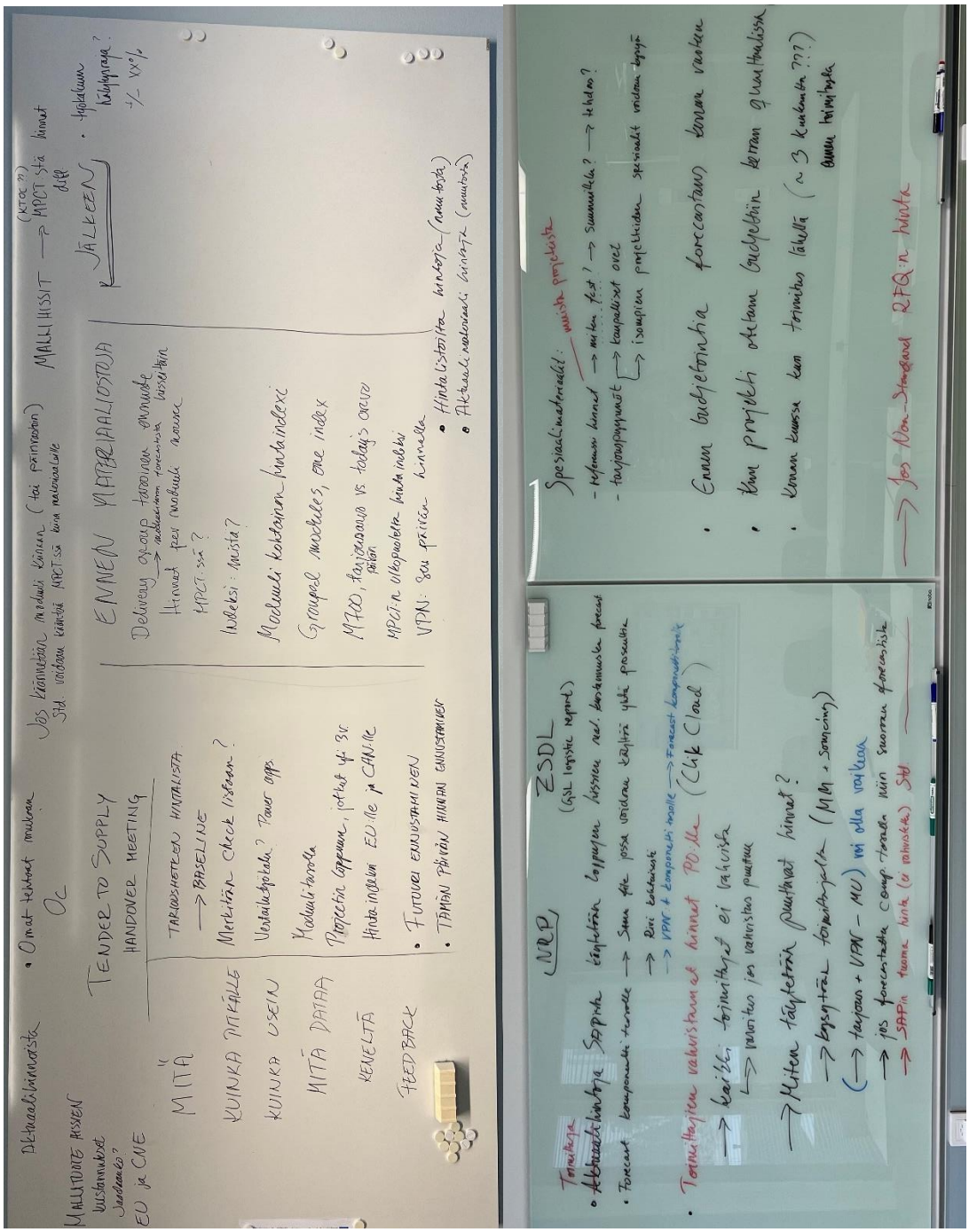

Figure 1-1 Whiteboards from co-creation workshops

Field notes from the validation workshop

AREA	TOPIC	TIME
	Tender price baseline:	
DATA	How about the base line for the special materials? • The RFQ date can be used as a base line for c-process materials. ➢ To be included in the instructions.	(0:17:54)
DATA	Can there be different dates for different components? How do we manage these situations? • There is a decision to update the pricing tools every three months in the future. • Separate dates should be recorded as the base line for modules if price list update dates deviate more than 3 months from other modules. ➢ To be included in the instructions.	(00:20:48) (00:21:22)
DATA	There are new pricing tools coming; how can we ensure that the process is working with those as well? • Validating the new tools should be the next step. • Based on this study, we can share the requirements with the tool development team. ➢ Next step: review the process with tool developers.	(00:21:57) (00:24:21) (00:25:24)
SCOPE	It was agreed that it does not add any value to try to forecast further than 3 years ahead.	(00:28:43)
	Forecasting frequency: • An annual forecast once a year is reasonable. • Forecasting should be linked to annual index discussions with sales organisations according to the project calendar. ➢ To be included in the instructions.	(00:31:24)
SCOPE	Forecasting frequency: • A monthly forecast three months before expected delivery is reasonable at this point. It can be adjusted later, if needed. • Forecasting should be linked to the monthly sales reporting cycle. ➢ To be included in the instructions.	(00:32:43)

