Towards the Enhancement of Supply Chain Visibility in the FMCG Industry

Design of a comprehensive support tool to assess the maturity of supply chain visibility

L.A. Guleij – TU Delft – MSc. Thesis – August 2021

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Towards the Enhancement of Supply Chain Visibility in the FMCG Industry

Design of a comprehensive support tool to assess the maturity of supply chain visibility

by

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Summary

Background information
The Fast Moving Consumer Goods (FMCG) industry is driven by dynamic competition, globalization, and increasing pressure to improve efficiency and customer satisfaction. The increased uncertainty and complexity of coordination, result in the companies' necessity to innovate and obtain capabilities for responsiveness and decision-making. Hereby, creating supply chain visibility is crucial to oppose the problems supply chain managers are dealing with. However, in many cases limited insight exists into how the right information can be collected and how this visibility can be improved in practice. Emerging information technologies are opening the way for end-to-end supply chain visibility and improved supply chain management. Nonetheless, despite these current technical solutions, it is still challenging to receive the right information across the supply chain that is accurate, complete, in-time and of high quality.

The research goal
A first step towards strengthening the supply chain visibility of FMCG enterprises, is by assessing the performance of the companies' supply chain visibility. Currently, no comprehensive and all-encompassing tool exists that enables the measurement of visibility. Therefore, the research aims to:

Design of a support tool to assess the degree of supply chain visibility in the FMCG industry and find critical areas and opportunities to enhance supply chain visibility

The tool is designed from a business-to-business perspective of FMCG enterprises. Here, the premise is that the tool contributes to awareness for enterprises, finds critical areas for improvement, and offers support for setting action priorities. Furthermore, the tool provides grip for a systematic general and detailed supply chain analysis. This support tool has been developed in the commission of Royal HaskoningDHV (RHDHV), a leading engineering and consultancy firm, for the department Supply Chain & Operations. The support tool is divided into a Visibility Maturity Scan and a Detailed Supply/Demand Analysis.

Exploratory research
In the problem definition phase, practical issues and problems to improve supply chain visibility were identified. An in-depth literature study created an overview of the state-of-the-art on current coordination of FMCG supply chains, the added value of supply chain visibility, and barriers that occur. Also, existing metrics to assess the level of visibility were evaluated. The literature study was complemented with findings from empirical research. Interviews were executed with five supply chain managers of leading FMCG enterprises and various consultants of RHDHV. Hereby, a comprehensive understanding of the problems and complexity of enhancing supply chain visibility is gained. Insights obtained during the problem investigation phase formed the foundation for the design of the support tool.

The design and validation phase
By applying design science as methodology, the theoretical knowledge is transformed into an operational assessment method for the FMCG industry. During the design phase, a conceptual and detailed design was made in an iterative process. The detailed design was developed and implemented towards a digital tool including two analyses. The developed Visibility Maturity Scan exists of four main dimensions to measure the overall maturity visibility level (supply visibility, demand visibility, internal visibility, and others). Four criteria are used to assess information types: availability, accuracy, frequency, and timeliness. Automatically, a report is generated based on answers provided. This report presents the maturity of supply chain visibility, bottlenecks, and major improvement areas. On the other hand, the Detailed Demand/Supply Analysis focuses specifically on the suppliers or customers and are ranked based on the same criteria. Weighted factors can designate the importance of customers and

suppliers, and a dashboard gives insights into opportunities.

Validation sessions with FMCG managers were carried out to test the practicality, overall impression, and added value of the digital tools. The managers confirmed that the tool creates awareness for critical areas, identifies critical suppliers/customers, and provides support for setting action priorities. Also, it can be used as a regular health check and benchmark of the organization over multiple years. Improvement suggestions provided were related to extra elements to include in the assessment and adding general company-specific questions to allow for benchmarking between departments or companies. The main suggestion for the Detailed Supply/Demand analysis was the extension of the tool by ranking the customers based on the quality of master data (source data and base unit of measure).

The tool in practice
A potential risk of using such general tools for analysis is that subjectivity is involved. The evaluation can be biased and opinionated, since subjective elements as timeliness, sufficiency, and accuracy need to be assessed. To transfer these values into objective and less arbitrary outcomes, enterprise-specific information should be collected (strategy, structure, level of digitization etc.), and the importance of the elements and criteria included in the measurement should be determined. This information can be collected during an additional session with the client and action priorities can be determined. The additional information will also allow for more objective benchmarks.

The Visibility Maturity Scan provides grip for FMCG companies and is valuable during the project definition phase, where critical areas within the supply chain can be identified more easily. It can be placed at the website, sent by email, or used during sessions as starting point for further project proposals. The Detailed Demand/Supply Analysis provides detailed insights into the maturity of customers and suppliers in the business-to-business perspective and can be used as part of a project or detailed analysis. The tool can be used for benchmarking to a limited extent, but is more appropriate to monitor improvement processes within the same organization over time. All in all, the tool offers priorities, constraints, and implications that enterprises face in the transition towards a visible supply chain.

Contents

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List of Acronyms

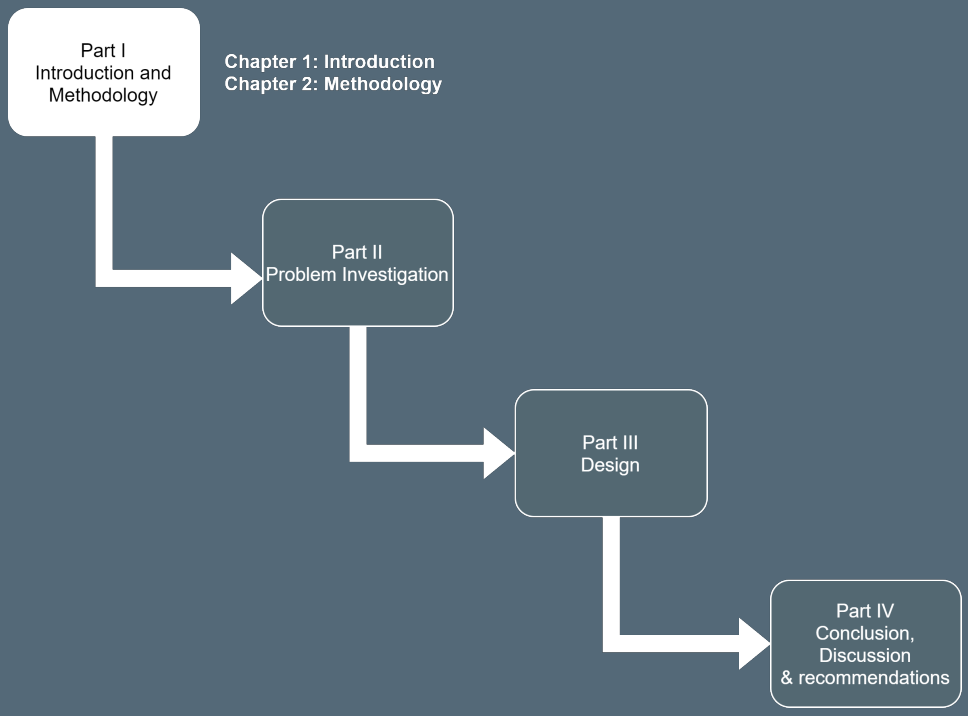
AI	Artificial Intelligence
ASN	Advanced Shipment Notification
B2B	Business-to-Business
CRM	Customer Relationship Management
CPFR	(Collaborative Planning Forecasting and Replenishment
CPG	Consumer Packaged Goods
DC	Distribution Center
ERP	Enterprise Resource Planning
FMCG	Fast Moving Consumer Goods
GPS	Global Positioning System
ICT	Information and Communication Technology
IT	Information Technology
JIT	Just In Time
KPI	Key Performance Indicator
ML	Machine Learning
OLA	Online-availability
OTIF	On Time In Full
POS	Point Of Sale
RFID	Radio Frequency Identification
RHDHV	Royal HaskoningDHV
SAP	Systems Applications & Products
SC	Supply Chain
SCM	Supply Chain Management
SCV	Supply Chain Visibility
SKU	Stock Keeping Unit
TMS	Transport Management System
WMS	Warehouse Management System
3PL	Third Party Logistics

I

Introduction & Methodology

The Fast Moving Consumer Goods (FMCG) industry is driven by dynamic competition, globalization, and increasing pressure to improve customer satisfaction, which makes supply chain management complex. Enhancing supply chain visibility could oppose these problems, but supply chain managers often have limited insight into how this visibility can be improved. A first step that needs to be made to enhance supply chain visibility, is assessing their current performance. Currently, no comprehensive assessment method exists that measures the level of visibility. This thesis aims to develop support tools to assess the maturity level of supply chain visibility and analyses the demand and supply visibility in-depth.

The first chapter starts with a background and problem description of this research. The needs and problems in current FMCG supply chains become clear in paragraph 1.1 and 1.2. Paragraph 1.3 describes the research relevance from three perspectives: scientifically, practically and societal. From these paragraphs, the thesis objective and the deliverable are presented in paragraph 1.4. The chapter is closed with the design scope (paragraph 1.5 and the report outline (paragraph 1.6). Chapter 2 describes the thesis process in six sequential stages (paragraph 2) and the thesis approach (paragraph 2.2). In the latter, the input, tasks, and output per stage performed are given. Also, the data collection methods used are described.



1 Introduction

1.1. Background

In the last decades, the business perspective has been changed by globalization, increasing pressure and dynamic competition (Pundir et al. (2019); Caridi et al. (2010b); Williams et al. (2013)). The increased complexity, uncertainty, continuous change, and the constantly varying customer demands, result in the company's necessity to innovate and obtain efficiencies (Manders et al. (2016). Additionally, building the capability to respond fast to changes is essential for supply chain management (SCM) (Williams et al. (2013)). Hereby, the availability of the right information enhances the level of supply chain visibility and plays a main role to improve management (Wei and Wang (2007); Lummus et al. (2005)). The pressure and complexity in supply chain logistics can clearly be seen in the Fast Moving Consumer Goods industry (FMCG) where visibility becomes increasingly important for enterprises dealing with challenges from different directions and dimensions (Zhiwen et al. (2020)).

The FMCG industry is an important contributor to economic growth and the well-being of countries worldwide. FMCG, also known as Consumer Packaged Goods (CPG), are products that are consumed often, highly in-demand, sold in large quantities, and have relatively low costs. Examples are packaged food, personal care products, and electronics (van Elzakker et al. (2012)). This industry has grown rapidly over the last decades and the market is expected to reach the value of $15,361,8 billion by 2025 which shows an increase of 5.4% from 2018 to 2025 (AMR (2019)). Also, in this sector, globalization, rapid changes in demand, and competition has resulted in unpredictability and instability of the industry driven by disruptions and unforeseen discontinuities (Oraman et al. (2011); Scholten and Schilder (2015)). Researchers gained attention on supply chain visibility which has been seen as the key criteria to long-term competitiveness by keeping control of the company's supply chain (Bartlett et al. (2007);Swift et al. (2019)). It has the potential to improve both operational efficiency, planning activities, and coordination. This can contribute to flexibility, speed, innovation, and sustainability (Caridi et al. (2013), Gardner et al. (2019)). However, achieving visibility in the FMCG supply chain to create responsiveness, resilience, and oppose current problems, is complex (Zhang et al. (2008).

Digitisation pursues the transformation of the landscape for global supply chains. Emerging information-led technologies are paving the way for end-to-end supply chain visibility and improved SCM (Kayikci (2018)). The technologies are developed by the need for better decision-making processes, control, operations efficiency, and transparency (Končar et al. (2020)). Such technologies can be key enablers to collect data, automate processes, and make it able to track and trace goods (Wen (2010)). The growth of technical systems has improved the possibility and ease to access information and to lessen the vulnerability and the impact of disruptions (Caridi et al. (2014)). However, achieving real-time information among and across chains that is accurate, complete, in time and of high quality is not always easy to achieve (Williams et al. (2013); Oláh et al. (2018)). Despite (technical) solutions, nowadays it is still challenging to receive the right information across the supply chain to improve decision making and improve performance.

1.2. Problem Description

Creating supply chain visibility is essential in the FMCG industry dealing with more complex networks, increasing number of stakeholders, competitive pressure, rapidly changing business environment, and globalization (Pundir et al. (2019); Caridi et al. (2010b); Williams et al. (2013)). Researchers agree that enhanced visibility results in benefits like operational efficiency, resource productivity, and planning effectiveness. Also, improvements in speed, competitive level, and customer satisfaction can be gained just as a decrease in costs and an improvement in the decision-making process (Caridi et al. (2014); Pundir et al. (2019); Kulp et al. (2004); Caridi et al. (2010b)).

Supply chain experts of Royal Haskoning DHV (RHDHV), a leading engineering and consultancy firm RHDHV, also observe the increasing demand for a visible supply chain. The consultants working at the Supply Chain & Operations department are often approached by supply chain managers and operators from the FMCG sector addressing the need for this visibility to improve the current supply chain performance and questioning how this can be accomplished. However, achieving visibility improvements are complex and not just a simple system implementation project (Zhang et al. (2008); Iyver (2012)). RHDHV wants to focus more on enhancing supply chain visibility besides their core businesses as investment decision making, predictive simulation, plant and site optimisation, facility design, and CAPEX consulting. These current services partly contribute to the enhancement of internal and overall supply chain visibility and do not specifically focus on improving demand visibility (customer side) and supply visibility (supplier side). Therefore, RHDHV is asking for ways to analyse and find opportunities to strengthen the supply chain visibility of FMCG enterprises. Based on the current status of the company, the client needs can be divided into a support tool to investigate the current overall visibility level of an FMCG enterprise, and an detailed analysis that focuses specifically at the inbound and/or outbound. There is a need for a tool to identify critical areas that require improvements and find opportunities in a structured way. This type of tool could be used during a detailed project execution. Also, this can be used as starting point for further investigation and to respond to the companies' needs effectively.

A literature search has identified multiple authors have developed a model to assess the level of supply chain visibility (Caridi et al. (2013); Barratt and Barratt (2011); Barratt and Oke (2007); Papert et al. (2016); Brandon-Jones et al. (2014); Williams et al. (2013)). However, these models are primarily focused on measuring supply chain visibility and not on opportunities and recommendations. The metrics are constructed for different industries and only include limited dimensions of visibility and criteria to determine this maturity level. Also, the unit of analysis is focusing on a specific, limited part of the supply chain instead of overall supply chain visibility. A tool that satisfies the demands of RHDHV does not exist yet. A comprehensive support tool for the FMCG industry that measures the current level of visibility and also identifies opportunities and recommendations for improvement should be developed.

1.3. Scientific, Societal and Practical Relevance

This study will contribute on three different levels: scientifically, societal, and practically. The scientific relevance is the lack of an all-encompassing maturity visibility tool to measure the degree of visibility and identifies opportunities. Also, a tool that identifies critical suppliers and customers regarding supply chain visibility is missing. Scientifically this will contribute to the current knowledge of measuring supply chain visibility. Existing metrices that are developed primarily focus on visibility and not on opportunities and recommendations. Also, the measurements are applied to a specific, narrow part of the supply chain and aspects defining visibility and corresponding criteria are limited. Scientific research for a comprehensive metric for the FMCG industry specifically, is limited.

The societal relevance is that this study can bring FMCG companies a step closer to enhance supply chain visibility by finding areas for improvement. Having insight in the current state of visibility, knowing why visibility is assessed differently per customer/supplier, and having insight in opportunities for improvements, can be a small contribution to create full transparency and visibility in the future. Creating supply chain visibility is the first step also to elaborate cross-chain visibility and establishing closer collaboration between different supply chains. Other potential benefits in the long term that can be achieved besides reaching efficiency and cost savings, are the environmental goals. Possible benefits

could be fewer traffic movements, reduction of greenhouse gas emissions and congestion which will be of social importance.

Practically this research responds to the growing demand for supply chain visibility from both the FMCG industry as experts. This study will give understanding in the complexity of creating supply chain visibility, challenges, and opportunities. The tools can be applied by both FMCG companies as consultants. Consultants can use as support to asses the current level of visibility, find improvement areas, and define further project proposals. FMCG companies can use the tools to create more insight in possibilities to improve the current supply chain visibility. By enhancing the supply chain visibility, this study will also contribute at small scale to the future achievement of transparency, cross-chain collaboration and the establishment of technical concepts as dashboards and control towers.

1.4. Thesis Objective

Resulting from the background information, problem description and relevance in paragraph 1.1, 1.2 and 1.3 this thesis aims to:

Design of support tool to assess the degree of supply chain visibility in the FMCG industry and find critical areas and opportunities to enhance supply chain visibility.

The deliverable of this research will include an in-depth exploratory research about the current state of coordination in the FMCG industry, and a general understanding into challenges of receiving the right information to enhance supply chain visibility. Furthermore, a design is made for a supply chain visibility tool which contains different levels for analysis that can be divided into:

- **Visibility Maturity Scan**
- **Detailed Demand/Supply Visibility Analysis**

This research adapts a design methodology to achieve the research objective and details about the methodology for this research are described in chapter 2. The coherence of the two tools is visualized in figure 1.1, and the main functions of the tool are visualized in Figure 1.2. The detailed Demand/Supply Analysis can be used after after the use of the general Visibility Maturity Scan. However, this is not required and the detailed scan can also be used as separate analysis.

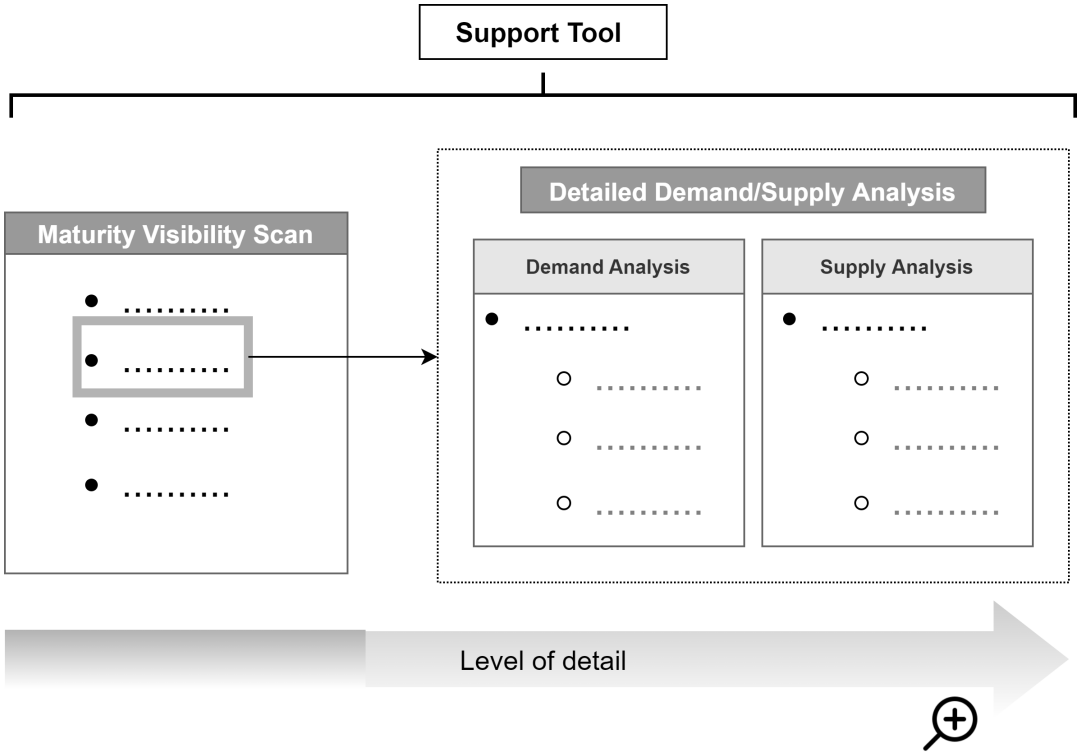


Figure 1.1: Structure and cohesion tool.

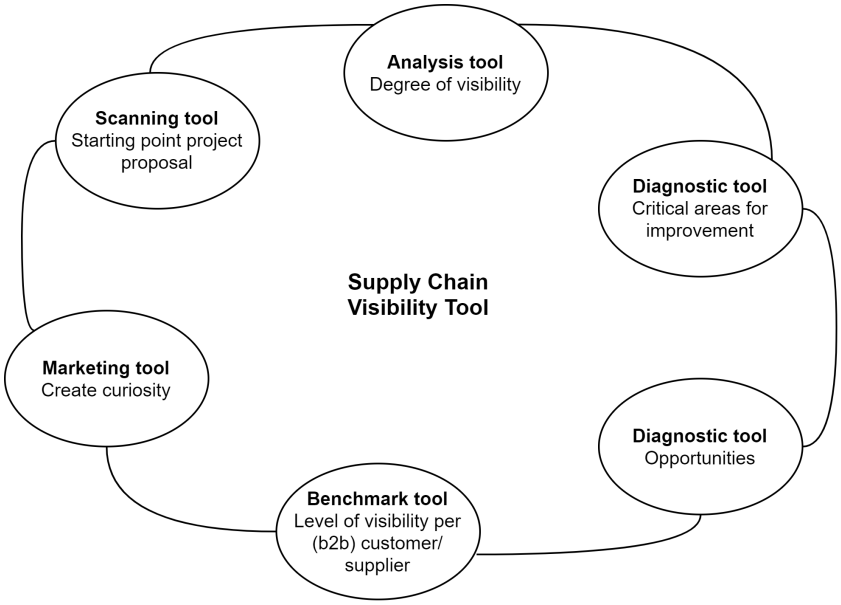


Figure 1.2: Functionalities of the Supply Chain Visibility tool.

The different aims of the Visibility Maturity Scan and the Detailed Demand/Supply Analysis that are visualized in the overview in Figure 1.1 is explained below. Also the application of the tools in the consulting practice of RHDHV is clarified.

Visibility Maturity Scan for RHDHV

Aim
Providing grip for a systematic overall supply chain visibility analysis from a b2b perspective. Analysis can function as starting point for discussion and the establishment of a detailed project proposal to enhance the companies' supply chain visibility.

Functions

- Analysis tool to identify the current degree of visibility
- Diagnostic tool for practitioners to easily find critical areas where visibility improvement is urgent
- Diagnostic tool for practitioners to identify opportunities for improvements
- Marketing tool to create curiosity for a scan and attract visitors the website of RHDHV
- Quick scanning tool for consultants functioning as starting point for a project definition phase

Applicability

- Tool can be used during a session
- Tool can be sent by email
- Tool can be placed at the website of RHDHV

User

- Supply chain managers of FMCG enterprises
- RHDHV expert if answers are provided by the FMCG enterprise
- Supply chain manager and RHDV together during a session

Required data
Expertise and insights into the current situation regarding supply chain visibility. If there is no representative having expertise in the entire supply chain, multiple managers can be united executing the scan together internally. As alternative, a limited part of the scan can be performed instead of the entire scan.

Detailed Demand/Supply Analysis for RHDHV

Aim
Providing detailed insights into the maturity of suppliers/customers (b2b perspective) regarding supply chain visibility as part of a project/detailed analysis. The goal is to create insights into critical customers and suppliers to enhance the supply and/or demand visibility.

Functions

- Analysis tool to identify the maturity of supply chain visibility of suppliers/customers
- Diagnostic tool for practitioners to easily find critical suppliers/customers where visibility improvement is urgent
- Diagnostic tool for practitioners to identify opportunities for improvements
- As benchmark too to compare the level of visibility of different suppliers/customers

Applicability
Tool can be used during a session.

User

- RHDHV expert based on answers provided by the FMCG enterprise
- Supply chain manager and RHDV together during a session

Required data
Data regarding the involved suppliers/customers and their purchasing and sales volume. This information provides insights in the importance of suppliers and customers. Furthermore available data of Key Performance Indicators (KPIs) related to the suppliers and customers should be collected to increase the validity (think of on-time delivery, accuracy of arrival times etc.)

1.5. Design Scope

Supply chain visibility is often used in literature in the context of cross-chain visibility and cross chain collaboration. This research investigates the complexity of collecting and sharing data in one supply chain. The FMCG industry is investigated and during the second part of the research (problem investigation (see 1.6)) the state of the art of coordination in this industry, possible information collection and exchanges, and corresponding challenges are analysed. Here, the focus lies on the whole supply chain from raw materials to the the manufacturing facility till end consumer to investigate the overall complexity and problems. The Visibility Maturity scan focuses on the supply chain visibility in the B2B perspective. Here the scope is defined as the flow of materials from the manufacturer to the international an local warehouses and distribution centers, and eventually till the retailers. The retailer in this scope is seen as the consumer (1.3). The Detailed Supply/Demand Visibility Analysis is focused on demand and/or supply visibility as stated by the needs of RHDHV (Figure 1.4). Here, also the scope is limited to B2B perspective and the visibility towards end-consumers is not included. The supply visibility represents the flow of goods towards the distribution centers and local warehouses. The demand visibility represents the flow of goods towards the retailers. This can be supplied immediately from the manufacturer or from the distribution centers/warehouses.

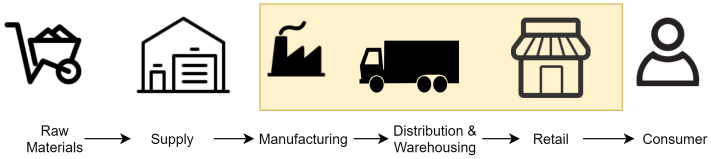


Figure 1.3: Design scope Visibility Maturity Scan.

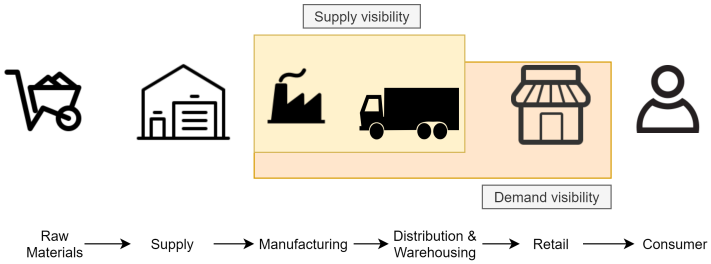


Figure 1.4: Design scope Detailed Demand/Supply Visibility Analysis.

The characteristics of different consumer goods determine the complexity and operational logistics. Therefore the type of products that are analysed during this research are limited to non-perishable and non-electronics goods. Personal care products and pet food are examples of these goods and analysed in this research.

1.6. Report Outline

This report guides the reader through the eleven sequential chapters.

The first chapter introduces the research background, problem statement and relevance. **Chapter 2** elaborates on the thesis methodology to achieve the defined thesis goal. This chapter also describes what research questions are being answered in the problem investigation part, and how the data is collected. Additionally, the design process and its validation will be explained.

Chapter 3 till **chapter 6** cover an extensive problem investigation where both a literature study as empirical research is performed. The empirical research is based on interviews with experts from RHDHV and supply chain managers working for FMCG companies. This research aims to identify the problems, challenges, and opportunities regarding the collection and exchange of information that can enhance supply chain visibility. **Chapter 3** investigates the characteristics of the FMCG supply chain known in literature and **chapter 4** elaborates on the current knowledge in literature about supply chain visibility,

the advantages, and challenges. Also the state-of-the-art of the assessment of supply chain visibility is presented in **Chapter 5**. The last chapter of the problem investigation part, (**chapter 6**), lists the results of an interview study with experts. Findings of this chapter are used as basis for the development of the tool.

In **chapter 7** requirements and functionalities are formulated for the development of the design. In **chapter 8** the conceptual design is developed including the determination steps that need to be established. **Chapter 9** elaborates these conceptual designs into detailed designs. Here all determinations are made regarding the software used, included dimensions, criteria etc. The tools are being verified and validated in **Chapter 10**. Here, the final suggestions by experts are presented.

Chapter 11 discusses the research process, the main findings of the research, and the value created by the literature and interview study. Finally, **chapter 12** provides conclusions of the study, further research suggestions, and practical purposes.

2

Thesis Methodology

2.1. Thesis process

Traditional academic research approaches strongly focus on describing, explaining and criticizing, but have limited focus on the actual design of solutions for problems (Higgs and Rowland (2000)). As a consequence, gaps arise between theory and practice. Design science as method bridges this gap and performs research to underpin a recommended design. This method aims to study, investigate, and research from academic and organizational perspectives, focusing on problem-solving, problem understanding, and evaluating designs (Dresch et al. (2015)). This methodology focuses on the outcome to solve the client's specific problem (Winter (2008)).

The methodology used for the specific design process of this research is based on the five-stage prescriptive model of Clive L. Dym and Patrick Little (Dym and Little (1999)). Following these steps outlined by Dym and Little, learns to examine the problem by developing the clients' engineering statement, make progress through several design stages, and lastly by documenting this process. The design cycle for this research can be seen in Figure 2.1 and styles the processes in a sequence of six stages. An extra phase is adapted to determine requirements and functionalities.

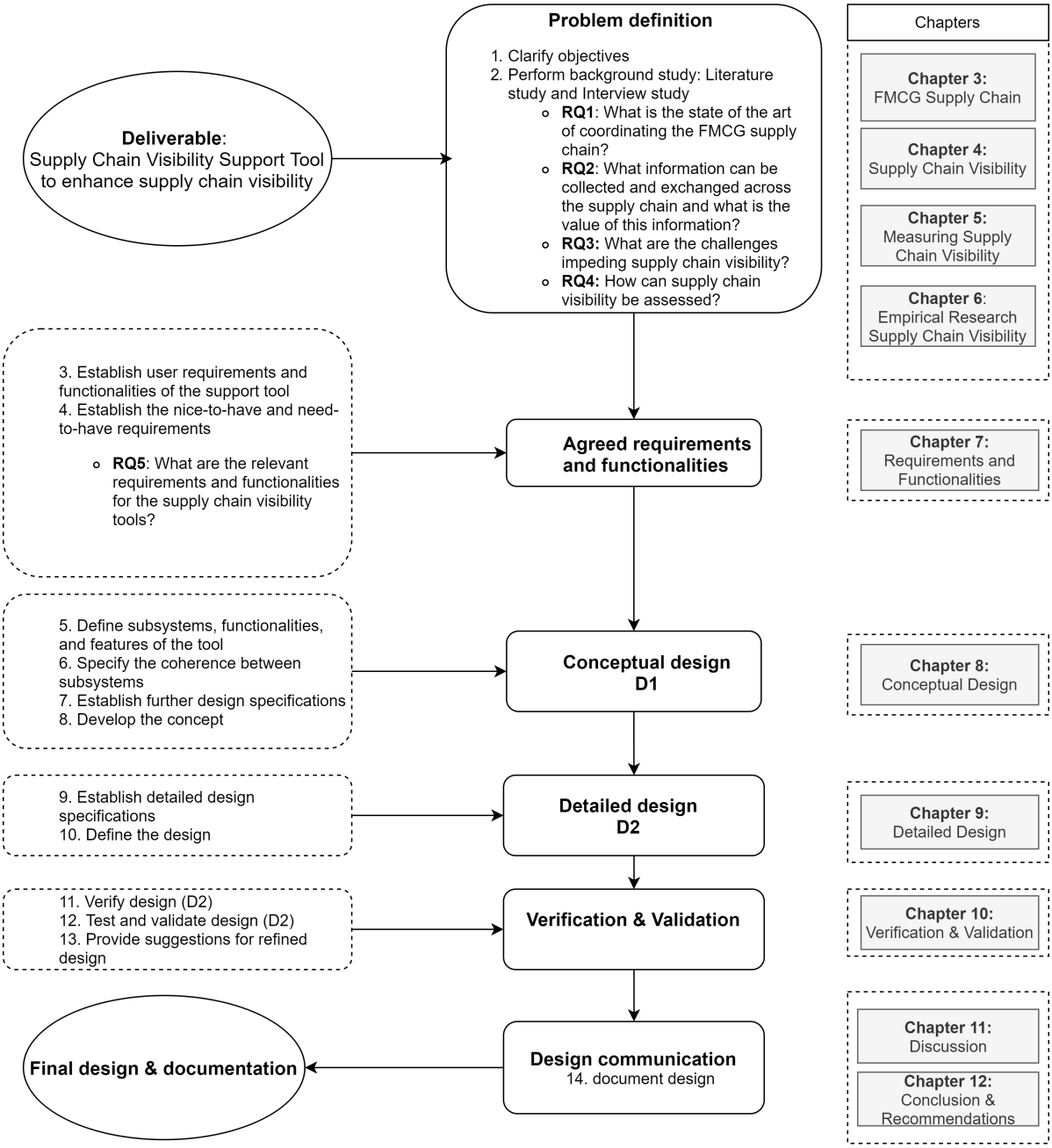


Figure 2.1: Thesis process.

2.2. Thesis Approach

All steps of the design process and included tasks will be clarified in this section. Also, the input for these tasks and the output will be described. Additionally, the methodologies used to collect the information are explained.

Stage 1: Problem Definition

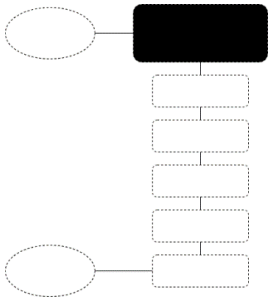
Input

The need for comprehensive measurement tool to assess the level of supply chain visibility.

Tasks

Clarify design objectives (1)

Perform background study: literature study and interview study (2)



Output

Revised problem statement

Refined objectives

Insights in coordinating FMCG supply chain logistics

Insights in opportunities and challenges of information collection and exchange

Insights in the assessment of supply chain visibility

First, a background study will be performed to investigate the state of the art of the FMCG supply chain regarding the characteristics of the industry, its complexity and how coordination takes place. Also, the possibilities to create supply chain visibility and exchange information across the chain are investigated. The challenges of obtaining supply chain visibility and the way visibility is assessed are also covered in the literature research. Besides a literature study, interviews are executed with consultants of Royal HaskoningDHV, and with FMCG supply chain managers. Together this forms an in-depth analysis of the current problem definition and the complexity behind enhancing supply chain visibility. During the problem definition four research questions will be investigated and answered:

RQ1: What is the state of the art of coordinating FMCG supply chain logistics?

RQ2: What information can be collected and exchanged across the supply chain and what is the value of this information?

RQ3: What are the challenges impeding supply chain visibility?

RQ4: How can supply chain visibility be assessed?

Method: literature study & semi-structured interviews

The first method used is a literature study. Online databases are applied to find relevant articles. Google Scholar is used as main database because of the broad content. Science Direct is used as a supplementary database. An overview of keywords that will be used to answer the research questions are presented in Table 2.1. Different combinations of keywords should be used.

Table 2.1: Keywords for literature study.

	Keywords
RQ1	'Coordination', 'FMCG' , 'FMCG industry', 'Trends', FMCG Logistics' , 'FMCG supply chain structure', 'Complex', 'Complexity drivers', 'Supply Chain Management'
RQ2	'Supply chain information', 'FMCG', 'information exchange', 'supply chain collaboration' , 'value of information', 'use-cases', 'benefits'
RQ3	'Challenges', 'supply chain visibility', 'barriers', 'information sharing', 'trust', 'knowledge sharing', 'collaboration' , 'cultural barriers', 'issues'
RQ4	'Assessment', 'supply chain visibility', 'metrics', quantitative measure', 'qualitative measure', 'value of visibility'

The articles will be selected first based on titles, but also on the abstracts, introduction, discussion, and conclusions. Furthermore, the backward snowballing search will be applied, which means that articles are found by looking into the reference list of a relevant article that is already used (Mourão et al. (2020)).]

The second method that will be used as data collection strategy, are semi-structured interviews. Up-front open-ended questions will be formulated as guidance. However, discussions or other subjects can start as well. This has the potential to reveal more information. In total, five consultants of RHDHV and five supply chain managers will be interviewed. Advantages of an interview study are the detailed information collection, a better understanding of subjects, and exploration of opinions, values and beliefs (Ratislavová and Ratislav (2014). However, limited generalization can be performed since only a few persons are interviewed (Payne and Williams (2005)). It is hard to determine a suitable number of interviewees (Kvale (2007)). However, a number of ten interviews in total from the consultant perspective and the industry perspective is chosen to increase reliability and consistency of findings.

Stage 2: Agreed Requirements and Functionalities

Input

Objectives

In-depth problem statement

Tasks

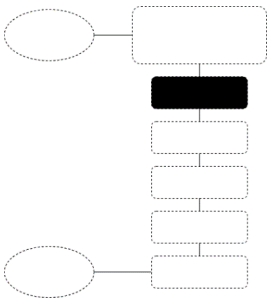
Establish user requirements and functionalities of the support tool (3)

Establish the nice-to-have and need-to-have requirements (4)

Output

Agreed requirements

Agreed functionalities



The fifth research question that is answered in this stage is:

RQ5: What are the relevant requirements and functionalities of the supply chain visibility tool?

Method: literature study, semi-structured interviews & evaluation sessions
First, a list of requirements will be defined based on literature research, semi-structured interviews, the desires of RHDHV, and the requests by the researcher. These requirements will be evaluated with consultants of RHDHV to select the need-to-have and the nice-to-have requirements. The need-to-have requirements form the foundation during different iterations phases towards the detailed design. The

requirements will be used during the verification of the design and should be met. The functionalities of both tool will be defined based on the final set of requirements.

Stage 3: Conceptual Design

Input

Objectives

Agreed requirements (need-to-have)

Functionalities

Tasks

Define subsystems, functionalities, and features of the tool (5)

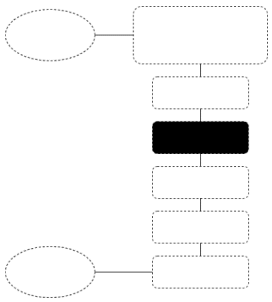
Specify the coherence between subsystems (6)

Establish further design specifications (7)

Develop the concept (8)

Output

Conceptual design (D1)



Method: design & evaluation sessions
All findings in the previous stages are combined and used for the first design: the conceptual design. Here, all functional elements that need to be determined are described, together with the coherence between all these sub-elements. The concept will be visualised and forms the basis for the detailed designs. The conceptual designs will be evaluated by experts of RHDHV.

Stage 4: Detailed Design

Input

Conceptual designs

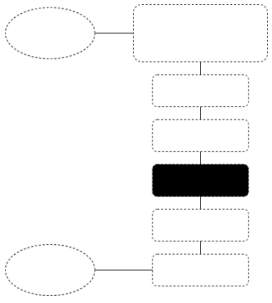
Tasks

Establish detailed design specifications (9)

Define the design (10)

Output

Detailed designs of tool



Method: design, & evaluation sessions
The functional elements and subsystems of the conceptual design are elaborated in detail during this stage. The coherence between all these elaborated elements are defined as well and will result in two detailed designs for the analyses of the tool. Choices are made in this detailed design which includes the determination of dimensions included to measure supply chain visibility, the way the information is collected, and how the results are presented, among others. This detailed design will be evaluated with experts of RHDHV, and an iterative process will take place to define the final detailed design (D2). Thereafter, this design will be developed into digital tool.

Stage 5: Verification and Validation

Input

Detailed design (D2)

Tasks

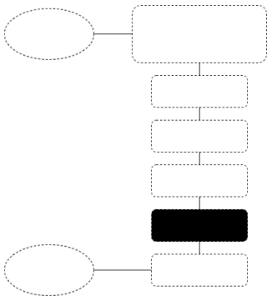
Verify the design (D2) (11)

Test and validate design (D2) (12)

Provide suggestions for refined design (13)

Output

Final design of tool



Method: verification session & validation expert sessions
First, the detailed design is verified with experts of RHDHV by looking if the designs comply with the predefined requirements. Furthermore, the tool are validated during sessions with experts working in the FMCG industry. This will result in final suggestions and will be valuable to redefine and optimize the previous detailed design. The shortcomings and unclarities are discussed.

Stage 6: Design communication

Input

Problem definition

Agreed requirements and functionalities

Conceptual design

Detailed design

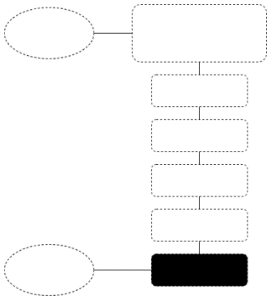
Insights from verification and validation sessions

Tasks

Document design (14)

Output

Final design and documentation



The last stage documents all research executed and steps made during this design of the supply chain support tool. Also conclusions, a discussion and recommendations for future research are defined.

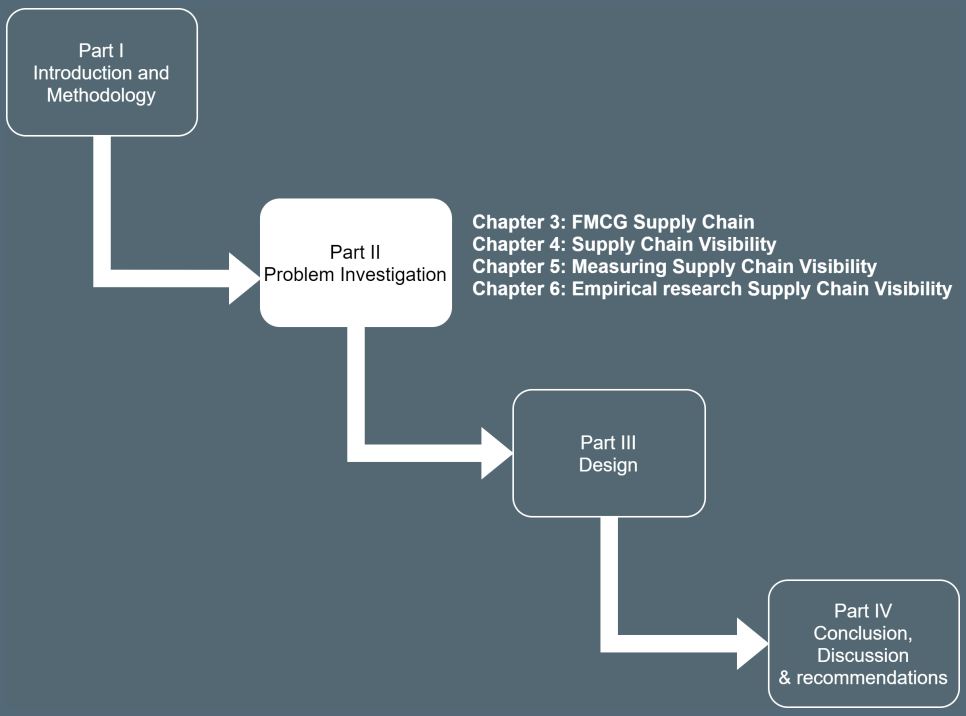
II

Problem investigation

The chapters in this second part of the research elaborate on the problem investigation (stage 1) of the design process. This part aims to identify the problems related to supply chain visibility. Therefore a literature study is performed related to the coordination of the FMCG supply chain, the advantages and value of information exchange, corresponding challenges, and visibility assessment. An interview study with supply chain managers and consultants of RHDHV is carried out to confirm and supplement the problems and challenges found in literature concerning enhancing visibility. All in all, these findings create a general understanding of the complexity and the value of supply chain visibility, which helps to design adequate support tools.

The research questions answered in this part are:

- *What is the state of the art of coordinating the FMCG supply chain?*
- *What information can be collected and exchanged across the supply chain, and what is the value of this information?*
- *What are the challenges impeding supply chain visibility?*
- *How can supply chain visibility be assessed*



3

FMCG Supply Chain

There is a large volume of published studies describing the role of supply chain visibility in many industries due to changed market perspectives. Also, the FMCG industry is under pressure and is demanding better supply chain visibility. In this chapter, the characteristics of the consumer goods industry, major trends, supply chain characteristics, and complexity are described. Insights in the industry and its supply chain will answer the first research question: *What is the state of the art of coordinating the FMCG supply chain?*

3.1. Product Characteristics

FMCG products, or consumer-packaged goods (CPG), are typically consumed, bought rapidly, and sold in large quantities for relatively low costs. The goods are non-durable, and examples are personal care products, household care goods, food products, and detergents, among others (Muthu Lakshmi and Suresh; Kuzmina et al. (2019)). Other characteristics of FMCG goods are low involvement towards the product, little time needed to choose a product, and fast consumption by the customers. The continuously purchasing character of these products leads to a market-driven competition. This results in many advertisements and discount campaigns in this branch (Montazeri et al. (2021)). The FMCG industry is a relatively low margin and high volume business, but since the products are used daily, the shelf life is short, and the turnover large (Varma and Ravi (2017)). As the products are bought frequently, the market is very large and competitive.

The type of products chosen in the research scope (see paragraph1.5) are non-perishables, and non-electronics consumer goods in the product categories of skincare, personal care, home, hair, oral, and pet food. Attributes mentioned above are characterising these products, and since the goods are non-perishable, less pressure is on shelf life and temperature conditions. Here, less tight control is required compared to perishables.

3.2. Trends

The FMCG market is driven by ongoing competition for market share. The main emerging trend is globalization and the increased complexity of the supply chain and its logistics (Zhiwen et al. (2020). The supply chain has crossed borders, and activities are typically outsourced to leverage costs on one side and access new emerging markets on the other side (Bhosle et al.). Plants are located close to main markets, and when activities are outsourced, close collaboration and communication are necessary. Globalization, an increase in the number of competitors, and outsourced processes have put pressure on the market. Here, efficiency and tight logistics are essential. Traditionally, enterprises try to create efficiency by focusing on minimizing production costs. Now, attention has shifted from only reducing production costs to extending this focus towards logistical performances, fast replenishment, and the reduction of inventories. Improved forecasts for example, can lead to the reduction of inventory but can also save other costs as labour-, holding-, transport and expedite costs. Different innovations for the production, sales and distributions are necessary, but also brand development plays an important role

(Bilgen and Günther (2010)). In general, efficiency can be achieved by identifying opportunities, eliminating wasteful and unprofitable processes, and reducing risks throughout the supply chain. Lower risks result in lower disruption costs, among others. Most focus nowadays to obtain these efficiencies, lies in forecasting, production planning, sales planning, reducing delivery times and risk exposure (Deloitte (2017)).

Another clear trend that takes place impacting the FMCG market are the demographic shifts. The population increases rapidly, just as the life expectancy. The age group older than 65 is expected to grow even more excessively. Also, certain population groups are growing faster than years ago because of economic growth. Increasing disposable income levels are affecting buying patterns. Companies anticipate on this ageing and growth of population categories by making group-specific products, for instance, anti-ageing products (Chatterjee et al. (2010)). Besides the size of the population and income levels, other demographic growth drivers for the FMCG market are population density. This can influence the location for operations, the attendance of downstream industries and local supply chains. So, the demographic shifts described affect the supply chain of the FMCG market. Also, the economic policies and legislation per country influence the supply chain activities (KPMG (2016)).

The consumer desires have been changed as well. Firstly, consumers demand a wider range of products and affordable luxury products. This results in an increasing variety of products and the range of packaging sizes, prints, and product characteristics have grown as well. The production of large batches of one or a few products has shifted to short production cycles of several products belonging to the same product families. Here machine changeovers are frequently occurring (Bilgen and Günther (2010)). Other trends regarding consumer desires are the health consciousness among consumers that has changed over the past couple of years. People are showing more interest in health and wellness, which can clearly be seen in the rapidly growing food and beverage market (Nazir et al. (2019)). Internet access, online sales, smartphone usage, and social media channels are the main reasons why consumer desires are influenced and changed rapidly. Product information is accessible at all times, just as stories beyond the label indicating where the product is manufactured (Consulting). A growing number of consumers are making purchases based on ethical values. This open access to information can influence decisions based on raw material characteristics, production methods, working conditions of employees, and human rights (Annunziata et al. (2011)). Since product information is accessible, products can easily be compared, and consumers' desires are being affected. Companies are creating online campaigns at social media channels to influence buying behaviour and increase their sales market. Brand development and product differentiation are crucial to develop and stay competitive in the market (Kuzmina et al. (2019)). The rise of digital consumers and online sales has resulted in the use of technologies to analyse and understand their consumers.