SCOPE	Forecasting frequency: • The quarterly forecast should start 18 months before expected delivery. This will support early budgeting. • Forecasting should be linked to the quarterly RUSH reporting cycle. ➢ To be changed in the instructions.	(00:33:01)
	This study is currently focused on our unit, but there are other units that deliver large projects as well, so we should look into the future and try to find a common way to forecast projects with high monetary value and a long lead time. ➢ Next step: investigate possibilities for extending the process to other units.	(00:41:55)
	There is an interesting opportunity if we could utilise this in the tendering phase to build an understanding of what the estimated cost level could be at the time of delivery. It could help with price negotiations if we understood if the cost level would go up or down. ➢ Next step: investigate possibilities for utilising the process in tendering to support price negotiations.	(00:45:06)
SCOPE	Forecasting frequency: How about when we need to split the module into several delivery groups? Is that causing issues with the forecasting? • For the monthly sales forecasting, we have supplier-confirmed prices available from SAP, which allows quite accurate delivery group pricing. • Quarterly forecasts for divided modules can be split in proportion to module splits. ➢ To be included in the instructions.	(00:50:57)
	It is important that we put focus on this because the original issue has not vanished anywhere; instead, we have had quite recently some cases where the expectations of the result were high, but finally the outcome turned out to be something totally different. It is a big hit to our result. We need to manage this better.	(00:53:42)
SCOPE	The forecasting unit should be in euros. The unit is reporting the result to the financial team in euros, so it would make sense to also create the forecast in euros. ➢ To be changed in the instructions	(01:02:39)

GUIDELINES - Material cost change forecasting in projects

GUIDELINES - Material cost change forecasting in projects

Milestone	#	Task	Assignment	When	Notes / Instructions
Plan delivery project	1	Identify the date when the price lists were updated last time to the tendering tool for EU and China materials	Tender engineer	Tender to supply handover meeting	1) Record the date to the handover check list 2) For c-process materials use the quotation date 3) If the price list udate dates differ significantly (3 months or more) then record separate date for those modules
Plan delivery project	2	Collect the tender cost data at module level	Tender engineer	Tender to supply handover meeting	Module cost break down file with component level prices
Plan delivery project	3	Verify that tender price exists for all components	Tender engineer	Tender to supply handover meeting	Missing prices to be recorded to the tender cost for forecasting
Plan delivery project	4	Create project control file	Suppy Manager/ Supply Engineer	After Full-chain start up meeting	
General	5	Update forecasting index to the sourcing sharepoint	Sourcing	Reqular updates	1) Cost model index every three months after cost model review round 2) Commodity index every three months after monthly reporting cycle 3) Inflation index once a year during budgeting 4) European indexes and Chinese indexes separately
Plan delivery project	6	Select forecasting index based on project initial delivery group plan	Suppy Manager/ Supply Engineer	Together with project control file creation	1) Cost model index when forecasting horizon is less than 1 year 2) Commodity index when forecasting horizon is more than 1 year 3) Inflation index when forecasting horizon is more than 2 years 4) Use 3 years index if initial delivery plan is more the 3 years
Plan delivery project	7	Create initial project forecast on module level	Suppy Manager/ Supply Engineer	Together with project control file creation	Forecast = Tender price x forecasting index (EUR) 1) Forecast to be created on module level 2) Forecast European and Chinese materials separately 3) For the modules divided in different delivery groups use the full module forecast divided according to the delivery group split
Plan delivery project	8	Review recieved forecast with sourcing	Suppy Manager/ Supply Engineer	Before first project reporting	
Plan delivery project	9	Review project forecast to see if manual adjustment is needed	Sourcing	Before first project reporting	
Perform order engineering	10	Update project control file	Suppy Manager/ Supply Engineer	Before project reporting	
Perform order engineering	11	Review if forecast needs to be updated	Suppy Manager/ Supply Engineer	1) For the monthly sales forecast 2) For the quarterly RUSH reporting 3) According to the project calendar when FL index is reviewed	1) Once a month if delivery is within three months or less 2) Once a quartal if project is included into the unit budget or if the delivery will be within 18 months or less 3) Once a year if the delivery will be more than 18 months and the project is not included into the unit budget
Perform order engineering	12	Select forecasting index based on project latest delivery group plan	Suppy Manager/ Supply Engineer	Before project reporting	See intruction from point 6
Perform order engineering	13	Update forecast for project to the project control file	Suppy Manager/ Supply Engineer	Before project reporting	Forecast = Tender price x forecasting index See other instructions from point 7
Perform order engineering	14	Review recieved forecast with sourcing	Suppy Manager/ Supply Engineer	Before project reporting	
Perform order engineering	15	Review the validity of special material RFQs and update if needed	Sourcing	Before project reporting	
Perform order engineering	16	Review project forecast to see if manual adjustment is needed	Sourcing	Before project reporting	Review and adjust against Supplier RFQs if possible
Perform order engineering	17	Repeat from point 10 until no return point is given	Suppy Manager/ Supply Engineer	Repeating until NRP	
Variation requests	18	Identify the date when the price lists were updated last time to the tendering tool for EU and China materials or the date when RFQ was recieved	Tender engineer / Supply Manager / Supply Engineer	When VPN is approved and updated to the control file	Assigned to the one who calculates the VPN
Variation requests	19	Collect the VPN cost data at module level	Tender engineer / Supply Manager / Supply Engineer	When VPN is approved and updated to the control file	Cost break down on module or component level
Variation requests	20	Verify that tender price exists for all components	Tender engineer / Supply Manager / Supply Engineer	When VPN is approved and updated to the control file	Missing prices to be recorded to the VPN cost for forecasting
Variation requests	21	Select forecasting index based on project latest delivery group plan	Suppy Manager/ Supply Engineer	Before project reporting	See intruction from point 6
Variation requests	22	Update forecast for project to the project control file	Suppy Manager/ Supply Engineer	Before project reporting	Forecast = VPN price x forecasting index See other instructions from point 7
Variation requests	23	Review recieved forecast with sourcing	Suppy Manager/ Supply Engineer	Before project reporting	
Variation requests	24	Review project forecast to see if manual adjustment is needed	Sourcing	Before project reporting	Review and adjust against Supplier RFQs if possible
Variation requests	25	Update project control file	Suppy Manager/ Engineer	Before project reporting	