This open access to information and the desire for consumers to access information about the product, origin of resources, and locations of plants are related to another main trend: focus on sustainability. This focus has grown over the last decades on both the demand as supply side. The sustainable mindset of the consumer has created different expectations and requirements, and companies focus on sustainability to meet these expectations. A sustainable character can create positive market advantages through company image and an increase in firm profitability by saving costs (Sawant and Attarwala). The scarcity of natural resources is one reason driving the costs of raw materials, energy, and transportation costs (Yang et al. (2008)). Gained attention to sustainability can be seen in the reduction of materials, improvement of waste disposal, and the increased focus on recycling. Furthermore, technologies and markets emerged in bioplastics, compostable materials, and biodegradable materials due to this gained attention (Farmer (2013)). More enterprises produce environmentally, sustainable, and ethically sourced products, where the manufacturing processes has limited impact on the environment, and where logistical processes are optimized in terms of miles, emissions, footprint, and assets efficiency (SCCG (2004)). The sustainability aspects of products are becoming more and more accessible for consumers, and measurable values that are most often highlighted are carbon footprint, water usage, and energy consumption.

The mentioned emerging trends in the FMCG sector appear from either changed desires from the consumer side or the supply side. The supply and demand trends are interrelated and impact the way

the FMCG market is operating. The main trends discussed and their relationships can be seen in Figure 3.1.

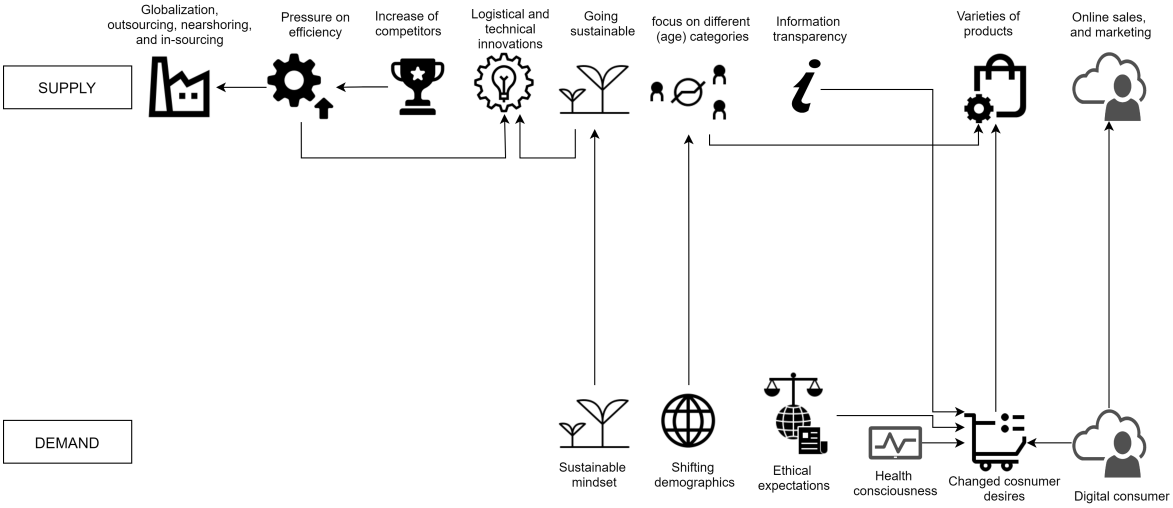


Figure 3.1: Trends shaping the consumer goods industry (work author).

3.3. FMCG Supply Chain Structure

Typical supply chain activities cover operations from product development, sourcing, production, packaging, to logistics, warehousing, forecasting and planning. Also, the information streams to coordinate these actions are part of the supply chain activities (Ray et al. (2016)). A typical FMCG supply chain exists of activities whereby raw materials and components are procured and supplied for production. When products are manufactured, they are stored until picked up and transported to Distribution Centers (DCs), and sometimes they are directly transported from the manufacturing line to the outbound docks. Often pallets are used for transport, and these pallets need to be prepared based upon orders. From DCs, products are transported to companies' warehouses and from there towards stores where the products are sold to consumers (Deketele et al. (2010)). Often cross-docking is applied to eliminate inventories by not entering the distribution centre's warehouse but immediately unloading and transferring goods in the right outbound trucks towards the retail outlets (Benrqya et al. (2020)). Road transport is often used in lower levels of the supply chain because of the flexibility of the mode and the relatively low costs. Trucks are most often used to transport semi-goods and materials from plant to plant, move finished goods to the distribution center, and deliver retail supplies. At higher levels, goods are also transported by barge, plane or train (Deketele et al. (2010)). The typical supply chain activities can be seen in Figure 3.2. In reality, the exact structure of the supply chain and sequence of supply chain activities differs per company. The number of suppliers, plants and distribution centers differs per enterprise and impacts the complexity of the supply chain activities (Bilgen and Günther (2010)).

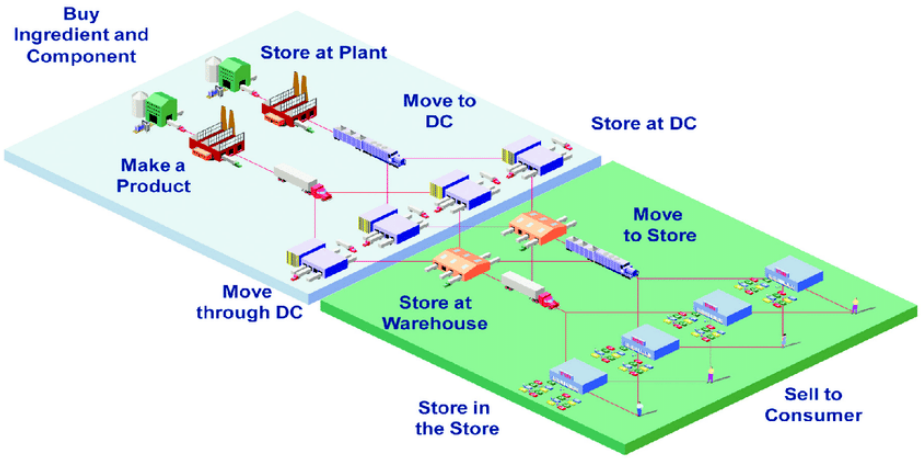


Figure 3.2: Supply Chain activities (Bala and Kumar (2011)).

The supply chain can also be exposed from a process view perspective, whereby the processes are indicated by cycles. Each cycle is performed at the interface between two supply chain stages, as shown in Figure 3.3 (Kain and Verma (2018)). The processes can be executed in response to an order (pull) or anticipate to orders (push). Figure 3.3 shows a pull principle where the processes are executed in response to a customer that makes an order. When the processes are started to anticipate to customer orders, this is called push processes.

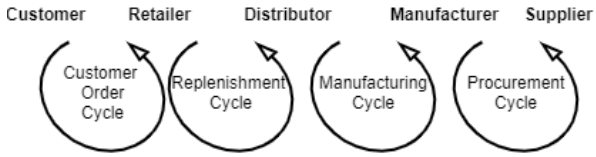


Figure 3.3: Process cycle view of the supply chain (Kain and Verma (2018)).

3.4. Supply Chain Complexities

Competition is not only focused on company versus company anymore, but has been shifted towards supply chain versus supply chain, resulting in more challenges. Many drivers can be found in literature that influences the supply chain complexity, which echoes true the whole chain. The relationship of characteristics in the supply chain and its complexity is not just a simple linear structure. A small change does not initiate only a chain reaction but often leads to exponential effects on managing the interactions between elements in the chain (Cheng et al. (2014). An overview of the complexity drivers is shown in Table 3.1, where the manufacturer is used as a base perspective to illustrate the complexity internally, upstream and downstream.

Internally the number of information flows is a key characteristic indicating the complexity. These information flows are mainly determined by the number and diversity of products and components, the volumes, and the number of plants. The diversity of products is related to the level of heterogeneity and the number of produced products. If the variety of products manufactured increases, the complexity of the processes and planning of the product flows are also increasing. The same holds for the number of components needed to produce a particular product since more interactions are needed, more risks can occur, and decision making will become more complex (Isik (2011); Serdarasan (2013); Bozarth et al. (2009)). High produced volumes do not necessarily indicate a more complex process. Often low volume production processes contain a higher level of detail, more jobs that must be managed, and a larger number of interactions between different areas in the plant. The volumes and the characteristics of the products (number, diversity, components) define the complexity. Another main driver for complicated supply chains is the degree of manufacturing schedule instability. This is a major issue for companies resulting in low service levels, excessive inventory levels, or stock-outs. High costs

are associated with changeovers, and instability in the production schedule creates issues impacting lower-level planning and control of activities (Bozarth et al. (2009)). Many businesses are growing and resulting in the need to extend current plant facilities or additional manufacturing locations. This clearly results in extra flows of goods, information flows and relationships that need to be managed. Lastly, the inter-dependency of products, items, and processes of products may cause complexity since interdependent states can not be operated without the other state's influence. This can result in complexity in planning, forecasting, and logistics. (Isik (2011)). Internally the main complexity drivers are highlighted, but upstream and downstream drivers can make the overall processes even more complex.

The complexity upstream increases when the number of firms and suppliers a company is cooperating with is large. This means that interaction is needed through various information flows and material flows, and in addition, the number of supplier relationships that need to be managed increases. (Cheng et al. (2014); Bozarth et al. (2009); Caridi et al. (2010b); Isik (2011); Serdarasan (2013)). The degree of differentiation among suppliers is also a factor related to the size and technologies used by the different suppliers. This determines the number of resources that are needed to manage them (Caridi et al. (2010b); Choi and Krause (2006); Serdarasan (2013)). Other key drivers for upstream complexity are long supplier lead times and the reliability of the suppliers. Long lead times and unpredictability are forcing manufacturers to adjust their processes and planning at the last moment. Long lead times are a main factor influencing the performance of the inventory control process and creating the bullwhip effect. This effect can be described as an increasing swing in inventory in response to shifts in consumer demand as one moves further up the supply chain. This lead time and uncertainty increases with global sourcing. The latter also creates other consequences besides uncertainty. Companies need to deal with other laws influencing import and export, different currencies used, and cultural differences (Bozarth et al. (2009)). Furthermore, the more suppliers and manufacturers are spread worldwide, the harder it is for the company to coordinate geographically spread activities (Choi and Krause (2006)). The relationships between the suppliers' supplier and also between various suppliers can be different and decisive. Close interrelationships of suppliers can result in information sharing and collaboration for better coordination, knowledge, and improved processes. The number of suppliers that can produce or offer a certain product or material, affects the level of dependency of a supplier. When the manufacturer depends on one or a few suppliers, the level of competition is lower and options for negotiations are smaller. This can result in high costs for the company and lack of motivation for efficiency for this powerful supplier. The complexity increases with the level of interdependence of suppliers (Choi and Krause (2006); Isik (2011); Serdarasan (2013); Bode and Wagner (2015)).

The downstream complexity has similarities with the internal and upstream complexity since the complexity is characterised by the number of customers and heterogeneity in customer needs. When the number of customers increases, the management of relationships, tasks, orders, and logistics becomes more complicated. When the desires and wishes of customers are diverse and when more heterogeneity exists, the potential for conflicting manufacturing tasks can occur. Also, the number of tasks that need to be performed with its corresponding complexity to create multiple products, increases (Cheng et al. (2014); Bozarth et al. (2009); Isik (2011)). Another problem driving the complexity is that shorter product life cycles put more pressure on the number of parts and products needed in a certain time period (Bozarth et al. (2009); Alias et al. (2014); Serdarasan (2013)). Lastly, the FMCG supply chain's main complexity and issue is the demand variability and the complexity of estimating this demand. Variability in demand can result in difficulties regarding reordering and stock levels. Re-ordering to a fixed stock levels can sometimes result in high inventories levels and at other moments to stock-outs. This can arise when only relatively small fluctuations exist in demand, but coordination in ordering policies at different points in the supply chain is lacking (bullwhip effect). Demand variability is therefore very hard to manage (Bozarth et al. (2009)).

Overall complexity drivers can also be mentioned, like the variety of total supply chain members that can simultaneously interact with one another, resulting in more information flows. These supply chain members may also be members of other supply chain networks making logistics complex. Also, the constantly changing network structure is a complexity driver (Cheng et al. (2014)). The goals of stakeholders in the chain are often different and can be contradictory. Continuous improvements and search for possibilities and agreements with supply chain partners are therefore needed, but are time-consuming

and hard (Isik (2011); Cheng et al. (2014)). The degree of predictability and uncertainty are related to each other and are a main driver of problems in supply chains. In some markets, the demand is more predictable, like seasonal products as ice cream, and can positively influence efficiency. However, the inability to accurately predict is a main issue for supply chain managers. Lastly, the demand of predictability and the maturity of IT systems and possibilities to implement new technologies are important. The latter can support complexity and create efficiencies in both material as information flows (Cheng et al. (2014), Serdarasan (2013); Blecker et al. (2005);Vogel and Lasch (2016)).

Table 3.1: Overview of complexity drivers in the FMCG supply chain.

Complexity driver	*Supporting literature*
Internal manufacturing complexity	
Number of products	(Bozarth et al. (2009), Isik (2011), Serdarasan (2013))
Diversity of products	(Isik (2011), Serdarasan (2013))
Number of components	(Bozarth et al. (2009), Isik (2011), Serdarasan (2013))
Number of processes	(Isik (2011), Serdarasan (2013))
Volume size	(Bozarth et al. (2009))
Number of manufacturing locations	(Isik (2011))
Manufacturing schedule instability	(Bozarth et al. (2009))
Interdependency between products and processes	Isik (2011)
Upstream complexity	
Number of suppliers	(Cheng et al. (2014), Bozarth et al. (2009), Caridi et al. (2010b), Isik (2011), Serdarasan (2013))
Degree of differentiation among suppliers	(Caridi et al. (2010b), Choi and Krause (2006), Serdarasan (2013))
The delivery lead time and reliability of suppliers	(Bozarth et al. (2009))
Extend of global sourcing and geographical spread	(Bozarth et al. (2009), Choi and Krause (2006))
Level of inter relationships among suppliers	(Choi and Krause (2006), Isik (2011), Serdarasan (2013))
Level of dependency of a supplier	Isik (2011), Bode and Wagner (2015))
Downstream complexity	
Number of customers	(Cheng et al. (2014), Bozarth et al. (2009), Isik (2011))
Heterogeneity in customer needs	Bozarth et al. (2009))
shorter product life cycles	Bozarth et al. (2009), Serdarasan (2013))
Demand variability	Bozarth et al. (2009)
Overall supply chain complexity	
Variety of total supply chain members that can simultaneously interact with one another	(Cheng et al. (2014))
Supply chain members who may also be members of other supply chain networks.	(Cheng et al. (2014))
Constantly changing network structure.	(Cheng et al. (2014))
Number of goals of supply chain members	(Cheng et al. (2014), Isik (2011))
Degree of predictability	(Blecker et al. (2005); Cheng et al. (2014))
Degree of connection	(Cheng et al. (2014))
Degree of market uncertainty	(Vogel and Lasch (2016); Cheng et al. (2014), Serdarasan (2013))
IT Systems and new technologies	(Serdarasan (2013); Blecker et al. (2005); Piya et al. (2020); Vogel and Lasch (2016))

3.5. Conclusion

This chapter provides an answer on the first research question: *What is the state of the art of coordinating FMCG supply chains*. Understanding the characteristics of fast moving consumer goods, the structure and trends affecting supply chain management are important to understand the complexity of coordinating FMCG supply chains. Besides the supply chain structure and these trends that drives the industry, other complexity drivers are investigated. These complexity drivers are divided into internal manufacturing complexity, upstream complexity, downstream complexity, and overall supply chain complexity. The analysis shows the factors that make supply chain activities and its coordination complex. These drivers are strongly related to reasons why supply chain visibility is hard to be enhanced. Internally this is hard since the number and diversity of products, components and processes are large, making it hard to have a clear overview at all times. The same holds for the upstream complexity, driven by the number of suppliers and dependency on the suppliers. Downstream the number of customers involved, the heterogeneity in needs and variety in demand are examples why visibility is hard to achieve. This chapter gave background information and thorough understanding of problems and complexity in the industry. This gives a guideline where the design of the visibility tools should focus on to achieve improvements in the FMCG sector.

4

Supply Chain visibility

This chapter contributes to the background study about the need for supply chain visibility and its challenges. Two research questions will be answered in this chapter: *What information can be collected and exchanged across the supply chain and what is the value of this information?*, and *What are the challenges impeding supply chain visibility?*

4.1. Definition

The term 'supply chain visibility' is often used in practice and literature. Nonetheless, the concept is ambiguous, and various definitions are proposed. The investigation of supply chain visibility as definition has shown that all explanations found in articles are related to the ability of information. Wei and Wang (2007) state that visibility is the extent to which actors have access to information, and Schoenthaler (2003) states that visibility implies that important information is available to those who need it. Additionally, the focus is not only on the availability of information, but also information sharing is emphasized in multiple definitions. Wei and Wang (2007) note that visibility is the extent to which actors share information that is useful for operations. The specific type of information intended with supply chain visibility is not defined specifically by authors, but some define the aim of available information in articles. Wei and Wang (2007) for instance, state that the information is available to those who need it for monitoring, controlling, and changing supply chain strategy and operations from service acquisitions to delivery. Others emphasize that supply chain visibility aims for a better decision-making process and mitigates risks (Tohamy et al. (2003), McCrea (2005)). A more general definition of supply chain visibility is defined as the extent to which a supply chain has access to or share information which they consider as key and useful for their operations Barratt and Oke (2007).

4.2. Types of information within the supply chain

Different information streams are available within the supply chain owned by several parties. Looking at the FMCG sector, some information is commonly exchanged between stakeholders, and other information is (consciously) not shared. As stated in paragraph 1.1, and 1.2 this information could improve efficiency. The main information types obtained from literature will be described in the following paragraph.

Inventory information

Inventory information contains details about the inventory levels, safety stock level, the replenishment policy, and stock capacity (Lee and Wu (2006), Brunaud et al. (2019), Lotfi et al. (2013)). This type of data can reduce the stock level and related costs allowing precise forecasts and improvements of the decision-making process (Lotfi et al. (2013)). Knowing the status of the inventory levels and safety stock of customers, could provide insight in the moment of re-ordering. For the supplying enterprise, this is valuable to better align their production and planning. Also, the replenishment policy of the b2b customers gives information about their threshold and re-order moment. Since the early 1980s, the concept of Vendor Management Inventory (VMI) emerged where vendors are responsible for the moment and amount of replenishment. Here, the vendor has full insight into the inventory and this

can be both beneficial for the supplier and buyer. The supplier can optimize the own production, replenishment schedule and transportation under the conditions that the customer service level is met. On the customer side, the administration costs and inventory costs can be reduced when the concept of VMI is applied. Lead times, risks, and costs can be minimized for both parties (Claassen et al. (2008)). Nonetheless, achieving such collaboration can be obstructed by a risk of loss of control by the customers. Also, the cost can increase leading to minimal benefits for suppliers (Tyan and Wee (2003)).

Sales information
Sales data describes the demand and real purchasing quantity. When sales data is shared with a supplying b2b company, this information can prevent order blow-ups, shortages in demand, and gives insight in customer demands (Lotfi et al. (2013)). In recent years Point of Sales (POS) data is shared more often by both manufacturers and retailers, which is the data collected when the transaction with a customer took place (Simon (2008)). Traditionally this data is sent manually and distorted with each successive link. In a fortified supply chain, this information is accessible directly at different levels of the supply chain. In this way, decisions can be made based on actual demand and the bullwhip effect can be reduced. This effect implies that distorted information from a downstream echelon in the supply chain can lead to large inefficiencies and variability at upstream actors in the chain (Wei and Wang (2010));Mason-Jones and Towill (1997); Croson and Donohue (2003)). So, not only demand will be better met, also the production planning and stock availability can be improved. The determination of re-order points will become more easily and noise from demand trends can be reduced. The nature of the demand pattern determines how valuable the POS information is (Steckel et al. (2004)).

Order information
When an order is placed, the desired quantity per type of product is specified and sent to its suppliers. An order confirmation is often sent, which is a document issued by a seller that confirms and accepts a purchase of a certain order in which the quantity, quality, price and other terms of the deal are defined (de Vasconcelos and Kaminski (2013)). If modifications take place this is communicated as well. Mature companies often sent an Advanced Shipment Notification (ASN) when a truck leaves the supplier. This is an electronic notification or alert and contains information about the loaded components, delivery note, and the estimated arrival time. The availability and accuracy of this information strongly influence the reliability of suppliers (Fuchs et al. (2018)). Other important order information that needs to be communicated is the status of the order (for tracking and tracing), the lead time, and notifications in case of delayed delivery (Burmeister and Liang (2016). However, the availability and the accuracy of the location and order status differs per case and per supply chain echelon. GPS (Global Positioning Systems) is often used to track trucks. Nonetheless, this only provides the truck's location, which is not associated with the load down to the pallet or item level. In-between send and receiving points, a truckload can often not be tracked anymore when it has arrived at a loading dock (He et al. (2009)). Other order information that can be shared is the prospective order planning information to suppliers (Chen et al. (2007)). Receiving the mentioned information flows from your suppliers, can lead to quick bottleneck determination, possibilities for adjustments in activities like production and delivery, and customer service can be improved (Lotfi et al. (2013)).

Forecast information
Several members across the supply chain make independent forecasts of the future market demand (Burmeister and Liang (2016)). These forecasts are normally attempted to anticipate on demand, based on historical data, expected sales, and actual demand (Stank et al. (1999)). Sharing these demand forecasts with stakeholders can influence fundamental decisions. The suppliers can adjust their production processes, where the inability to share probable forecasts can lead to critical failures like excessive inventories. This is the case when inflated forecasts are used, but optimistic forecasts on the other hand can result in the unavailability of products (Özer et al. (2011)). Clear benefits of sharing demand forecasts are accurate predictions leading to competitive advantages, better decision making, and improved planning processes. Additionally, it is easier to manage price structures and inventories ((Lotfi et al. (2013); Yue and Liu (2006)). Traditionally, retailers are taking responsibility for the forecasts since they are closest to the market. However, collaboration can improve this, and schemes such as Collaborative Planning, Forecasting, and Replenishment (CPFR) facilitate the share of information from customers and suppliers to exchange information and make better forecasts and improve

the planning together (Burmeister and Liang (2016)).

Product information
Typical product information that supply chain stakeholders share, are the product characteristics as type, category, ingredients, quality, size and weight (Bechini et al. (2008), Lotfi et al. (2013)). Also the demand for trace-ability information regarding the origin of materials is rising. Not only the origin, but also product processing history is requested more often (Olsen and Aschan (2010)). Other information related to products, is the production schedule and the producing ability. This information is owned by the manufacturer that can influence customer order decisions. The producing ability could indicate how sure and reliable a delivery could be (Burmeister and Liang (2016)) and can avoid the causes of the bullwhip effect (Lotfi et al. (2013)).

Other information
So far, only information of disruptions related to demand or supply is mentioned. Supply disruptions indicate the disruptions in transport or production of suppliers. Demand disruptions relate to modification in demand or orders. Other disruptions not appointed yet, are disruptions arising from natural hazards, political, or economical circumstances. (Wakolbinger and Cruz (2011)). Moreover, information of new products and development plans can be shared as well to ensure that the delivery of materials and start of production is performed in time (Lotfi et al. (2013), Lee and Whang (2000)). Furthermore, promotional event information (Abdullah and Musa (2014)), feedback from customers on products and services (Parameswaran et al. (2001), and knowledge (Barson et al. (2000)) can be shared.

The main information types found in literature as described in paragraph 4.2, are summarized per category in Figure 4.1.

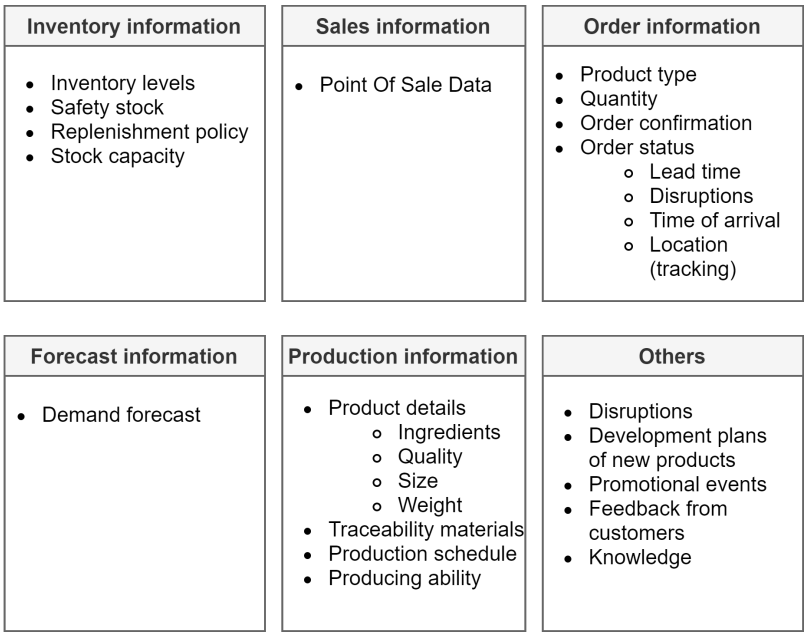


Figure 4.1: Distinction of information types (work author).

The information types discussed in paragraph 4.2 and summarized in Figure 4.1, can be exchanged between supply chain partners in different echelons. Based on the information obtained from literature, an overview is constructed where possible upstream and downstream information exchange between partners is visualized (Figure 4.2). This is not based on a real cases, but derived from literature to provide a broad and general overview of possible information exchanges. In reality, many suppliers, plants, warehouses, retailers and consumers are involved, resulting in the complexity to collect the right information at the right time.

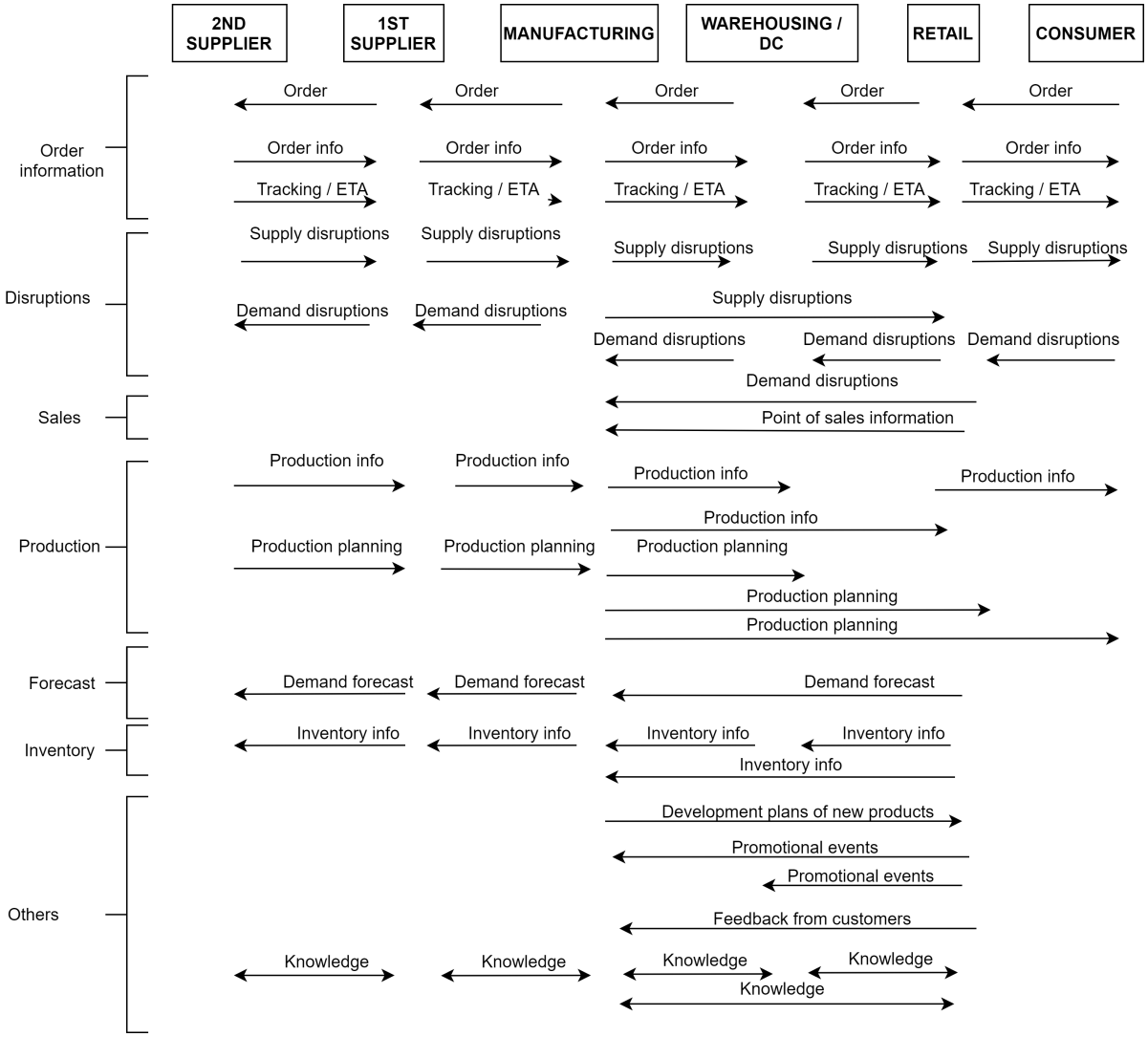


Figure 4.2: Possible information exchanges between supply chain parties based on literature (work author).

4.3. Potential of SC visibility

Much research is performed and examples exist clarifying the potential advantages of creating supply chain visibility. The main advantages found in literature can be treated under seven themes: efficiency and coordination, responsiveness, risk management, transparency, collaboration, cost reduction, and improved customer service. These themes are illustrated in this section.

Efficiency and coordination

The main goal of supply chain visibility is to strengthen company performances by improving efficiency and coordination, which is a broad comprehensive concept (Caridi et al. (2013)). A lack of visibility leads to inefficiencies in the whole chain: inefficiencies in the internal manufacturing plants, (Barratt and Oke), inefficiency at operational level in terms of tracking, planning and monitoring business operations, and it also impedes strategic competencies (Somapa et al. (2018)). Having accurate information available can support the decision-making process and coordination (Caridi et al. (2013), Barratt and Oke (2007)) and therefore the overall efficiency. Information flows that can improve coordination and decision making in the main business clusters are related to demand forecasting, production planning, ordering process, inventory management, manufacturing execution, logistics, and quality management (Somapa et al. (2018), Caridi et al. (2013), Nooraie and Parast (2015)). Improvements in planning can be realised when planning-related information is optimal (material requirements, forecasts, production schedules, transportation schedules) (Wei and Wang (2010)). In that way, resource usage can be

better matched and capital can be reduced. Better alignment of production and logistics results in reduced stock holding inventory, which has positive result on time and costs. (Bartlett et al. (2007)Wei and Wang (2010)).

Responsiveness

Supply chains are complex and changing rapidly. Responsiveness corresponds to the ability to respond and adjust processes time effectively (Sandberg and Jafari (2018)). Responsiveness is important, but the available information from the demand and supply side is often insufficient for enterprises (Williams et al. (2013)). High-quality information exchange between partners fosters early problem detection (Grabot et al. (2010)) and overall responsiveness (Barratt and Oke (2007)). A responsive supply chain leads to reductions in lead time, service reliability, flexibility and quick responses (Singh (2015)).

A positive effect of timely obtaining information and improving responsiveness can be seen by the reduced demand distortion, termed as the bullwhip effect (see paragraph 4.2)(Mason-Jones and Towill (1997); Croson and Donohue (2003)). Effects as excessive inventories, poor customer service, lost revenues and ineffective transport services can be prevented when information is exchanged on time (Lee et al. (1997), Cachon et al. (2007)).

Risk management

The supply chain complexity and challenges nowadays result into vulnerability of the supply chains and the need for insights in products for both consumers as companies. A better supply chain visibility can lessen this vulnerability and the impact of disruptions leading to reliable and stable performances (Caridi et al. (2014)). When companies obtain visibility, they are able to anticipate, act pro-actively, and therefore reduce risks. This holds for both upstream as downstream businesses. Many risks exposed are hard to foresee and thus monitoring and being aware of all occurrences internally, upstream and downstream, is of paramount importance (Silva et al. (2017)). A broad range of contexts can lead to supply chain disturbances. Risk management varies from responding to natural disasters to all other risks associated with the companies businesses. Examples are demand and supply fluctuations and rapid growth (Nooraie and Parast (2015)). Traceability is a specific aspect of visibility and is defined as the capability for ascertaining provenance (Sodhi and Tang (2019)). Traceability results in cost savings, better control of supply chain functions, and eventually risk management (Nooraie and Parast (2015)).

Transparency

The terms transparency and visibility are used interchangeable in practice, but are indicating different definitions according the theory. Where visibility refers to insights in the upstream and downstream operations in the supply chain, transparency denotes this visibility but also the disclosure of information to the public and to a broader set of participants (consumers, investors and other important stakeholders) (Sodhi and Tang (2019)). Creating transparency is a way to transfer power and responsibilities from a company to other stakeholders, reducing information asymmetry (Egels-Zandén and Hansson (2016)). In order to obtain transparency for companies, visibility needs to be achieved first.

Examples of supply chain transparency can be the disclosure of information across all tiers of the entire supply chain or supplier information like the names of contracted suppliers, locations, or activities. Cases of child labour can be countered by creating transparency (Sodhi and Tang (2019)). Transparency is also often used in the disclosure of sustainability. Here, the performance of involved actors regarding environmental regulations and norms are being assessed. These norms can be energy usage, water consumption, recycling, air pollution among others (Gardner et al. (2019)). Other examples of supply chain transparency are the disclosure of supply chain costs (labour, material, transportation etc.), and the workplace safety compliance of the supplier. The latter includes to what extent the factory meets safety, health and other standards.

Transparency can result in major benefits. First of all, having visibility in the supply chain can create value for the company by managing and reducing risks, as already mentioned. The efficiency can be improved by creating better supply chain visibility, as discussed before, by making it possible to base decisions on real-time information. Mitigating disruptions is also easier and proactive strategies can be created. The change of reputation damages will be lower. Enabling transparency is a way to improve

the reputation, for instance by meeting safety standards (Sodhi and Tang (2019)). Therefore, creating transparency is a way to build trust (Dingwerth and Eichinger (2010)). Another benefit is the possibility to name and shame individual companies for their behaviour (Egels-Zandén and Hansson (2016)) and uses it as a powerful tool to hold actors accountable for their actions (Dingwerth and Eichinger (2010).

Collaboration

Information sharing plays a critical role and impacts the level of supply chain visibility (Baah et al. (2021), Lotfi et al. (2013)). This supply chain visibility and availability of information creates opportunities for information sharing and collaboration where two or more independent parties work jointly (Saenz et al. (2015)). Supply chain visibility contributes to deeper collaboration which does not only include information sharing as collaborative activities, but also collaborative communication, mutually knowledge creation, and joined relationship efforts (Scholten and Schilder (2015)). Collaboration can be defined as both vertical and horizontal collaboration. Vertical collaboration indicates a cooperation with customers, internally across functions, with service providers and with suppliers. Horizontal collaboration indicates this cooperation with competitors and non-competitors (Barratt (2004),). Figure 4.3 illustrates these co-operations.

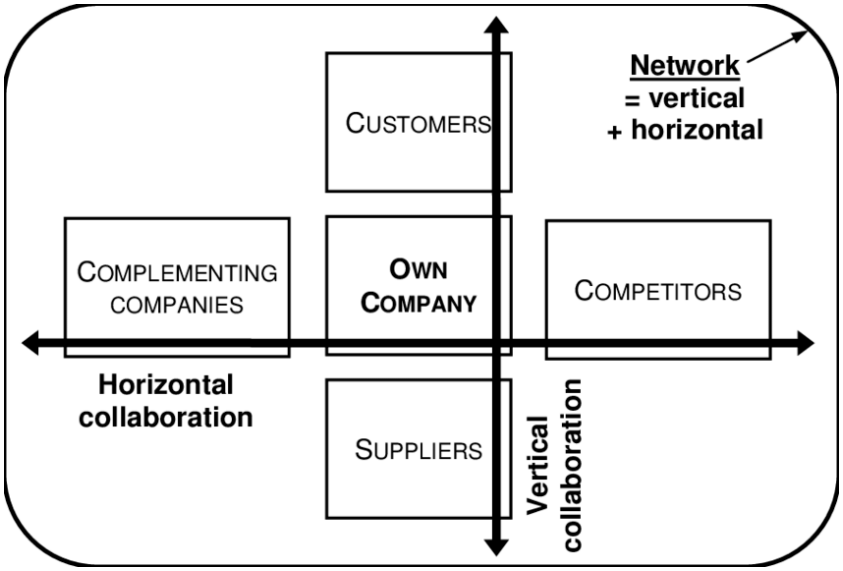


Figure 4.3: Vertical and horizontal collaboration illustrated (Bjornfot et al. (2011)).

Clear advantages of collaboration can be found regarding the reduction of logistical costs due to improved transportation, efficient storage facilities, and economies of scale in deliveries. Also, service levels can be higher because of short lead times and more frequent deliveries. When markets are shared, collaborative distribution channels can be beneficial and reduced investments can save costs (Bjornfot et al. (2011)). Manufacturers mainly experience these advantages in cost reduction or inventory reduction (Lotfi et al. (2013)). Other partners may benefit on different levels from this shared information and collaboration. Examples are improved predictions, reduced emissions if transport is shared, and improved expertise when knowledge exchange takes place (Brun et al. (2020), Ke and Wei (2008), Danloup et al. (2015)). Especially the opportunities for sustainability that collaboration has to offer has gained more attention over the years. However, economic reasons are still the main reason for collaborations (Chen et al. (2017)).

Cost Reduction

Many authors illustrate the benefits of supply chain visibility in terms of improved quality, flexibility, service level, and cost (Caridi et al. (2014)). Different type of costs can be distinguished. Stock-outs associated with loss of income and inventory shortages can be saved when inventory levels are visible (Kulp et al. (2004). Backorder penalty costs related to these stock outs can also be lessened (Cachon and Fisher (2000)). Unfulfilled demand could be cancelled or back-ordered, which also saves

expenses. In the latter case, the direct costs are related to a delay in transportation and extra costs for administration and material handling. Also fines that are contractually set when back-orders take place, can be optimized by having better visibility (Liberopoulos et al. (2010)). Besides the stock-out costs and back-order costs, reduced inventory costs result from lower inventory levels and in-time replenishment actions (Barratt and Oke (2007). Furthermore, distribution costs can be saved when transport activities are integrated when transport assets, utilization, and effort can be saved. Planning, allocation and controlling resources can be optimized resulting in savings(Gustin et al. (1995)). The total cost of supply chain management are related to many factors. Striving for efficiency at different levels, responsiveness, reduced risks, quality and excellent service levels, all contributes to the total cost reduction (Caridi et al. (2014)). Lower costs for the enterprise could provide lower prices for customers and even lead to higher demand at the long-term (Lotfi et al. (2013)).

Improved Customer Satisfaction

Visibility can fill gaps to reduce costs, improve speed, increase efficiency and provide responsiveness. These factors amongst others positively impact the level of customer service and customer satisfaction (Pundir et al. (2019)). According to Gunasekaran et al. customer service and satisfaction is influenced by the flexibility to meet particular customer needs, the customer query time, and the customer's perceived value of the product (Gunasekaran et al. (2001)). This flexibility to meet customer needs is strongly related to the availability of products. The occurrence of stock outs negatively impacts the customer satisfaction, leading to a lower selling market and turnover (Dadzie and Winston (2007)).

4.4. Value of information exchange

This subparagraph will elaborate more specifically on the exact value of information exchange. Also, to which stakeholder the benefits apply, is clarified more in detail. First, the main benefits and value of enhanced supply chain visibility found in paragraph 4.3 are summarized. Thereafter, causal relationships will be explained to indicate the relationship between possible advantages that can be gained in the supply chain. Also, the value of information sharing from the customer/supplier perspective and the FMCG enterprise perspective will be addressed. First, the visibility benefits found in literature, are listed below:

- Increased efficiency and coordination
  - Improved production planning
  - Accurate forecasts
  - Better ordering process
  - Improved logistics
  - Optimized resource usage
  - Improved inventory management
  - Improved quality management
  - Time savings
  - Improved decision making
- Greater responsiveness
- Better Risk management
- Possibility to create transparency
- Deeper level of collaboration
- Cost reductions
- Improved customer satisfaction
  - Flexibility to meet customer needs
  - Customer query time decreases
  - Level of customer perceived value of the product improves

These seven main effects of enhanced supply chain visibility are interrelated. Increased efficiency for example, can reduce costs ending with higher customer service and satisfaction. To illustrate the relationship between the main benefits listed above, a causal relation diagram is made (Figure 4.4). Since all the causal relations are positive, this is not specified in the Figure. An example of such a positive effect is the arrow that indicates the effect of increased efficiency on costs. If efficiency increases, the cost reduction increases as well.

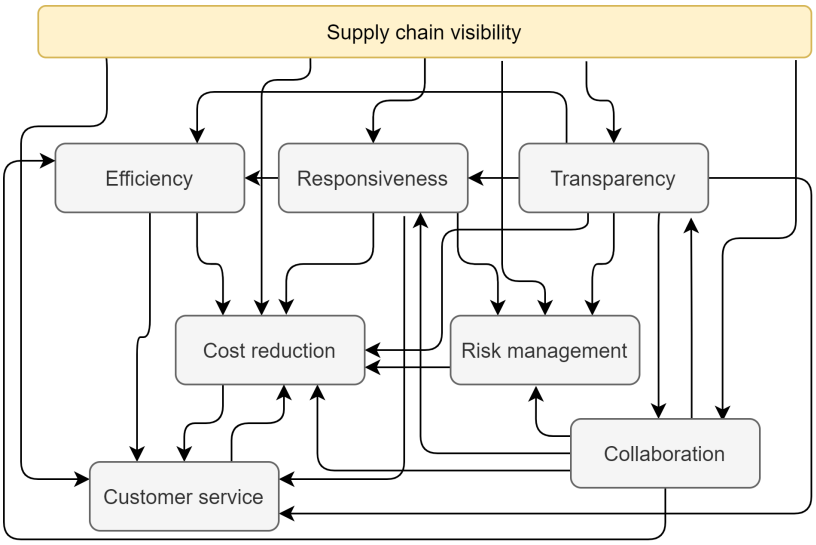


Figure 4.4: Relationship between the high level benefits of SCV (work author).

The causal relationships will be clarified briefly:

- Supply chain visibility results in a direct positive effect on efficiency, responsiveness, transparency, risk management, and customer satisfaction as described in paragraph 4.3.
- Increased efficiency results in improved customer service and cost reduction (Pundir et al. (2019); Dadzie and Winston (2007); Caridi et al. (2014)).
- Greater responsiveness has a positive effect on the efficiency (Caridi et al. (2013); Barratt and Oke (2007)), cost reduction (Cachon et al. (2007)), and customer service (Singh (2015); Gunasekaran et al. (2001)).
- Creating supply chain transparency positively impacts the responsiveness, risk management, collaboration, customer satisfaction, and enables cost reductions directly. These effects are mainly caused by improved reputation, built trust, shared risk, and the possibility to hold other actors accountable for their actions. (Sodhi and Tang (2019); Dingwerth and Eichinger (2010); Dingwerth and Eichinger (2010)).
- Better risk management has cost reductions as a direct consequence (Nooraie and Parast (2015)).
- Deeper collaboration with supply chain partners can create more transparency (Saenz et al. (2015)), but also the possibility to manage risks, improve customer satisfaction, and reduce costs (Bjornfot et al. (2011); Lotfi et al. (2013)).
- Cost reductions can lead to improved customer satisfaction levels as well, since lower costs can cut costs for the end consumer too (Lotfi et al. (2013)).

The above mentioned effects are results of supply chain visibility from a high level perspective. Zooming in into the direct results of improved supply chain visibility at lower level, can be seen in the business clusters demand forecast, production planning, ordering process, inventory management, manufacturing execution, logistics, and quality management (see paragraph 4.3). The effects of the information types described in paragraph 4.1 are analysed and shown in causal relationship diagrams. Here, a distinction is made between the benefits of information sharing for the suppliers/customers and the value of received information for the FMCG company itself. These effects of receiving and sharing

information can be seen in the visualisation in Figures 4.5 and 4.6. As can be seen, an arrow with a + sign indicates a positive causal relationship, and a - sign shows a negative relationship.

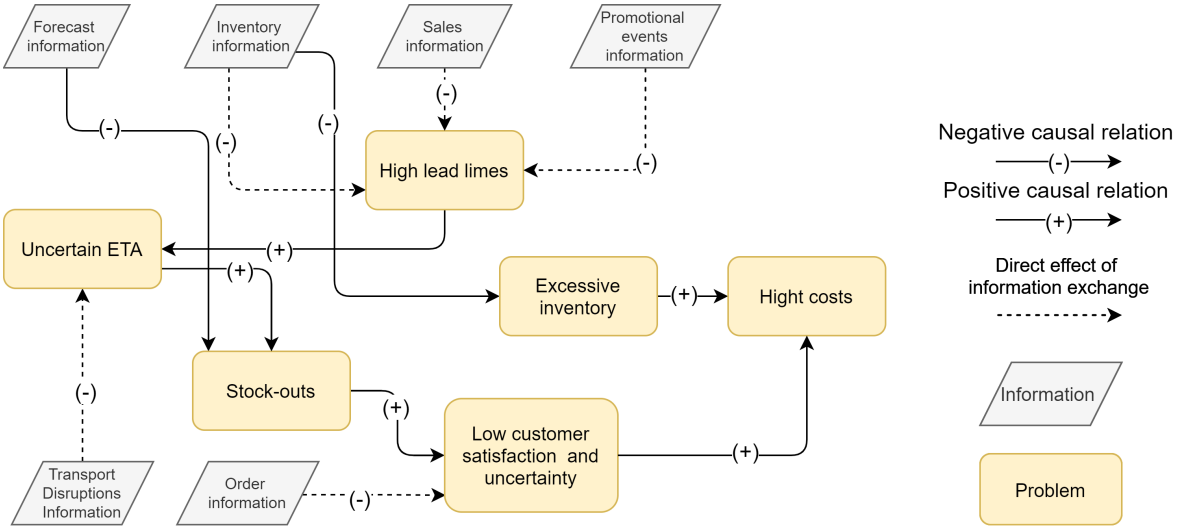


Figure 4.5: Value of information sharing (supplier/customer perspective) (work author).