Milestone	#	Task	Assignment	When	Notes / Instructions
Purchase, manufacture and deliver materials	26	Update project control file	Suppy Manager/ Supply Engineer	Before project reporting	
Purchase, manufacture and deliver materials	27	Review if forecast needs to be updated	Suppy Manager/ Supply Engineer	1) Within monthly sales forecast 2) Within RUSH reporting 3) According to the project calendar when FL index is reviewed	1) Once a month if delivery is within three months or less 2) Once a quartal if project is included into the unit budget or if the delivery will be within 18 months or less 3) Once a year if the delivery will be more than 18 months and the project is not included into the unit budget
Purchase, manufacture and deliver materials	28	Upload the supplier confirmed prices from SAP	Suppy Manager/ Supply Engineer	Before project reporting	
Purchase, manufacture and deliver materials	29	Select forecasting index based on project latest delivery group plan for the modules without supplier confirmed costs	Suppy Manager/ Supply Engineer	Before project reporting	See intruction from point 6
Purchase, manufacture and deliver materials	30	Update forecast for project to the project control file	Suppy Manager/ Supply Engineer	Before project reporting	Forecast = Tender price x forecasting index See other instructions from point 7
Purchase, manufacture and deliver materials	31	Use mean precentage error (MPE) to evaluate forecast accuracy when actual costs available	Suppy Manager/ Supply Engineer	Before project reporting	Positive MPE means under forecasting Negative MPE means over forecasting Adjust the forecast for rest of the materials based on MPE result if needed
Purchase, manufacture and deliver materials	32	Review the validity of special material RFQs and update if needed	Sourcing	Before project reporting	
Purchase, manufacture and deliver materials	33	Review recieved forecast with sourcing	Suppy Manager/ Supply Engineer	Before project reporting	
Purchase, manufacture and deliver materials	34	Review project forecast to see if manual adjustment is needed	Sourcing	Before project reporting	Review and adjust against Supplier RFQs if possible
Purchase, manufacture and deliver materials	35	Repeat from point 26 until last delivery group is invoiced	Suppy Manager/ Supply Engineer	Repeating until last DG is invoiced	
General	36	Generate validation forecast from past data	Sourcing	Before implementation	Different projects from three scenarios 1) forecast horizon less than year 2) forecast horizon 1 years 3) forecast horizon 2 years
General	37	Calculate mean absolute deviation (MAD) for validation forecasts and naive forecast	Sourcing	Before implementation	Use tender price as naive forecast MAD = SUM | actual - forecast | / n
General	38	Compare the results agaist validation criteria	Sourcing	Before implementation	Validation criteria: MAD for validation forecast is lower than MAD for naive forecast
General	39	Compare the MAD results against validation criteria on module level	Sourcing	Before implementation	
General	40	Define forecasting method based on forecastability of each module	Sourcing	Before implementation	Identify is alll forecasting indexes work equally well for each module and if some modules are too difficult to forecast and naive model should be used instead.