The value of information exchange for the suppliers and customers (retailers/shops) of FMCG enterprises is shown in figure 4.4, and will be explained:

- **Sales information**: if the point of sales information of the customers (retailers/shops) is shared with the FMCG enterprise, this can minimize the chance of stock-outs and high lead times for the retailers and shops (Lotfi et al. (2013); Steckel et al. (2004)). The FMCG enterprise can better meet demand when this sales information is received. Fewer stock-outs will result in better inventory management and customer satisfaction of the customers of FMCG enterprises (these are the shops and retailers).
- **Forecast information**: if the demand forecast of retailers and shops are shared, this can adjust the production processes of the FMCG enterprises. In this way, stock-outs for the consumers (retailers/shops) that FMCG companies deliver to, can be prevented (Özer et al. (2011)). This could prevent stock outs from the perspective of retailers and shops.
- **Inventory information**: if inventory levels and replenishment policies of the consumers (retailers and shops) are shared with the FMCG company, the inventory management and related costs can be optimized for those consumers (Lotfi et al. (2013) by better aligning production and reordering regarding the FMCG enterprises.
- **Promotional events**: the exchange of accurate promotional event information owned by customers (retailers/shops) make it easier to respond and adjust production processes and inventory management for the FMCG enterprise (Abdullah and Musa (2014)). In this way, stock-outs for the retailer during an promotional events, can be prevented.
- **Order information**: order information contains information from the supplier about product availability, status of the order, expected arrival time, etc. When the suppliers of FMCG enterprises share accurate order information, this can improve the certainty that products can be delivered in time to their customers (which is the FMCG enterprise in this case). As a result, customer satisfaction from the suppliers perspective can be improved (Lotfi et al. (2013)). This means that and FMCG enterprise as customer is more satisfied.
- **Transport disruptions**: Sharing information of transport disruptions from the supplier side could result in higher reliability and customer satisfaction regarding the FMCG enterprise that are receiving the products (Fuchs et al. (2018)).

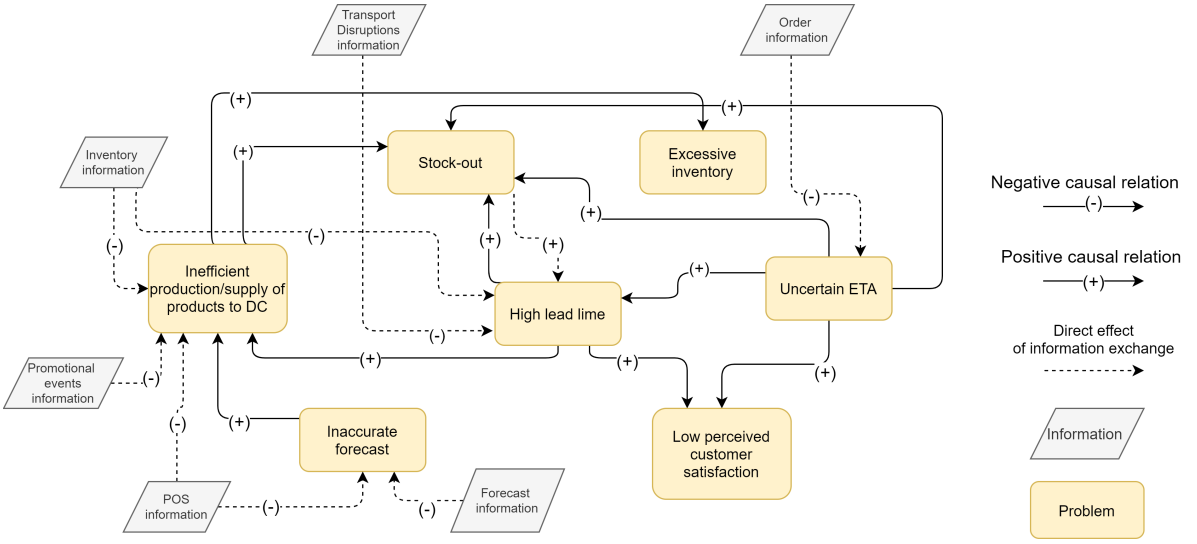


Figure 4.6: Value of receiving information (focal company perspective) (work author).

The value of information exchange for FMCG enterprises:

- **Sales information**: when Point Of Sales information of the retailers/shops is shared with FMCG enterprises, the demand can be better met from the FMCG company perspective. Also, forecasts can become more accurate, the production planning and stock availability can be improved, and the supply of products to the DCs can be optimized (Steckel et al. (2004)).
- **Forecast information**: when forecast information is shared by the customers (retailers/shops) of FMCG firms, the FMCG enterprises can improve the accuracy of their own generated forecast. This also has a positive effect on their inventory management (Özer et al. (2011)).
- **Inventory information**: if the retailers and shops share inventory information with the FMCG enterprises, the FMCG enterprise can reduce this stock level, related costs, and reduce the lead time to deliver products. The FMCG firm is also able to allow precise forecasts and improvements in the decision-making process (Lotfi et al. (2013)).
- **Promotional events**: if retailers share their promotional event information, FMCG enterprises can respond easier to the demand and adjust their production processes or the supply of finished goods towards the warehouses. This result in better inventory management for the FMCG enterprises (Abdullah and Musa (2014)).
- **Order information**: from the FMCG perspective, receiving order information from its suppliers (for example product availability, status of the order, and expected arrival time) can improve the certainty that products can be delivered in time. As a result, the FMCG enterprises' lead time and level of customer satisfaction can be improved. (Lotfi et al. (2013)).
- **Transport disruptions**: if transport disruptions are not communicated in time by the supplier of goods, alternatives can be arranged to undermine the lead time. When transport disruptions are communicated in time, this results in higher reliability and customer satisfaction regarding the FMCG enterprise that are receiving the products (Fuchs et al. (2018)).

4.5. Contracts

The extent to which information is exchanged is largely defined and established contractually. Besides cost and penalty determination, also the information that needs to be communicated is often set (Galvan Granat (2017)). The main goals of contracts are the delineation of authority-responsibility and to share risks among partners. It provides means to enforce coordination (Ghosh and Fedorowicz (2008); Colicchia et al. (2017)). However, it is problematic that stakeholders often have conflicting objectives, impeding the willingness to share information. A win-win situation is sought by both parties while making a contract. However, not such an ideal situation exists, and contracts are compiled based on power

regimes and certain dominance. The size and power of the stakeholder impact this dominance (Galvan Granat (2017)). The mechanisms contract, power and trust are strongly interrelated, and influence and are influenced by each other (Ghosh and Fedorowicz (2008)). The contract specifications are periodically revised and defined, including the information exchange. Contracts are therefore key factors for information sharing (Ha and Tong (2008)).

4.6. Challenges obtaining visibility

There is a large number of published studies about challenges impeding supply chain visibility. Ten studies are investigated to find the main barriers of obtaining this visibility and information exchange (Fawcett et al. (2007); Özkanlısoy and Akkartal (2021); Khurana et al. (2011); Willem and Buelens (2009); Weippert et al. (2003); Lotfi et al. (2013); Chae et al. (2005); Bureš (2003); Barson et al. (2000); Kumar and Pugazhendhi (2012)). Both obstacles focused on IT implementation, as obstructions for information sharing are researched. These barriers are divided into five main categories; financial, technological, legal, social-cultural, and organizational.

Financial constraints can be seen as a key barrier to information sharing in supply chain. Many authors recognised high investment costs as major barriers to successful information exchange and collaboration (Fawcett et al. (2007);Barson et al. (2000);Lotfi et al. (2013);Kumar and Pugazhendhi (2012)). Besides the investment costs, maintenance costs and specialized manpower costs are seen as financial constraints (Khurana et al. (2011);Kumar and Pugazhendhi (2012)). Also, many financial resources are needed for IT consultants, staff training, and knowledge transfer Özkanlısoy and Akkartal (2021); Barson et al. (2000)). These cost considerations are the main challenge to support sufficient information systems (Khurana et al. (2011).

The lack of suitable technical support is a great barrier to attain supply chain visibility. Often no inadequate information systems are present, or the IT infrastructure is poorly designed. Sometimes there is a total lack of technology (Özkanlısoy and Akkartal (2021); Fawcett et al. (2007); Kumar and Pugazhendhi (2012); Barson et al. (2000)). The lack of information systems and the absence of adopting information sharing, can be the result of the complexity of implementing advanced systems. Integration problems are also main barriers that need to be tackled to attain visibility (Fawcett et al. (2007); Kumar and Pugazhendhi (2012); Barson et al. (2000)). Here, difficulties arise in case of integrating own systems with each other, but also when these are integrated with systems of partners. Disparity in technological capability and IT maturity is a major cause, making interoperability hard to achieve. A variety of hardware, software an data standards used by stakeholders can conflict (Fawcett et al. (2007)). Khurana et al. mentions the difference in programming languages and definitions as challenge for integration. When systems are successfully integrated or information systems are implemented, often a lack of efficiency and effectiveness takes place. This inefficiency of utilizing shared information impedes further collaboration (Lotfi et al. (2013)). A last factor that obstructs visibility, is the fact that enterprises do not know where to start digitization (Özkanlısoy and Akkartal (2021)).

Legal barriers are critical for sharing information and creating supply chain visibility (Lotfi et al. (2013)). Bureš points out the impact of bureaucracy, hierarchy, and administrative institutions. Here, the number of procedures are normally larger and are worsening knowledge share. Less formalized organisations can be more flexible and open to share information (Willem and Buelens (2009); Khurana et al. (2011)). Current legal status can influence the ease of information exchange and matters as electronic transmissions or the use of electronic signatures can be legally complicated. (Weippert et al. (2003)). Security and privacy concerns are a major issues and trusted networks need to be created to share information (Lotfi et al. (2013); Özkanlısoy and Akkartal (2021)). The anxiety for information security, threats of unauthorized access to information, entry to sensitive information by competitors, and cyber attacks, are barriers that impede supply chain visibility (Kumar and Pugazhendhi (2012)).

Social-culture barriers are seen as crucial factors that influence the reluctance to share information and implement IT infrastructure. The lack of trust is perceived as an important barrier in literature and often addressed. The role of trust in relationships makes it hard to share sensitive information (Chae et al. (2005); Barson et al. (2000); Lotfi et al. (2013)). A major fear exists of misuse of information (Khurana

et al. (2011)). Not only trust issues among supply chain play a role, also the lack of trust in supply linkage and information technology tools (Kumar and Pugazhendhi (2012); Khurana et al. (2011)). The latter aspect related to the reliability of information systems, is mentioned by multiple authors (Kumar and Pugazhendhi (2012); Khurana et al. (2011); Lotfi et al. (2013)). Here, the major fear is connected to functionality and accessibility of the information systems. A technology mindset and knowledge about information systems are often lacking (Fawcett et al. (2007)l Kumar and Pugazhendhi (2012)). It is proven that much time and energy is needed to learn to use IT systems impeding the change in the technology mindset (Lotfi et al. (2013)). Another main barrier is the risk of information sharing. Many partners are reluctant to share rewards and risks, since this is based on trust and often contains sensitive information (Fawcett et al. (2007); Kumar and Pugazhendhi (2012); Barson et al. (2000)). The companies culture strongly impacts r willingness and support to share information (Barson et al. (2000)). Information is a symbol of power that stakeholders do not want to lose when sharing it (Khurana et al. (2011). Changing the businesses culture is a long term process. However, changing peoples way of thinking is important since it can be the key bridge to innovate and collaborate (Fawcett et al. (2007)). If there is a lack of commitment of willingness to change, it will be hard to achieve this. Participants need full commitment to both share information as using new ICT tools and systems (Fawcett et al. (2007); Weippert et al. (2003)). When information is not shared, communication technologies are useless (Khurana et al. (2011)). And when no sophisticated infrastructure exists yet, members also need to be wiling to invest (Khurana et al. (2011)). Internal resistance is and lack of commitment is a major social-cultural barrier. Other fears that often arise are the loss of authority, power, and knowledge, due to IT SCM systems (Kumar and Pugazhendhi (2012); Bureš (2003)). A last main barrier is the differences in values, goals and priorities. Personal intents can differ and disrupt coherence (Khurana et al. (2011)). Conflicting motives, self interest and incentive issues can hinder the achievement of supply chain visibility (Bureš (2003); Barson et al. (2000); Lotfi et al. (2013)).

Lastly, organizational barriers are prime challenges. Poor infrastructural facilities and lack of technology inside an organization is a hurdle (Kumar and Pugazhendhi (2012); Özkanlısoy and Akkartal (2021); Fawcett et al. (2007); Barson et al. (2000)), just as the lack of managerial support and commitment (Kumar and Pugazhendhi (2012); Weippert et al. (2003)). Past experiences of opportunistic behaviour can form this lack of support in using information (Khurana et al. (2011)), or by practices of information system breakdowns (Kumar and Pugazhendhi (2012)). Oftentimes, a fear exists of losing company stability and market position if company-specific information is shared (Barson et al. (2000)). Another main barrier is that managers do not realize the contribution and benefits of information sharing (Khurana et al. (2011); Fawcett et al. (2007)). Besides the lack of insights into benefits, the lack of training and experience inside an organization is considered as one of the barriers of information sharing (Khurana et al. (2011); Kumar and Pugazhendhi (2012)). Understanding is needed about systems' capability and limitations (Weippert et al. (2003)), and this knowledge and expertise should also be maintained (Khurana et al. (2011)). A last organizational barrier that needs to be tackled is the sharing spirit influenced by bureaucracy, administrative control, and hierarchy that negatively impacts the sharing of information in the supply chain (Bureš (2003); Khurana et al. (2011)).

All barriers are listed as overview in Table 4.1.

Table 4.1: Barriers obtaining visibility.

Financial Barriers	
High investment cost	Fawcett et al. (2007); Khurana et al. (2011); Kumar and Pugazhendhi (2012); Barson et al. (2000); Lotfi et al. (2013)
Costs of maintenance	Khurana et al. (2011); Kumar and Pugazhendhi (2012)
Costs of specialized manpower	Khurana et al. (2011); Kumar and Pugazhendhi (2012)
Costs of training	Khurana et al. (2011); Barson et al. (2000)
High costs consultants	Özkanlısoy and Akkartal (2021)
Unclear financial results	Özkanlısoy and Akkartal (2021); Khurana et al. (2011); Barson et al. (2000)
Technological Barriers	
Lack of technical support	Özkanlısoy and Akkartal (2021); Fawcett et al. (2007); Kumar and Pugazhendhi (2012); Barson et al. (2000)
Complexity of implementing advanced systems	Fawcett et al. (2007); Khurana et al. (2011)
Enterprises do not know where to start digitization	Khurana et al. (2011)
Incompatability / integration problems	Fawcett et al. (2007); Khurana et al. (2011); Kumar and Pugazhendhi (2012); Barson et al. (2000)
Lack of efficiency and effectiveness of information system	Lotfi et al. (2013)
Variety of hardware, software, data standards	Lotfi et al. (2013); Khurana et al. (2011)
Legal Barriers	
Formal rules, guidelines, procedures and regulations	Willem and Buelens (2009); Weippert et al. (2003); Khurana et al. (2011); Bureš (2003); Lotfi et al. (2013)
Security and privacy concerns	
Social-Cultural Barriers	
Resistance to change	Özkanlısoy and Akkartal (2021); Kumar and Pugazhendhi (2012); Lotfi et al. (2013)
Lack of technology mindset	Fawcett et al. (2007); Lotfi et al. (2013)
Culture (information sharing)	Fawcett et al. (2007); Fawcett et al. (2007); Khurana et al. (2011);
Different values/goals/priorities	Khurana et al. (2011); Bureš (2003); Barson et al. (2000); Lotfi et al. (2013)
Lack of commitment and willingeness to change	Fawcett et al. (2007); Weippert et al. (2003); Barson et al. (2000); Khurana et al. (2011)
Lack of trust	Chae et al. (2005); Khurana et al. (2011); Barson et al. (2000); Kumar and Pugazhendhi (2012); Lotfi et al. (2013)
Risk	Fawcett et al. (2007); Kumar and Pugazhendhi (2012); Barson et al. (2000)
Reliability	Kumar and Pugazhendhi (2012); Khurana et al. (2011); Lotfi et al. (2013)
Fear of authority loss	Kumar and Pugazhendhi (2012); Bureš (2003)

Organizational Barriers	
Poor infrastructural facilities	Kumar and Pugazhendhi (2012); Özkanlısoy and Akkartal (2021); Fawcett et al. (2007); Barson et al. (2000)
Fear of losing company stability and market position	Barson et al. (2000)
No insight into benefits	Khurana et al. (2011); Fawcett et al. (2007)
Lack of managerial support	Weippert et al. (2003); Fawcett et al. (2007); Khurana et al. (2011); Kumar and Pugazhendhi (2012)
Lack of training and experience	Khurana et al. (2011); Weippert et al. (2003); Kumar and Pugazhendhi (2012)
Level of bureaucracy and administrative control	Khurana et al. (2011); Bureš (2003)
Accuracy of shared information	Özkanlısoy and Akkartal (2021); Lotfi et al. (2013)

4.7. Conclusion

This chapter answered research question *What information can be collected and exchanged across the supply chain and what is the value of this information?* Main information types within the supply chain, based on literature review, can be categorized by inventory information, sales information, order information, forecast information, and product information. Furthermore, other crucial information is information about transport disruptions, new products, development plans, promotional events, and customer feedback on products and services. In general, improved supply chain visibility positively influences efficiency, coordination, responsiveness, and risk. Also, it improves the level of transparency and collaboration. Furthermore, the effects of visibility can be seen in cost reduction and improved customer service. The exact value of certain information is hard to define since many supply chain elements are related. Shared information from customers and suppliers can both be valuable for the receiving as the sharing party. More specifically, the main value of information exchange is related to the stock-outs, excessive inventory levels, lead times, production planning, forecasts, customer satisfaction, and transparency. The relationship between certain information and common problems are explained.

Additionally, the following research question is researched: *What are challenges impeding supply chain visibility?*. The main barriers that impede supply chain visibility are the lack of technical support and the resistance to change. Five main barrier categories are discussed: financial, technological, legal, social-cultural, and organizational barriers. High costs and unclear financial results impede the investment into sufficient IT systems. Incompatibility, integration problems, and lack of efficiency are stated as main technological barriers. Social barriers are seen as crucial factors that influence the reluctance to share information and implement IT infrastructure. The lack of trust in IT systems and supply chain partners is perceived as a major barrier, strongly influenced by risk and reliability. Finally, business culture strongly impacts the willingness and support to share information. Here, support of the management is needed.

Together, these results provide important insight into the value of information and the main barriers that hinder enhancing supply chain visibility. The insights are used as foundations to design the support tools to find opportunities to strengthen the supply chain visibility.

5

Measuring Supply Chain Visibility

This chapter answers the fourth research question: *How can supply chain visibility be assessed?* To answer this question, a systematic literature study is performed of existing measures for supply chain visibility. Extant metrics are analysed in terms of the scope and output of the measurement. Also, the dimensions that cover and measure supply chain visibility, and criteria to assess the level of visibility are analysed. A comparison is done between eleven studies that have developed a supply chain visibility measure (Caridi et al. (2010a); Caridi et al. (2013); Barratt and Barratt (2011); Barratt and Oke (2007); Papert et al. (2016); Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Bartlett et al. (2007); Klueber and O'Keefe (2013); Wei and Wang (2010)). An overview can be found in Table 5.1.

5.1. Scope extant metrics

The industries that are assessed in the literature are diverse. Some of the sectors where the metrics of supply chain visibility are applied are the apparel industry, the pharmaceutical sector, the automotive sector, and manufacturing industry among others. Also, the scope of the measures differ. Some of the metrics are applied at supply chain level where the visibility between the focal firm, customer, and suppliers is measured (Caridi et al. (2013); Barratt and Oke (2007); Barratt and Barratt (2011)). Papert et al. developed a metric where also the manufacturer, logistic service provider, wholesaler, and retailer are included. However, the unit of analysis of most measures are at firm level, where the maturity of visibility is reviewed between a focal firm and a supplier and/or customer (Caridi et al. (2010a);Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Bartlett et al. (2007); Wei and Wang (2010)).

5.2. Output extant metrics

A large part of the metrics is quantitative and another part is qualitative (see Table 5.1). One study about the assessment of SC visibility does not include a specific measurement at all, but only lists the crucial dimensions for the assessment of supply chain visibility (Klueber and O'Keefe (2013)). As can be seen in the overview, the output of the developed measurements differs. Some visibility scores are expressed as index (Caridi et al. (2010a); Caridi et al. (2014)), or score (Williams et al. (2013); Papert et al. (2016); Brandon-Jones et al. (2014); Kim et al. (2011); Wei and Wang (2010)). Quantitative measures express the perceived level of visibility in different categories; lack, low, relatively low, medium, or high (Barratt and Oke (2007); Barratt and Barratt (2011)). Bartlett et al. (2007) uses three levels in which supply chain visibility can be expressed: transparent, translucent and opaque. As mentioned before Klueber and O'Keefe does use a scale to express visibility, nonetheless only critical elements are mentioned. Main goals of the measurements are to analyse and find holes in the network to improve.

Industry	Dimensions of SCV	Criteria of visibility	Output	Quantitative/ Qualitative	Literature
Different industries	Transactions/events, status information, master data and operational plans	Quantity, accuracy and freshness	Index of supply chain leader's visibility of its inbound supply chain	Quantitative	Caridi et al. (2010a)
Apparel	Transactions/events, status information, master data and operational plans	Quantity, accuracy and freshness	Index of supply chain leader's visibility of its inbound and outbound supply chain	Quantitative	Caridi et al. (2013)
Grocery	Amount of useful information shared	Quality, timeliness and usefulness	Perceived level of visibility: high, medium, relatively low, low, lack of visibility	Qualitative	Barratt and Barratt (2011)
CPG	Amount of useful information shared	Type, medium for, nature and quality of information shared (accuracy, timeliness etc.).	Perceived level of visibility: high, medium, relatively low, low, lack of visibility	Qualitative	Barratt and Oke (2007)
Pharmaceutica	Functions of technologies: identification, locating, sensors, communication, data storage, logic	Availability, identity, position, status quo	Level of visibility enhancements by automatic identification (auto-ID) technologies (0, 0.25, 0.5, 0.75, 1)	Quantitative	Papert et al. (2016)
Mining, construction and manufacturing	Visibility of inventory and demand levels	Scale of Braunscheidel and Suresh: extent to which the levels are visible	Level of visibility: score between 0 and 1	Quantitative	Brandon-Jones et al. (2014)
Variety of industries	Demand visibility (customer POS/Sales, customer promotions, customer inventory, customer forecast), supply visibility (supplier advanced shipping notice, supplier order status, supplier inventory, finished goods), market visibility (overall demand, overall supply).	Timeliness, accuracy, completeness, in a useful format	Level of visibility. Score between 0 and 5 (1 = strongly disagree and 5 = strongly agree)	Quantitative	Williams et al. (2013)

Industry	Dimensions of SCV	Criteria of visibility	Output	Quantitative/ Qualitative	Literature
Tele-communication equipment	Supplier information: order completion status, back inventory status, production schedules, current production capacity, demand planning information. Buyer information: inventory status, order status, production plans, production capacity, demand forecast information.	The extent to which the buyer's/supplier's information is visible to the buyer/supplier through IOIS.	Role of inter-organizational information systems (IOIS) in achieving SC visibility. Visibility form buyers' perspective and from suppliers' perspective. Seven-point Likert scale is used.	Quantitative	Kim et al. (2011)
Automotive	6 quality dimensions, 6 cost dimensions, and 6 delivery dimensions	Amount of information shared (opaque, translucent, transparent)	Transparent level of SCV, translucent level of SCV, opaque level of SCV	Qualitative	Bartlett et al. (2007)
Aviation	Strategic orientation, stakeholder capabilities, information elements and sharing, supply chain compliance, operational flexibility, environment, benefits	No measurement	Components of requisite SCV but no exact measurement	x	Klueber and O'Keefe (2013)
Variety of industries	Visibility for sensing, visibility for learning, visibility for coordinating, visibility for integrating	Set of criteria per dimension	Scale 1-5 very disagree - very agree	Quantitative	Wei and Wang (2010)

5.3. Dimensions and criteria extant metrics

Caridi et al. and Williams et al. emphasize the importance of including a comprehensive metric where different dimensions of visibility and information types are included. Somapa et al. (2018) underlines the significance that details about scales should be given to distinguish and judge the different level s of criteria. Additionally, the time, effort and costs should be minimal and reasonable (Caridi et al. (2010a)). An overview of the dimensions included in the existing metrics of the ten authors, can be found in Table 5.1. Most notable are the differences in comprehensiveness. Where Caridi et al. only assesses four information types (transaction information, status information, master data, and operational plans), other authors examine a more comprehensive and detailed set of information types. Williams et al. (2013) for example, includes ten different information types divided into three main categories (demand visibility, supply visibility, and market visibility). Most criteria used to judge the level of visibility, are related to the availability, quantity, accuracy, freshness, timeliness, and usefulness of information. Here, a different choice is made by the authors about the used criteria. Since the metrics can be implied within limited time, not all criteria mentioned are included into one metric, but choices are made.

5.4. Conclusion

This chapter answers the research question: *How can supply chain visibility be assessed?* Extant literature gives many insights into elements included for assessment, and the criteria that are used. Although the metrics are developed for specific industries, many elements can be used as inspiration for the final design of the tools used for RHDHV. Differences between the metrics can be seen by the included dimensions and criteria per measurement. The comprehensiveness differs vastly, and distinct choices are made by the researchers regarding the quantitative or qualitative expression of the supply chain visibility. Also, the supply chain segment where the metrics can be applied is often limited to a specific part. Main limitations in the current assessments for supply chain visibility are related to the comprehensiveness and the selection of criteria. The completeness will be a major focus during the design phase, since the current measures are not all-encompassing. Furthermore, elements of the existing measurements can be used for the design.

6

Empirical Research Supply Chain Visibility

In this chapter, findings from interviews with FMCG supply chain managers and consultants of Royal HaskoningDHV are summarized. During the interviews, challenges and opportunities are investigated to enhance supply chain visibility in the FMCG industry. The interview protocol, including the invites and the outline of the semi-structured interview, can be seen in appendix A. The interviewees are listed in Table 6.1 and 6.2. The topics covered during the interviews are divided into four categories: analysis of supply chain structure, problem identification, Visibility related information, and visibility needs. The answers provided by the supply chain managers and consultants are summarized in this chapter and divided in the main topics discussed. In Appendix A.6 an overview can be found of the interesting subjects and answers that were provided per supply chain manger and RHDHV experts specifically.

Table 6.1: Interviewed consultants RHDHV.

Name	**Date**	**Department**	**Function**	**Years of experience in SC**
Expert1 RHDHV	17-3-2021	Resources Logistics & Power	Senior consultant	20 years
Expert2 RHDHV	18-3-2021	Resources Logistics & Power	Project Engineer	19 years
Expert3 RHDHV	17-3-2021	Resources Logistics & Power	Supply Chain and Operations consultant	6 years
Expert4 RHDHV	19-3-2021	Data & Digital Consultancy	Supply Chain and Operations consultant and Strategy consultant	13 years
Expert5 RHDHV	24-3-2021	Multi-Project Management & Consultancy Multinationals	Director Advisory Group Project Management & Consultancy	7 years

Table 6.2: Interviewed Supply Chain Managers RHDHV.

Name	Date	Function	Product type	Years of experience in SC
SCM A	31-3-2021	Logistics Supplier Manager	Personal care	20 years
SCM B	9-4-2021	Supply Chain Director Benelux	Personal care	12 years
SCM C	9-4-2021	Supply Chain Manager	Personal care	21 years
SCM D	30-3-2021	Supply Chain Director Benelux	Pet food	12 years
SCM E	30-3-2021	Vice President Strategic Supply Chain Projects	Cleaning products	33 years

6.1. Interview with Consultants RHDHV

Experienced consultants in the FMCG industry from different departments are approached. Since 2000, RHDHV focuses on solving logistical problems and since 2009, predictive modelling is introduced as the main expertise. In this period main focus was on heavy industry and from 2015, RHDHV strongly developed in supply chain and logistic consultancy in the FMCG consultancy. Currently, RHDHV is re-branding to supply chain and operations consulting. Core services currently are opportunity evaluation and investment decision-making, plant and site optimisation, facility design, and CAPEX consulting. Expanding services are program management, process operations consulting, Supply chain assessment and network optimization and strategy development. Main findings during the interviews that align with literature can be divided and discussed in the following main topics: problems and tendencies in the FMCG industry, technological, and socio-cultural related challenges. Findings from the five interviews are summarized in the next sub-paragraphs.

6.1.1. Problems and tendencies in the FMCG industry

FMCG companies are growing and activities are expanding around the world, resulting in complex supply chain management. Suppliers of FMCG companies also have their own suppliers and customers who are spread around the world. Many companies understand their level one supplies but have no visibility in their level two and three supply. The large networks contribute to this lack of insight and make it hard to know exactly what is happening and when something went wrong. However, that is exactly how efficiencies can be gained. Information technologies can link data and alert when a link is broken, but key milestones in supply chain processes need to be identified and communicated. Since cooperation with many stakeholders take place, this is not easy when you are dealing with a large amount of data. Another problem that takes place often, are the disruptions in the supply of raw materials and components, and weigh heavily in costs. As mentioned, a growing amount of data becomes available which can be used for more efficient inbound processes for instance. However, the amount of data enterprises have to deal with, becomes exponential. The amount of data is not only related to the total number of supply chain partners/nodes, but also to the types of products that are produced. If more products are produced the amount also multiplies. This is less problematic at the outbound side of the plants as stated by two consultants since most enterprises are dealing with fewer business customers than suppliers.

Other main problems mentioned by the experts are the misalignment of sales and production, unknown arrival times of products, and the pressure that is exerted by retailers. The latter can be seen when delivery is not on time and fees are invoiced, resulting in high cost. Also, due to globalization, warehouses are located in many cities to cover uncertainty. Closer collaborations and integrated approaches are essential to create efficiencies.

Other recent tendencies are that the outbound process is shortened. Delivery is often directly arranged to end-consumers and retailers are more often omitted in this process. Furthermore, the need for a transparent supply chain is becoming more important and customers want to access information regarding the origin of products and the circumstances of employees. Lastly, all consultants raised the

unique pandemic that started in 2019 and which has forced companies in re-looking into their sourcing strategies. As a consequence, more enterprises are switching from global to local supply chains to become more resilient.

6.1.2. Technological Challenges of SCV

Technological challenges are definitely known by the experts of RHDHV. Technologies can help to link data, alert when a link is broken, detect the root cause of a broken link and helps to make decisions based on data instead of experience. Technologies can also increase the efficiency of communication when manual communicating practices are limited. However, not all clients and partners the consultants have worked for, had sophisticated data systems to exchange and receive data. The amount of data exchange is also strongly related to the maturity level of partners and their data systems. On the one hand, the ability to share information, and on the other hand, the technical ability should be available. Consequently, a valid transition is needed leading to interpretable information. This is seen as a difficult task. A frequent problem mentioned by the consultants is that companies do have sophisticated technical systems, but do not always exploit enough value from the systems. The ERP system for instance, contains much data, but usage is often limited. Another main challenge is not only to connect data between different locations, but inside the company itself it can already be hard using many different IT systems having their own formats. A promising technology for future that is seen by the experts of RHDHV is the implementation of Blockchain to save and sent data efficiently and safely.

6.1.3. Socio-Cultural Challenges of SCV

Besides technological challenges, the consultants also addressed many social and cultural challenges to receive the right information to enhance supply chain visibility. Often information is not shared, since parties consider certain data as sensitive information. Even within organisations it can already be a hurdle to receive information of its own sister company. Fear to share information is derived externally often due to competition and internally due to honour issues. Parties within the supply chain are still overwhelmed with uncertainties in the supply chain activities upstream. Information sharing could help but an interaction of information sharing should be found. Full insight in data seems unrealistic by many of the experts, and therefore the focus should be on the valuable information. At the same time complete trust in the received data is needed to extract value out of it.

6.2. Interview with FMCG Supply Chain Managers

The supply chain managers' experiences have gained insight into the complexity of the supply chain. Also much expertise is available about the supply chain structure, structure, the typical disruptions, and challenges of exchanging information across the supply chain. The following sub-paragraphs will illustrate these topics and discuss the findings of five interviews with managers of leading FMCG managers. More information about these managers can be found in Table 6.2. In addition, the interview structure is presented in Appendix A.5.

6.2.1. Supply Chain Structure

The companies of the interviewed managers all have a unique supply chain structure, but similarities exist. First of all, the companies are selling different FMCG products, and one delivers bulk chemicals besides consumer goods, which makes this supply chain structure much different. Secondly, all companies interviewed are global players where factories are distributed over continents and products sold internationally. Most of the production is in-sourced and a smaller part of activities is outsourced by contracted manufacturers. One company is outsourcing the production of the products completely. In some cases, warehousing and the fulfilment of distribution center activities are outsourced, like storage and handling. The five companies are contracting Third-Party Logistics (3PL) as a logistical service provider responsible for transportation.

For the five companies analysed, many supplying companies are involved where packages, raw materials, and components are supplied to the manufacturing locations. Also, many parties are involved on the demand side where the finished goods are delivered to retailers, web shops, professional end-users, and smaller shops. Especially e-commerce has grown in recent years, which can be seen by the large increase of e-commerce clients that have their own e-commerce warehouses and purchasing a complete finished good. The distribution of products is often directly from the factory to major clients that ordered large quantities. The delivery to smaller companies is often arranged through a distribution center. The distribution centers in these cases are located closely to the plants.

The managers of the multinationals interviewed are dealing with a supply chain structure that is organised per continent. The plants in Europe are responsible for the supply of products for Europe, and other continents have their own manufacturers. The distribution centers are also allocated for the supply of products in a certain area. For instance, one DC is responsible for the Benelux and the other DC for France. The different departments as procurement, planning, customer service, and logistics, are working closely together.

6.2.2. Problems and tendencies in the FMCG industry

Typical supply chain disruptions occur across the supply chains of the multinationals and the results of the interviews found quite similar views. From the inbound perspective, products and raw materials are often not delivered in time which causes many problems downstream like the inability to start production and unavailability of products. This can result in out-of-stocks in the warehouses and DC's, leading to insufficient customer service levels. Different grounds can explain this inability to deliver in time, like disruptions of the supplier of their supplier or unforeseen supply problems as fire or transport problems. The unavailability of stock can also occur due to the fact that the demand planning was not sufficient. An underestimated forecast for demand or supply results in misalignment in production planning and the need to adapt the production planning continuously. On the other hand, not only stock-outs occur but also excessive inventories take place. Especially when products are changed often or when design adaptions occur, these products can not be sold anymore. Finding a balance between the amount of safety stock and excessive inventory is a main problem for all the FMCG enterprises.

Other disruptions in the manufacturing facility itself can occur like machinery breakdowns, packing line defects or contamination issues resulting in delays. If the quality of the raw materials or finished goods does not meet specifications, delays also occur and sometimes result in high lead times and stock outs. Problems at the operational level in warehouses and distribution centers, are the inefficient usage of a second warehouse, or space issues. Not every warehouse is designed optimally for all products. When capacity is insufficient, other products need to be temporarily stored somewhere else until space

is available again. Lastly, transport-related problems were addressed that result in late delivery to clients and end-users. Obviously, this is undesirable and can lead to lower satisfaction rates of clients and penalties.

6.2.3. Challenges Key Business Processes

Challenges exist according to the supply chain managers to conquer mentioned supply chain disruptions. These disruptions are influenced by many factors as the ability and willingness to share information, trust, company culture, and technical issues. The complexity and the progression made in the last years became apparent during the interviews with the supply chain managers. The main challenges are discussed, and the areas where opportunities lie are presented.

Demand forecasting

From the supply chain managers' perspective, supply planning is the planning of how and when goods will be moved from the distribution center to the retailer/shop. Production planning and demand forecasting is long-term focused. The latter is achieved by collaborating between the marketing department, sales department, and the demand planning team. The marketing and sales department know exactly what products are sold when promotional events occur and if new products are launched. Demand planning is using a forecasting tool based on historical models. These two separate forecasts are compared, and meetings take place to narrow the gap between these two forecasts. In the end, the demand forecasts of different locations are combined and collected by an international team. Afterwards, the forecast bias (structurally underestimated or overestimated) and the forecast accuracy (accuracy at SKU level) is analysed.

An incorrect demand forecast is problematic since the production planning is not flexible to adapt. In case of under forecasts, inventories are often shared between countries of the company. However, when every country structurally underestimates the demand, powerful countries are getting priory to products. Overestimation is also a main problem with insufficient forecasts. When excessive inventory is built they can not be sold anymore. This takes place when products are changed because of new production lines or new designs. It can be hard to find a new purpose for these products and disposal of these products is not sustainable. A loss of income is inevitable in this case. To conquer these problems, more sophisticated forecasting tools could combine more data. Now forecasts are mainly based on the sell-in data, the products sold to the retailers and shops. The sell-out data, the amount of products sold by the retailers to end-consumers, is very valuable to improve the forecasts and therefore the inventory levels.

Vertical collaboration in terms of forecast sharing appears between the company and the suppliers of products, components or raw materials. However, this is not always performed at the right level and with the right quality. One manager appointed that it is hard to find the right aggregation level. Some of the managers spoken share their forecasts in Excel files extracted from the ERP system with critical suppliers indicating the expected purchasing quantity needed for the coming months. Regarding less critical suppliers, they are able to fulfil the requests of resources and that they can respond to demand fluctuations. These expectations of volumes are also shared with the logistical service providers and are shared manually.

Production planning

The challenge for production planning is strongly related to the demand forecast as described in the paragraph above. An incorrect demand forecast is problematic since the production plannings is not flexible to adapt. An accurate forecast will result in a stable production where the overproduction or underproduction is acceptable. The availability of accurate forecasts of the customers (retailers and shops), and their sell-out data could improve the forecasts. This sell-out data is also called the Point of Sales data.

Inventory management

The suppliers' inventory levels of raw materials, products or components are uncommon to share regarding the manager spoken. This is much data to process since the inbound deals with many material streams and enterprises. The inventory levels of the warehouses and DCs of the FMCG company

itself are mostly known. In contrast, valuable information for the supply chain managers that is often lacking is the inventory level information of the retailers and shops. Traditionally, inventory levels are replenished when the retailers are placing an order. The sourcing department, supply planning, and logistics are in close communication about inventories and product availability. The companies used advanced inventory systems. The inventory optimisation software slapstick, is one software mentioned by the manager and used as an add-on of the ERP system to create order advice automatically.

It is hard for the FMCG companies to forecast their customers' orders, since limited information of inventory levels is available and only the moment of the last order and the quantity of that order is known. Anticipation, when unexpected orders of large quantities are placed, is hard. This can result in high lead times and unsatisfied customers. In most cases, Vendor Management Information (VMI) concepts are not applied, where transparency in inventory levels of both parties provides a dynamic relationship between buyer and purchaser. This inventory management concept smoothens the purchasing process, where the company can adapt its purchasing and production processes easier to prevent stock-outs. None of the companies spoken had a system like VMI and indicated that it could already be difficult to achieve visibility in their own inventory levels. This is especially the case when warehouse activities are outsourced and dependent on the information of 3PL. However, one of the companies had direct insights into the inventory level of bulk chemicals stored in a bulk tank. Sensors were placed to detect the volume and a Just In Time (JIT) principle was maintained to deliver new loads in time. This ensured a low inventory for the seller and the replenishment is organized without an order since the company has direct insights into the stocks. The level was measured by using sensors that also followed primary processes. In this way, the company could give additional advice regarding water usage and the way of purifying. This was seen as an extra service to bind customers. These sensors can be a solution to improve inventory levels. Nonetheless, technically it is not that easy to move and collect the sensor information to the back office. Also, the sensors turned out to be costly, and it was complicated to decide how much to customer needs to pay and if this was taxed by the product price or by a separate tax. These are examples of complex matters why an extensive application is not a reality yet for many enterprises. A similar result in the FMCG industry can be achieved by sharing real-time sell-out data or Point Of Sales (POS). The interviewed firms do not have this real-time information available but do receive inventory information of their biggest clients.

This sell-out, or POS data, is sent in a certain interval manually. Problematic is that many retailers share that information in Excel files by mail, but ideally, this is integrated into the company's systems. The supply chain managers think that not all retailers share their sell-out data yet because of the sensitive character of this information. Namely, this can be used in the negotiations and can influence the commercial discussion, knowing all the details of the amount of sold products and the current commercial and market situation. Trust is an important issue in sharing sell-out data. Another problem of sharing this information is the interval and format in which this information is shared. This differs per retailer, and the level of information is sometimes very detailed at SKU level and sometimes very general and limited. However, this information will significantly increase the forecast and improve the production planning, and also the balance of excessive inventory and stock-outs can be managed more efficiently. In an ideal situation, the sell-out data or POS is automatically communicated when products are sold and scanned at the register by a customer. In doing so, the replenishment at two levels, store replenishment and warehouse replenishment, can be coordinated efficiently. Additional information that can be useful is the replenishment policies of retailers to better align the production planning.

Since no full insights in the retailer's inventory are known by the interviewees, the continued trade-off companies have to make is the amount of stock that should be hold. High stocks increase the service level, but that is unfavourable for the cash flow. When complete transparent inventory levels exist, the perfect stock level can be determined resulting in low costs, but enough to process the orders in time. To summarize, this inventory information is often missing. When the information is known, it is mostly updated inadequate and sent only in a certain time interval and is not always accurate and complete. Trust issues and fear for deterioration of market position play a main role in providing this information.

Logistics
A main challenge addressed by the FMCG supply chain managers is that disruptions are not always

communicated fast across the supply chain and therefore efficiency is lost. Communications of transport disruptions of suppliers are essential to adapt production planning. However, these disruptions are often not communicated on time. One supply chain manager explained the behaviour between suppliers and a FMCG company in this situation. If disruptions take place, the supplier wants to wait as long as possible to communicate this, since there is a chance that the disruption will be solved in time. Otherwise, an order will be placed at another supplier. However, when the disruption is not solved in time, the manufacturer gets this message too late and needs to adapt the production process. The interests of manufacturers and suppliers are different, but the communication of these transport disruptions are a problematic issue. Furthermore, maintenance plans of suppliers are also not always communicated, but are important to build up stock on time. In the case of maintenance plans, the company needs to approach the suppliers to collect this kind of information proactively. The FMCG managers understood this behaviour since they also do not always communicate their low inventory levels with their retailers. This is done consciously to prevent hoarding when the clients know that products are scarce. Late delivery to clients, on the other hand, is often communicated as fast as possible. Here a pro-active attitude is important since this influences the clients business as well. In some cases, companies work with penalties when products are delivered too late. Late delivery from the FMCG firms can create a bad image. A supply chain manager mentioned that customers always remember unreliability faster than good performances, which should be prevented.

All companies interviewed outsourced the transportation of goods by one or several logistic service providers. Goods are transported at pallets in trucks to DC's, warehouses, or shops directly. Customers ordering large volumes that take up a whole truck are typically being served directly from the factory. Small orders placed by customers are often delivered via a parcel delivery service like post.nl. The disadvantage of delivery with such a parcel delivery is a loss in flexibility. Often the FMCG companies are working together with several logistical providers. Some providers are serving only one company with one truck, and others share the load of multiple companies. In the latter case, an enduring balance and consideration need to be made with those logistic providers on how to groupage and divide the pallets that need to be transported over multiple enterprises. The transporter can optimize the profit when more enterprises are in, and the costs can be divided over multiple companies. However, a company wants to occupy as many pallets in on the truck, but this can be seen in the costs.

The most important KPI regarding the supply chain managers, related to transport, is the OTIF: on-time in-full. This indicates if a product is delivered in time and full or complete. In-time depends on the transport service, and in-full is related to the inventory. The company or end-user often receives an Estimated Time of Arrival (ETA) or a track and trace code. The ETA of consumers is often very accurate but are less developed in the case of B2B. However, arrival times are also important for retailers working with strict time blocks. Being on time is the responsibility of the logistic service provider, just as the tracking and tracing of trucks and estimating and updating the estimated time of arrival. The logic party loads the available data in their Transport Management System (TMS), indicating where trucks are and where they standstill. In an ideal situation, this information is sent to a cloud solution that can be accessed anytime by the FMCG company or the shops. Right now, the companies do not have real-time insight into this information and the needed information is sent manually. Often, another company acts as an intermediary and processes and sends information from the ERP system to the company. Transport companies are not very willing to share information at all times regarding the managers. They have their own IT structure and are not willing to change their IT infrastructure. One of the fears related to this, is the possibility to be hacked. The above-mentioned challenges are all related to the moment after production, but delayed trucks for the supply of raw materials can be problematic too, affecting the production planning.

Developments in transportation mentioned are the deployment of two drivers to expedite the lead time. Another interesting pilot that took place at a company was unmanned delivery. Here, transport providers deliver the load before the shop is opened, and the drivers are provided with a key or code to deliver. Advantages in this case are the minimal contact between the employees of the shop and logistics, but also between shopping public and logistics. Fewer employees are needed to receive the products, which saves costs. The shops that participated in this pilot are owned by the company itself, making it easier to run the pilot. Trust is an important fact in this situation, and this pilot is an

example of a development in the transport sector.

6.2.4. Technological challenges of SCV

Software Systems and manual operations

The multinationals all having software solutions to manage business operations and communication and were explained during the interviews. The Enterprise Resource Planning (ERP) systems cover programs for all main activities as procurement, production, material management, sales, marketing, finance and human resources (HR). All FMCG companies have an ERP system where the organisation of several business processes is integrated. Systems Applications and Products (SAP) is a main supplier of ERP solutions and applications, which is implemented by the companies interviewed. Orders received are loaded in SAP or Event-Driven Architecture (EDA) and processed automatically for order-picking and other services. Order management is mainly automated, but one manager addressed that smaller parties still order per mail or even fax. In those cases, logistical data exchange, like the volumes that will be delivered to warehouses and order volumes, is not extracted from the ERP system but is processed and sent manually via Excell files. Other types of information that is exchanged manually are sell-out data, changes in product catalogues and transport disruptions. In the ideal situation, all data streams are integrated into one system. In terms of transportation, teams of customer services communicate with the 3PL partners and the logistic service providers like Mainfreight also have their own software system. Also, they use a Warehouse Management Software (WMS) where orders are received, pick-ups are planned, and that is connected to the ERP system of the company. A software used for communication of one of the companies is Salesforce and is meant for customer relations as a Customer Relationship Management (CRM) system. However, Salesforce is not the only medium used for communication because many customers and suppliers still use email to communicate. The main disadvantage of email that is stated, is that it is harder to find messages back and that not all messages are stored in one place.

Data formats and masterdata

Technical limitations are seen as the main reason why information exchange is obstructed by all of the supply chain managers interviewed. The technical systems of the customers and suppliers of the FMCG enterprises that can process and send information, are often not mature enough. So, the professionalism of the customers and suppliers is impeding data exchange. Some warehouses are processing information manually. Often, different formats and programs (Excell, SNG, etc.) are used to manually send information. This makes it time-consuming to interpret and build this information of several parties into one format. Sometimes a standard format is sent in which the information is preferred to receive but is often not used. Every company is using their own software system and it is hard and costly to match systems together. It is complex to decide which costs lie at what party in the supply chain. A main underlying problem that is addressed by supply chain managers is that the master data is not organised well. This makes it it hard to compare data. The master data is the source data and the base unit of measure. This master data is of main importance to be in line throughout the chain to compare and use the information of different parties and departments. This is a problem for all large companies nowadays. Problematic is that no one feels responsible for the master data since it is present in the whole supply chain. It takes years for teams of experts and consultants to cleanse this master data and is often expensive. GS1 is an example is an external company aiming at uniform data coding, which is helpful to create interpretable information for all parties involved. This could help a lot, especially since the amount of data is growing and making this complex. An illustration was provided that if you combine information of every product, for all customers, and per day, you will have an explosion of data.

Technical developments

Some technologies can be promising to apply in the FMCG industry regarding the five supply chain managers. The use of Radio-frequency identification (RFID) as a technique can store and read information from a distance because of the RFID tags attached to products. This can save time because when using RFID, not every product at a pallet should be scanned separately but can be scanned at once and registered in the inventory system when a pallet is passing a RFID gate. Using RFID can save time but is also costly and therefore not widely applied. When production costs of RFID tags

can be decreased, it could become more promising according to two managers to apply in the FMCG industry. Another development mentioned is the demand for more interpretable data using software as PowerBI. This is a business analytics service that can visualize data and create its own dashboards. The graphs in this dashboard are generally easier to interpret in many situations than numbers. Another promising technical development is the emerge of blockchain to send, save and verify information in a de-central and transparent manner. This can be interesting to be applied to assess the level of sustainability. Other technical changes can be obtained in the area of automation in processing and analysing data to automatically create plannings and forecasts for example. Technical solutions in the warehouse and distribution can be improved by using more sophisticated picking systems. Still, the return of investment can only be obtained if the warehouse is large and serves many countries.

6.2.5. Socio-Cultural challenges

Trust

Trust is a critical factor for the success of sharing information, which all the supply chain managers strongly emphasized. One example explained where this trust issue is visible is looking into the retailers' willingness to share inventory information. Sharing this information can influence the commercial negotiations, knowing all details in good and bad economic times. Additionally, companies work together with several retailers that are also competitors with each other. If the information is shared, trust is needed to guarantee that the information is used securely. At the supplier side of raw materials, trust is also important in terms of fair communication of transport disruptions and other crucial information as explained before. In the contracting phase, suppliers are not only selected based on prices but also on their reputation and reliability.

The fear of misuse of the data and imprudence when information is processed and can be vulnerable for hackers, are main reasons why trust is important. Time is essential to create trust. Some of the supply chain managers worked for decades within a company working at strong relations with clients. Real-life visits and talks are needed, and this personal approach is often helpful to make steps in the willingness to share data. One manager saw that only small opportunities were created after 4 years of focusing on communication and making a personal connection. This is really a long term project, but it is essential.

Business culture

Different business cultures are affecting the willingness to share data and information. For instance, a retailer such as Kruidvat, is historically an Asian company and Etos is a Dutch company, which clearly shows differences in practice. An illustration is given by a supply chain manager where this difference was visible during formal processes as force majeure. This force majeure frees parties from liability or obligation in case of an extraordinary event. Legally a supplier does not need to share the volume that still can be delivered and German companies strictly follow this rule. On the other hand, American and Asian companies share that information much easier and are less strictly committing to all regulations and rules. This is one example, but business culture is affecting many more situations, the communication, and also the willingness to share information.

Contract negotiations

The contract negotiations between two parties are important moments to record the minimal and maximal information that should be shared. Important is that the advantages of information sharing can be emphasised and proved. However, this is not always easy. Furthermore, not in all cases data can be exchanged immediately. Sometimes new IT systems are needed to process this. The costs of this investment is something that can be included in negotiations but is a tough subject. The amount of information that a FMCG company is sharing with their stakeholders also depends on the size and the exact power position of the retailers and shops. It can be seen that companies as Albert Heijn and Kruidvat are very powerful in deciding what information is shared. Powerful retailers also have their own requirements like certain delivery terms, delivery conditions and updates in catalogues that need to be exchanged at certain intervals. They also have their own Electronic Data Interchange (EDI) systems where adaptions of FMCG companies are needed to transfer data. The retailers are also demanding certain changes of the FMCG company and this relationship is clearly visible during negotiations. Contract negotiations can be challenging if conflicting interests and lack of cooperation are appointed

during the interviews.

Contracted customers have more certainty than non-contracted parties. An example of a common clause included in contracts is fast majeure as described earlier. This frees parties from liability or obligation if an extraordinary event happened like an epidemic, war or fire. If that company can only deliver half of the products, the contracted customers have priority due to such an event. The supplier of critical raw materials are therefore always contracted parties. Other information often set in contracts is the minimum

6.2.6. Developments

To answer and bridge challenges in supply chain management, some trends and developments can be detected based on the interviews. First of all, the amount of data that is available and shared has increased. This covers information like forecasts, sell-out data, stock and trade data, and online availability leading to stronger vertical collaboration. Also, the product information is more shared in terms of sizes and weight and product characteristics. Companies such as bol.com want to obtain as much information as possible to provide this to their end customers and also want this information to improve their operational processes. The amount of data available has grown, but also the information requirements increased. Another development is the amount of feedback given throughout the supply chain. An example was given about a customer that orders a certain quantity of products and that feedback is sent by the FMCG enterprise about beneficial order quantities. In this case, costs can be saved for both parties. Also, KPIs are recorded more accurately and more shared used for strategic purposes (OTIF or reliability).

Trust is a main building block to achieve more data exchange. Therefore, the focus of the supply chain manager is on making personal connections and the creation of trust. Secondly, e-commerce has grown substantially, and especially during the pandemic. Therefore the relatively new KPI, OLA, is used more often. Here, OSA is indicating the on-shelf availability and OLA the Online availability. This online availability can be checked easily online. Having a low OLA means that on the one hand this could lead to missed sales, and on the other hand, this gives information about the inventory level of the e-commerce. In that case, the FMCG company can better predict when orders will be placed. Web-crawlers are computer programs and automatic search engines that browse on the internet and send a bid on the internet to look at the clients' websites for out-of-stock products. This is also a relatively new development.

The demand for a transparent supply chain is increasing, and right now the supply chains of the FMCG companies spoken are not fully transparent. Reasons for transport disruptions and stock-outs are not reported truthful. An example was given that in case of stock outs another reason was communicated with the customers like it was the result of an international issue. This is not informing the real cause. Also, when the company itself made a wrong disgraceful decision, this is also not communicated. The exact composition of the product and the proportion of ingredients is not shared, indicating that full transparency is not available yet. However, this makes sense otherwise it can be recreated easily by competitors. On the other hand, the absence of environmentally harmful ingredients as palm oil are presented. The consumers nowadays are more aware of the impact of these ingredients. The exact origin of ingredients and the locations of factories are not publicly presented and the origin of the suppliers' suppliers are even harder to trace. This is more common in food industries, where the exact location or the living conditions of animals are more transparent. Creating transparency is a trend of the last decades but still challenging without losing the market position.
Other collaborative developments that are relatively new are the access to bar codes to use in other stages of the supply chain so that less struggles take place at inbound. Furthermore, developments as Machine Learning (ML) and Artificial Intelligence (AI) can make fundamental changes possible by discovering patterns in supply data, detecting abnormalities, and enhancing decision-making. Furthermore, blockchain could contribute to access and transfer data easier and in a safe manner where less communication is needed, traceability can be strengthened, and costs can be reduced. The managers emphasized that technologies facilitate the ease to couple systems to each other and to transfer data and sensors or other technologies become cheaper and more reliable. Technologies as RFID tags can therefore be promising to adapt more in the supply chain processes.

Lastly, the managers all emphasized the uniqueness of the COVID-19 pandemic, which was very challenging. At the same time this was very instructive on how to switch and adapt in such a crisis. A major disruption in demand patterns took place, and much was possible in terms of fast adaption, decision making and getting permissions. Teamwork was optimal and this also created much energy. Therefore, the Covid-19 is a very useful case to use as an example in future situations.
A list of main developments found during the exploratory interviews are summarized and listed below:

- The amount of available data and information has increased
- The information requirements are more demanding
- The amount of shared information increased
- More feedback is given
- More focus on creating trust
- Growth of e-commerce
- Use of web-crawlers
- Demand for transparent supply chain
- New technologies applied in the industry (AI, ML, Blockchain etc.)
- Integration of systems
- Faster adaptions in decision making (Covid-19)

6.3. Overview of the challenges impeding supply chain visibility

The biggest challenges in managing supply chains are found during the interview execution and are summarized and listed below:

The challenge of available, accurate, and timely supply chain information

- Demand forecast: main challenge for FMCG enterprises is to optimize their demand forecasts. Collecting the promotional events information and point of sales data that retailers and shops own, could improve this. Also, the forecasts of these retailers and shops are often not shared, and if so, the level of detail of accuracy is often insufficient. Here opportunities are present to enhance supply chain visibility.
- Production planning: the main challenge for FMCG enterprises is not to produce too much or little and effectively align production processes. Accurate sell-out data and demand forecasts could improve the production planning, however this is often not available or inaccurate.
- Ordering process: the main challenge is to decide when to re-order. Insights in the inventory level of customers could optimize this process but are often lacking or inaccurate.
- Inventory management: direct insights in the inventory levels of customers or receiving point-of-sales data can improve the responsiveness. Also, insight into own inventory levels can be a challenge already, especially when this is outsourced. Furthermore, the amount of stock to hold is a hard question.
- Logistics: main challenge regarding logistics is to receive accurate and timely information about the departure time and the estimated time of arrival. Furthermore, transport disruptions are often communicated too late.

Technological challenges

- Integration of software systems internally and with supply chain partners

- Receiving information in the same format
- Creating clean master data

Socio-cultural challenges

- Creating willingness to share information
- Providing clear insights into the exact advantages of data exchange
- Creating trust

Other challenges

- Managing a large amount of data
- Utilizing and exploiting the capacity of current systems
- Connecting and interpreting internal and external data
- Finding the root cause of broken link or problem

6.4. Conclusion

This empirical research answered research question 1: *What is the state-of-the-art of coordinating FMCG supply chains?* The complexity of the supply chains structure is illustrated with examples obtained from interviews, just as the corresponding problems and tendencies. The informants in this study gave examples of coordinating and managing the supply chain dealing with challenges. The main problematic activities that are affected the most by these challenges and where coordination is difficult can be summarized by: supply planning and demand forecasting, production planning, inventory management, transport disruption management, and in time transportation and delivery. An in-depth explanation of why these activities are hard to coordinate and how this can be improved can be found in this chapter per topic. Examples to obtain easier coordination are given and includes among others: better contract agreements, exchanging more information, building up trust, and better communication of transport disruptions. Additionally, technical coordination systems and future promising opportunities are discussed, like the use of RFID tags, sensors, blockchain and Vendor Management Inventory systems. A common view amongst interviewees was that building trust should be the main focus to enhance supply chain visibility resulting in better coordination. The answers per interviewee had different focus areas. In some cases, more focus was on transportation and in others more emphasis was on the inbound or outbound processes. Together these results provided important insights into the complexity of coordination in the FMCG industry and focus areas on improving supply chain visibility.

The second research question that is answered is *What information can be collected and exchanged across the supply chain and what is the value of this information?* Respondents were asked what information is exchanged across the supply chain and what is information is received. Also, information that is lacking to deal with the typical supply chain problems is investigated just as the owner of that information in that case. Information that is exchanged and received can be classified into transnational information, order information, product information and information related to logistics. The interviewees agreed that overall those information types are available, but the accuracy and timeliness can be improved. Information that is often problematic to receive is sales data or sell-out data, sales forecasts, replenishment information, inventory level information, location status, and timely information about transport disruptions. A minority of the participants receives this information frequently, but often this is not complete and accurate. Main reasons why this information exchange is not optimal are related to business culture, the sensitive character of this information, fear of misuse, and technical issues. The added value of this information is especially focused on responsiveness, inventory management, risk management and efficiency. The critical information types, the added value, and the complexity of improving this data exchange became clear during the interviews.

The last research question investigated by the executed interviews is *What are the challenges impeding supply chain visibility?* A common view amongst interviewees was that the main challenges

are related to creating accurate plannings and forecasts, having better insights in product availability in warehouses and having real-time insights in sell-out-data. Receiving insights in the inventory levels of customers and suppliers, creating proactive communication of disruptions, and having real-time information of trucks is very challenging too. At the same time, it is important that the information exchanged and received is accurate, up to date and detailed. Another technical related challenge is the integration of different systems to collect and sent this data. Additionally, master data must be clean, and information should be received in the same formats to increase efficiency. Finally, to increase the amount of data exchanged, trust needs to be created and proof of concepts should be given about the beneficial effect of data exchange for multiple parties. In the end, this enhanced visibility can contribute to creating transparency and finding out the root causes of problems.

Together these answers to the first three results questions provide important insights into the problem statement of enhancing supply chain visibility in the FMCG industry.

Emphasis in literature study and empirical research

The emphasis on the trends, critical information, and barriers are slightly different in literature compared to findings from empirical research. However, many topics are strongly emphasised by both literature as empirical research. An overview of these differences in emphasis of the main subjects is presented in the overview of Figure 6.3. This knowledge will be used as basis during the design phase.

Table 6.3: Topics mainly emphasized in literature versus empirical research

TRENDS			
Literature Research	*Empirical Research*	*Literature & Empirical Research*	
Shifting demographics	Use of WebCrawlers	Globalization	Going sustainable
Health consciousness	Direct delivery to end-consumers	Logistical & technological innovations	Information transparency
	From global to local (covid-19)	Outsourcing	Variety of products
		Changed consumer desires	Online sales and marketing
		Pressure on efficiency	Ethical expectations
CRITICAL INFORMATION			
Literature Research	*Empirical Research*	*Literature & Empirical Research*	
Development of new products	ETA	Inventory information	Product information
Feedback from customers	OTIF	Order information	Transport disruptions
Knowledge	OLA	Sales information	Promotional events
		Forecast information	
BARRIERS			
Literature Research	*Empirical Research*	*Literature & Empirical Research*	
Not knowing where to start digitization	The large amount of data	Costs	Lack of technical support
Fear of authority loss	The transition of data into interpretable information	Unclear financial results	Different values/goals/priorities of supply chain partners
No insight into exact benefits	Organization of master data	Risk	Implementation issues
Lack of experience	Commercial negotiations	Reliability	Variety of hardware, software, and data standards
	Power position of other stakeholders	Fear of losing market position	Legal barriers
		Accuracy of information is not sufficient	Security and privacy concerns
		Lack of trust	Willingness/resistance to change
		Culture	

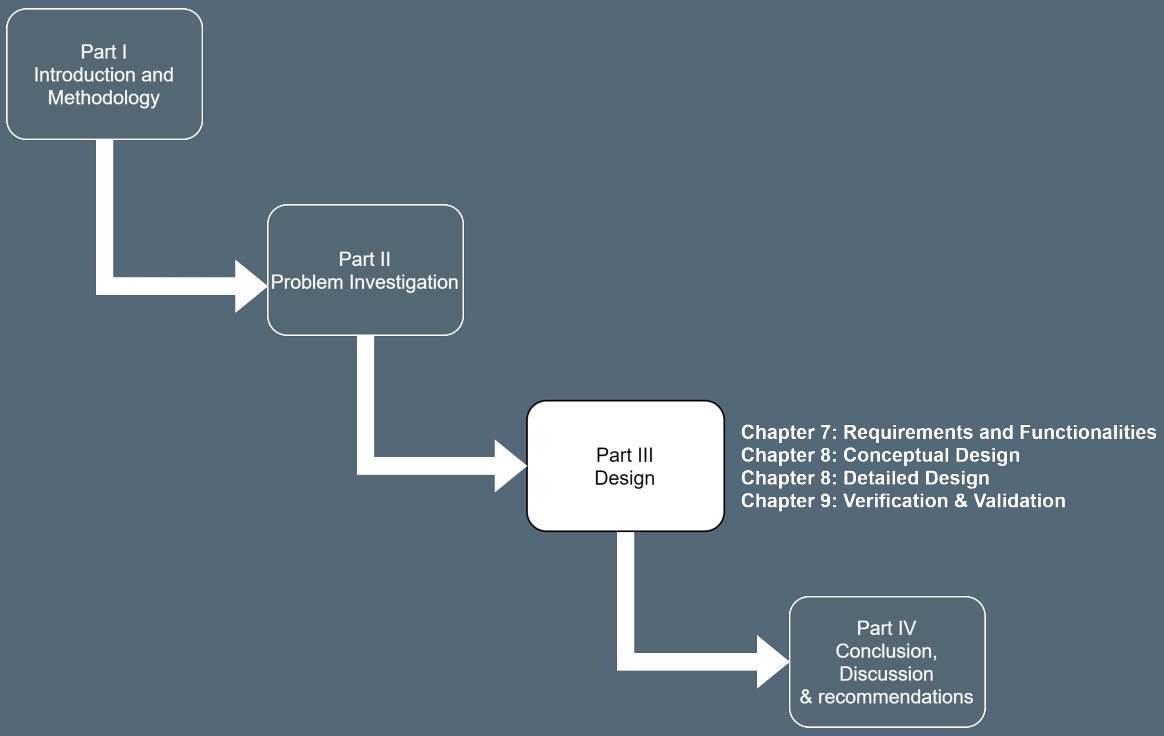
III

Design

This part provides the set of requirements and functionalities that the designs of the support tool should met. The set of requirements is composed, based on requirements found in literature and requirements defined by RHDHV. These observations are complemented with requirements found during empirical research with supply chain managers, and the requirements defined by the researcher. The final set of requirements is specified by RHDHV and the associated functionalities could be compiled.
The research question answered in this part is:

- *What are the relevant requirements and functionalities for the supply chain visibility tools?*

In the subsequent chapters, conceptual designs are developed that provide a basis for the detailed design. The detailed design is developed towards a digital tool, and this process is described. Furthermore, verification and validation sessions are outlined. During the validation sessions, the practicality, the overall impression and added value of the tool is tested, and suggestions for improvements are provided.



7

Requirements and functionalities

This chapter provides the criteria and functionalities of the tool. The tool exists of two different scans that can be executed, with a distinct level of detail. First, the design artefact will be reiterated. Thereafter the final set of requirements and functionalities are defined based on findings from literature, criteria defined by RHDHV, outcomes from empirical research, and the requirements of the researcher. The considerations made during this process are described in this chapter.

7.1. Design artefact

The artefact that will be designed in the following chapters will be described first in able to define an effective set of requirements and functionalities. As mentioned in 1.4, the tool that will be developed aims to support consultants to assess the current degree of supply chain visibility in the FMCG industry and find critical areas and opportunities. This can contribute to provide grip for a systematic analysis and the enhancement of supply chain visibility. The tool has different levels taking into account different detailing. The analyses consist of a Visibility Maturity Scan and a Detailed Demand/Supply Analysis. The quick scan provides a systematic overall visibility maturity level and can function as starting point for discussion and the establishment of a detailed project proposal. The goal is to design a questionnaire that can be placed at the website of RHDHV, can be sent by email, or used during a session to gain insights into the current status of an FMCG enterprise. Results should be provided immediately after execution of the survey. The detailed Demand/Supply Analysis provides detailed insights into the maturity of suppliers / (b2b) customers regarding supply chain visibility. Here insights into critical customers and suppliers to enhance the supply and/or demand visibility will be presented into a dashboard. This can be used during a sessions by RHDHV and the FMCG enterprise.

7.2. Approach to define requirements and functionalities

Requirements from different sources will be discussed. First, the set of requirements found in literature are listed, followed by requirements defined by RHDHV, and by supply chain managers during empirical research. Additionally, own preferences for the tool are named as well. During a session with two experts of RHDHV, expert RHDHV1, RHDHV2 (see appendix B), and the researcher, decisions are made in terms of the need-to-have and nice-to-have requirements. Thereafter, the final requirements and the resulting functionalities are determined that followed from the final set of requirements. This process is presented in Figure 7.1.

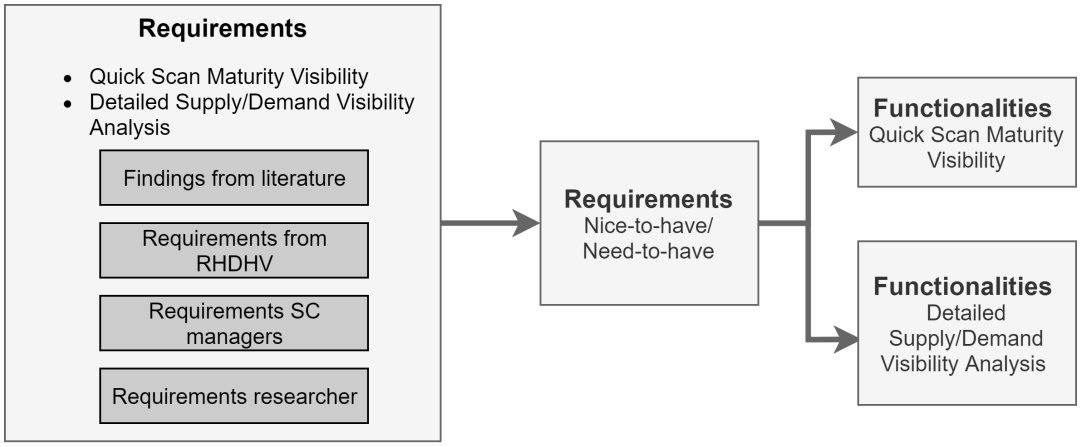


Figure 7.1: Process of the development of requirements and functionalities.

7.3. Requirements

Requirements designate the constraints that need to be met to function as a quick scanning tool and detailed analysis tool. The requirements found in literature are described in chapter 5. An overview of the requirements detected in literature and during interviews with supply chain managers are listed in this paragraph, just as the requirements by RHDHV and the researcher. During a session with experts RHDHV1 and RHDHV2, the final set of requirements is generated, and the requirements are labelled with *nice-to-have* and *need-to-have*. The *need-to-have* requirements are the minimal prerequisite that needs to be met and are grey coloured. The nice-to-have requirements are coloured as light grey, and the other requirements that are excluded are crossed out (see Figure 7.2). The latter can occur if requirements are not suitable, mentioned multiple times, or are contradictory to other needs.

Need-to-have
Nice-to-have
~~Excluded~~

Figure 7.2: Explanation colour of requirements in table cells.

Requirements from literature

In chapter 5, eleven extant tools that are present in literature are analysed. These authors have made different choices during the development phase of their tools. These choices made are formed into different requirements that are discussed. Furthermore, requirements are complemented with general requirements found in literate that relate to design decisions of tools and information technologies (Buede (1997); Sarkis and Sundarraj (2006); Somapa et al. (2018); Violante and Vezzetti (2014)). An overview of the requirements found in literature is presented in Table 7.1. During a session with the two experts, the need-to-have, nice-to-have, and excluded requirements are determined. All choices will be clarified briefly.

Table 7.1: Overview requirements from literature.

#	Requirement	Reference	Nice-to-have / Need-to-have
		LITERATURE	
1	Includes a comprehensive metric of visibility considering different dimensions of visibility	Caridi et al. (2010a); Caridi et al. (2013); Papert et al. (2016); Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Bartlett et al. (2007); Klueber and O'Keefe (2013); Wei and Wang (2007)	Need-to-have
2	Distinguishes different types of information flows	Caridi et al. (2010a); Caridi et al. (2013); Barratt and Barratt (2011); Barratt and Oke (2007); Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Bartlett et al. (2007); Wei and Wang (2010)	Need-to-have
3	Assesses visibility based on different criteria	Caridi et al. (2010a); Caridi et al. (2013); Barratt and Barratt (2011); Barratt and Oke (2007) Papert et al. (2016); Williams et al. (2013) Wei and Wang (2007)	Need-to-have
4	Provides details about scales to distinguish and judge different levels of the criteria	Caridi et al. (2010a); Caridi et al. (2013) Papert et al. (2016); Williams et al. (2013) Bartlett et al. (2007); Wei and Wang (2010)	Need-to-have
5	Includes measurable scales	Somapa et al. (2018)	Need-to-have
6	~~Tool can be used by a variety of users~~	~~Buede (1997)~~	~~Excluded~~
7	The distinguished levels should not be subject to individual interpretations	Klueber and O'Keefe (2013)	Nice-to-have
8	Expresses the maturity level of supply chain visibility quantitatively	Caridi et al. (2010a); Caridi et al. (2013); Papert et al. (2016); Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Wei and Wang (2007)	Need-to-have
9	Measures the maturity level of supply chain visibility qualitatively	Barratt and Barratt (2011); Barratt and Oke (2007); Bartlett et al. (2007)	Nice-to-have
10	Limited effort in time	Caridi et al. (2010a); Caridi et al. (2013)	Need-to-have
11	Limited effort in costs	Caridi et al. (2010a); Caridi et al. (2013)	Nice-to-have
12	~~Limited input needed~~	~~Buede (1997)~~	~~Excluded~~
13	Easy to use	Violante and Vezzetti (2014)	Need-to-have
14	~~Easy to integrate in current businesses~~	~~Sarkis and Sundarraj (2006)~~	~~Excluded~~
15	~~Able to integrate external systems and information sources~~	~~Sarkis and Sundarraj (2006)~~	~~Excluded~~
16	~~Limited maintenance needed~~	~~Buede (1997)~~	~~Excluded~~
17	Can easily be customized	Violante and Vezzetti (2014)	Nice-to-have

[1] A comprehensive metric of visibility with multiple dimensions is defined as needed. This followed logically from the design goal and deliverable that RHDHV predefines.

[2] The requirement that the tool distinguishes different types of information flows, is set as needed. This is required to design an all-encompassing measurement tool.

[3] Experts RHDHV1 and RHDHV2 emphasized the importance of using multiple criteria to judge the level of visibility of information flows. Therefore, this requirement is included as criteria.

[4] The fourth requirement found in literature is also defined as a requirement that the design should comply with. The scales of the criteria should be formulated as clear as possible in a way that the user can select an answer without doubt.

[5] The experts of RHDHV agreed that including measurable scales can create more value. This does not necessarily mean that the user should provide all the exact values of those measures in practice. The idea behind this requirement is that it will be easier for users to understand and estimate certain questions included in the tool if they have measurable scales. Therefore this

requirement is set as needed

[6] The tool will be designed for supply chain managers specifically in the FMCG industry. This requirement found in literature is eliminated.

[7] The experts discussed that ideally, the levels of the tool should not be subject to individual interpretations. Nonetheless, this is inevitable when supply chain visibility is assessed based on subjective criteria as on-time and accuracy. The possibility exists that these kinds of criteria are experienced differently by several users within the same company. For this reason, the requirement is set as nice-to-have but is not a strict requirement.

[8] Discussion took place to determine if the maturity level should be expressed quantitatively or qualitatively. The consultants of RHDHV determined that a quantitative output can give a result that is easily interpretable and preferred. This is set as a need-to-have requirement.

[9] A qualitative output is also desired besides a quantitative score. The experts specified that an overview with a score is required and that textual explanations are nice to include. Therefore this requirement is stated as nice-to-have, but not required.

[10] This requirement is set as needed since the tools should provide support within limited time. Especially the Visibility Maturity Scan should be executed within a restricted time frame.

[11] In practice it would be nice if the costs of the tool are limited. However, this is not considered during the design phase and is therefore defined as a nice-to-have requirement.

[12] Since the tool will be used as a quick scan, but also as a detailed scan during sessions, this requirement is rejected. During a detailed analysis, it will be useful if the client can collect data or key performance indicator information beforehand. Therefore this requirement is eliminated.

[13] The ease of using the tool in practice is set as a prerequisite by experts RHDHV1 and RHDHV2.

[14] The requirement related to the ease of integration in the current businesses is rejected. This is out of the design and validation scope.

[15] Also, the maintenance of the tool is not related to the design and usage of the tool by RHDHV and FMCG firms. This is related to the operational phase and ascertained as out of the scope.

[16] Experts RHDHV1 and RHDHV 2 agreed that it would be nice if the tool can easily be customized. However, since this is the first attempt to design this tool there are no strict deadlines when the tool should be finished. Since time is available, this requirement is set as nice-to-have.

Requirements of RHDHV

The requirements that are defined by RHDHV are discussed with the researcher. The need-to-have, nice-to-have, and excluded requirements specified by RHDHV are listed in Table 7.2.

Table 7.2: Overview requirements of RHDHV.

#	Requirement	Reference	Nice-to-have / Need-to-have
	RHDHV		
1	Measures the level of supply chain visibiliy	RHDHV1	Need-to-have
2	Finds critical areas for improvement	RHDHV2	Need-to-have
3	Provides recommendations	RHDHV1	Need-to-have
4	Provides correct information	RHDHV1	Need-to-have
5	Provides interpretable results	RHDHV1	Need-to-have
6	Has a wide range of functional elements	RHDHV1	Need-to-have
7	Visibility Maturity Scan functions as the starting point for further detailed analysis	RHDHV1,2	Need-to-have
8	Detailed Demand/Supply Analysis finds critical suppliers/ customers	RHDHV1,2	Need-to-have
9	User friendly	RHDHV2	Need-to-have
10	Low costs for set up	RHDHV2	Nice-to-have
11	Execution of Visibility Maturity Scan can be conducted within 15 minutes	RHDHV1	Need-to-have
12	A limited number of actions needs to be executed	RHDHV2	Need-to-have
13	~~Easy to integrate in consultancy work~~	~~RHDHV2~~	~~Excluded~~

Nine of the thirteen requirements are set as required (need-to-have), and need to be complied with.

As discussed before the requirement of low costs for set up is set as nice-to-have, but is not a strict requirement in the design phase. Furthermore the ease to integrate the tool in practice is set as prerequisite for the same reason as mentioned before: this is out of the design and validation scope. A new requirement that complement the criteria defined from literature, is that the scan should find critical areas for improvement (see aim of the thesis in 1.4). Furthermore it should provide recommendations, correct information and interpretable results. The quick scan functions as starting point for further detailed analysis and the detailed analysis finds critical suppliers and customers. Moreover, the scan should be user friendly which relates to the limited number of actions that needs to be executed when using the tool. A time restriction is set of 15 minutes in which the Visibility Maturity Scan should be conducted.

Requirements of FMCG Managers

During the empirical research, five supply chain managers of leading fast moving consumer goods companies are interviewed. During these interview the requirements for a supply chain visibility measurement tool are not asked directly, but are derived from the conversations. An overview can be found in Table 7.3. The choice to include these requirements are clarified briefly.

Table 7.3: Overview requirements of FMCG SC managers.

#	Requirement	Reference	Nice-to-have / Need-to-have
	FMCG SUPPLY CHAIN MANAGERS		
1	Measures the level of supply chain visibiliy from both the demand as supply side	SC manager company A, B (Appendix A.3)	Need-to-have
2	Includes visibility of (transported) goods	SC manager company C (Appendix A.3)	Need-to-have
3	Provides insights into the level of information exchange with supply chain partners	SC manager company E (Appendix A.3)	Need-to-have
4	Considers data/information that is sent by stakeholders both manually as automatically to assess supply chain visibility	SC manager company D (Appendix A.3)	Need-to-have
5	Measures operational/tactical and strategic supply chain visibility	SC manager company D (Appendix A.3)	Need-to-have
6	Creates an overview of problem areas	SC manager company A (Appendix A.3)	Need-to-have
7	Analyses can be executed within a limited time period	SC manager company C (Appendix A.3)	Need-to-have
8	Provides valuable recommendations	SC manager company A (Appendix A.3)	Nice-to-have

[1] The managers emphasized that supply chain visibility should be seen as visibility across the entire chain. This includes both upstream as downstream information and RHDHV agreed that this should be an included requirement.
[2] During the interview the SC manager of company C emphasized the importance of transport information to create a visible supply chain. RHDHV also recognizes the importance of transport information and is therefore included as a requirement of the tool.
[3] The third requirement from empirical research that is included holds that not only information owned by the company itself is tested, but also information that other stakeholders own. This is seen as important criteria for RHDHV and provides insights into the extent of information exchange with supply chain partners.
[4] SC manager D emphasized that supply chain visibility should not only be assessed based on information that is automatically sent, but also on information that can be exchanged manually between stakeholders. RHDHV agreed that this requirements should be included.
[5] Supply chain visibility can be seen approached from different perspectives: from an operational, tactical, and strategic level. Since RHDHV aims for an comprehensive measurement tool, it is decided to include elements from all levels. This is set as a requirement.
[6] Already mentioned by RHDHV as a needed requirement
[7] Already mentioned by RHDHV as a needed requirement
[8] Already mentioned by RHDHV as a needed requirement

Requirements of Researcher

The three different parties mention many requirements. The researcher has proposed three additional criteria that need to be included. These are listed in table 7.4.

Table 7.4: Overview requirements of researcher.

#	Requirement	Reference	Nice-to-have / Need-to-have
	RESEARCHER		
1	Needed actions for output should be automated as much as possible	L.A. Guleij	Need-to-have
2	The lay-out of the tool should be appealing	L.A. Guleij	Nice-to-have
3	Functions as an instrument to create awareness	L.A. Guleij	Need-to-have

It is important that the tool is automated as much as possible to save time. The quick scanning tool should provide results after answering questions, and the detailed scan should be automated as much as possible. Especially when the tool is used during a session, it desired to show results directly without losing time with manual calculations. Full attention should be paid to the client. Another requirement that was not mentioned yet, is that the tool can help to create awareness by FMCG enterprises. These two requirements are included after a discussion with experts RHDHV1 and RHDHV2. The second requirement of the researcher is that the lay-out should be appealing. Since this is a subjective measure and not main priority, this requirement is defined as nice-to-have.

Final set of requirements

The agreed requirements are summarized in table 7.5.

Table 7.5: Final set of requirements.

#	Requirement
1	Includes a comprehensive metric of visibility considering different dimensions of visibility
2	Distinguishes different types of information flows
3	Assesses visibility based on different criteria
4	Provides details about scales to distinguish and judge different levels of the criteria
5	Includes measurable scales
6	Expresses the maturity level of supply chain visibility qualitatively
7	Limited effort in time
8	Finds critical areas for improvement
9	Provides recommendations
10	Provides correct information
11	Provides interpretable results
12	User friendly
13	Visibility Maturity Scan functions as the starting point for further detailed analysis
14	Detailed Demand/Supply Analysis finds critical suppliers/customers
15	Execution of a quick scan can be conducted within 15 minutes
16	A limited number of actions needs to be executed
17	Measures the level of supply chain visibility from both the demand and supply side
18	Includes visibility of (transported) goods
19	Considers data/ information that is sent both manually as automatically to assess supply chain visibility
20	Provides insights into the level of information exchange with supply chain partners
21	Measures operational/tactical and strategic supply chain visibility
23	Functions as instrument to create awareness

7.4. Functionalities

Based on the final set of requirements that the tools need to fulfil, functionalities can be defined. A distinction is made between the Visibility Maturity Scan and the Detailed Demand/Supply Visibility analysis which are both parts of the tool. Since the level of detail differs for these two scans that are integrated into the tool, a separate list of functionalities is defined. The functionalities are derived from the final set of need-to-have requirements (Table 7.5). Some of these requirements are combined into one functionality. The exact derivation of specific requirements into functionalities, can be found in Appendix B. Below the functionalities are listed.

Visibility Maturity Scan

1. Measurement of the maturity of supply chain visibility
2. Measurement of supply chain visibility considers different dimensions of visibility and is based on criteria
3. Provides details about scales to distinguish and judge different levels of criteria
4. Measurement span both upstream and downstream supply chain visibility
5. Measurement span both the visibility of goods and the visibility of information
6. Identification of critical areas and opportunities of supply chain visibility
7. Provides grip
8. Generates awareness
9. Results function as a starting point of discussion
10. Presents results with limited manual actions needed
11. Presents results within 15 minutes
12. Visualizes results graphically for quick interpretation

Detailed Demand/Supply Visibility Analysis

1. Comprehensive measurement of the maturity of supply chain visibility per customer/supplier
2. Measurement of supply chain visibility considers different dimensions and is based on criteria
3. Measurement span both upstream as downstream supply chain visibility
4. Identification of critical areas and opportunities for supply chain visibility
5. Provides a benchmark of the suppliers/customers included in the analysis
6. Provides grip
7. Generates awareness
8. Results support as starting point to improve supply and demand visibility
9. Presents results with limited manual actions needed
10. Presents results with limited time needed
11. Visualizes results graphically for quick interpretation

7.5. Conclusion

In this chapter, a set of twenty-three requirements are developed that the tool should comply with. These requirements are developed in agreement with the consultants of RHDHV. The requirements are based on criteria from literature and requirements defined by RHDHV. These observations are complemented with results from the empirical research and requirements defined by the researcher. Some requirements defined, are related to the functionalities of the tool. Examples are that the tool should include a comprehensive metric of visibility or that it should express the maturity level of supply chain visibility quantitatively. Others are more focused on the usability in terms of time and user-friendliness. The final set of requirements is derived into functionalities for both the Visibility Maturity Analysis and the Detailed Demand/Supply Analysis and will be used to develop the tool. The list of requirements will be used during the design phase to verify if the design complies with the criteria compiled.

8

Conceptual Design

This chapter provides the functional design of the tool based on the functionalities defined in paragraph 7.4. These main building blocks of the tool analyses that are included in the scan are elaborated. Lastly, the concept of both tools is elaborated and visualized.

8.1. Conceptual Design Visibility Maturity Scan

In this paragraph the concept and included building blocks for the design of the Visibility Maturity Scan are determined. The input, elaboration steps, functions, subsequent stages and output are presented and explained visualised graphically in Figure 8.1 in three sequential phases. First, the included dimensions of supply chain visibility included in the assessment are determined, followed by the criteria and the corresponding scales. The second phase is related to the survey setup, and the last phase focuses on the formulation and realisation of the scan results and the opportunities.

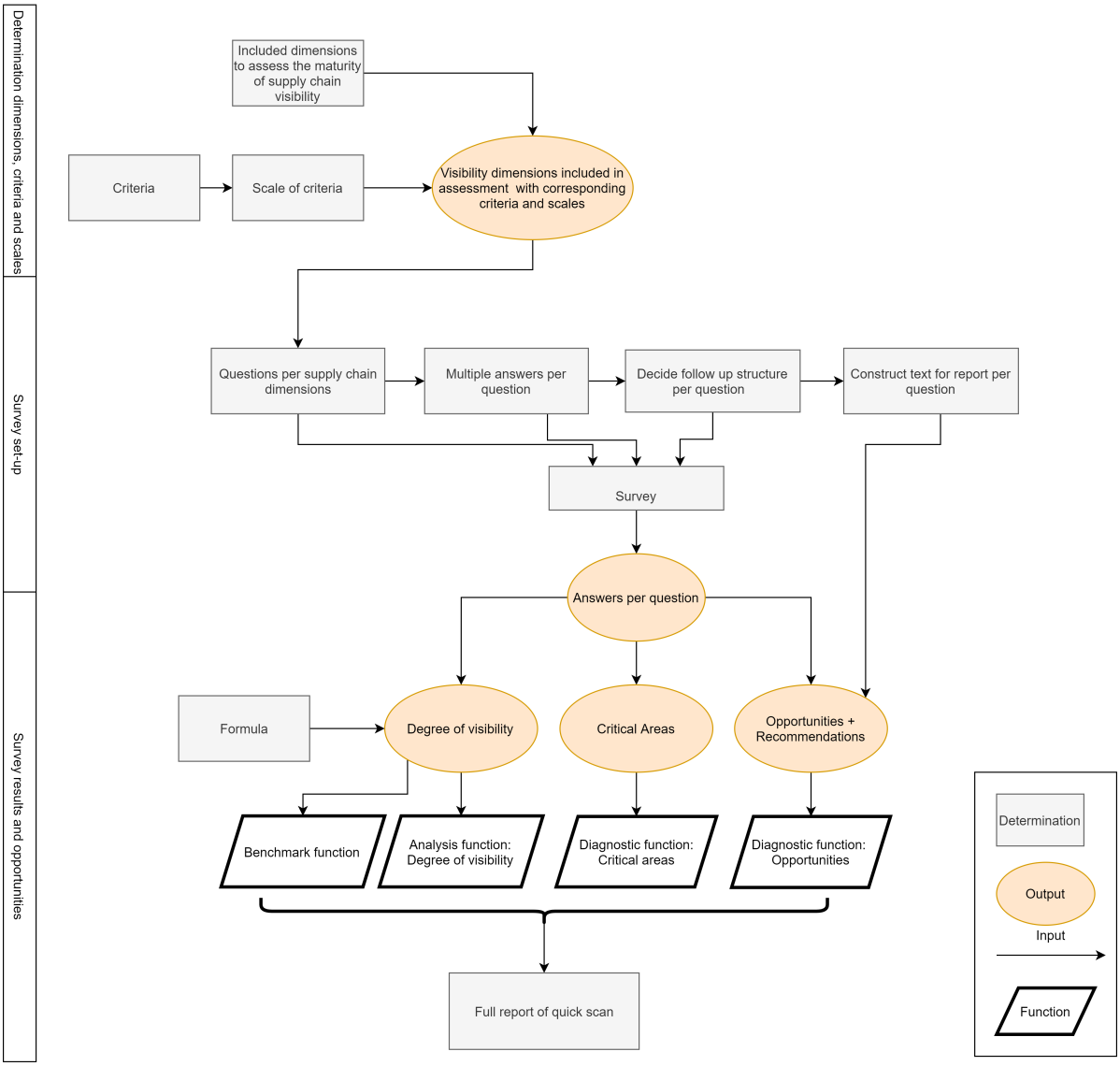


Figure 8.1: Conceptual diagram Visibility Maturity Scan.

The grey blocks in Figure 8.1 are determination steps will be elaborated in the next chapter (9). The orange circles present the output of certain steps, and can also function as further input for determination blocks. The outputs of the scan have different functions and are listed in the diamond-shaped blocks.

The determinations that need to be made to construct the final design are:

- Which supply chain visibility dimensions need to be included for measurement of visibility maturity level?
- Which criteria are used to determine the level of visibility?
- What are the scales per criteria?
- What questions needs to be included in the survey?
- What are possible answers per question
- What is the follow-up structure when a certain answer is chosen?
- What text should be included in the report if certain answers are selected?

- What formula is used for the calculation of the visibility level?
- What lay-out for the full report is used?

8.2. Conceptual Design Detailed Supply/Demand Visibility Analysis

The conceptual design for the Detailed Demand/Supply Visibility Analysis is graphically presented in Figure 8.2 and is also divided into three sequential phases. Again, the first phase focuses on the determination of included dimensions and criteria for assessment. The second phase is related to the survey set-up and set-up of the tool to visualize results. The third phase focuses on the calculation and presentation of the results. The main difference with the Visibility Maturity Scan tool is that the results are not generated automatically in a report but via a visualizing tool is used where the survey results can be loaded and used during a session.

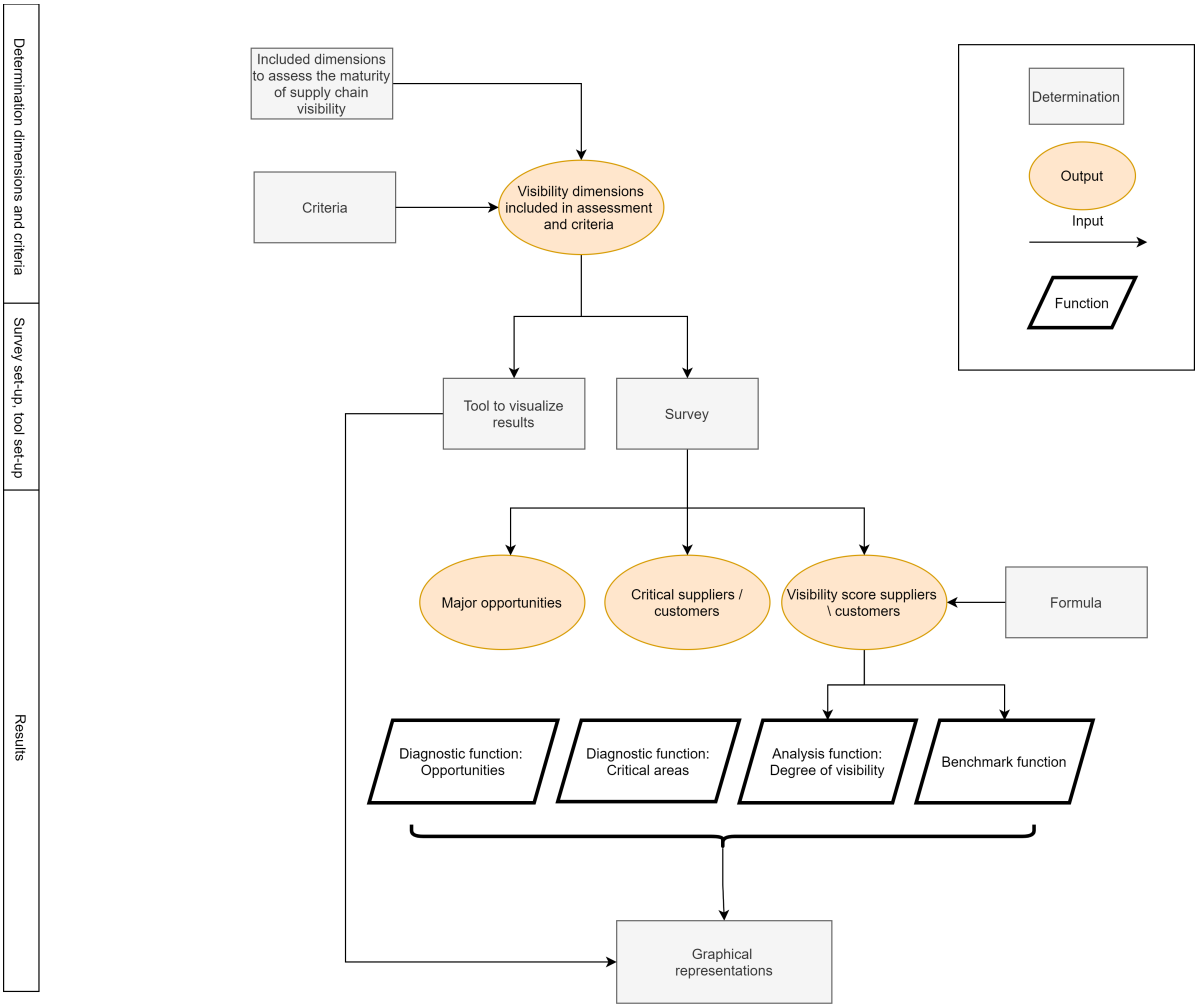


Figure 8.2: Conceptual diagram Detailed Demand/Supply Analysis.

The determinations that need to be made to construct the detailed design are:

- Which dimensions need to be included to assess the level of demand/supply visibility per customer/suppliers?
- Which criteria are used to assess the dimensions?
- How should the survey be set up?
- What formula is used for the calculation of the visibility level?
- How should the graphical representations look?
- How does the tool look like in able to visualize the results of the survey?
- What formula is used for the determination of critical suppliers/customers?
- How should the results graphically be presented?

8.3. Intermediate check of design requirements

Since the conceptual designs are still abstract, not all requirements that are defined can be tested. The requirements that are already met and that are applicable at the higher abstraction level, are listed below:

- Includes a comprehensive metric of visibility considering different dimensions of visibility
- Distinguishes different types of information flows
- Assesses visibility based on different criteria
- Provides details about scales to distinguish and judge different levels of the criteria
- Includes measurable scales

8.4. Conclusion

This chapter shows how the foundation of the tools is determined and is based on the functionalities that are derived in chapter 7. The conceptual designs of the two analyses included in the tool are visualized. Furthermore, the determinations steps that need to be developed are made clear. This is elaborated in the detailed design phase (chapter 10).

9

Detailed Design

In this chapter, the conceptual design is elaborated into a detailed design. In the detailed design phase, the principal attributes of the designs for both scans are determined and specified during an iterative process. Feedback is received from consultants of RHDHV multiple times to create the detailed designs presented in this chapter.

9.1. Detailed Design - Visibility Maturity Scan

First, the elaboration of the detailed design of the Visibility Maturity Scan will be illustrated.

Dimensions, criteria, and scales

As found in chapter 5, where existing assessment models for visibility are analysed, the focus of visibility often lays on demand and supply visibility. Supply and demand visibility are therefore included in the quick scan. RHDHV services are mainly focused on internal supply visibility and optimisation of own operations, networks and facilities. Including internal visibility, besides the supply and demand visibility, will create many opportunities for RHDHV to respond towards low quick scan scores of FMCG enterprises. During the interviews and in paragraph 3.2, important trends are named. The focus on trace-ability, morality, and transparency about the origin of materials has been increased. Also, all interviewees emphasised the issues and importance of data and its interpretation and connectivity. Since the origin of materials and data interpretation are commonly appointed as issues that strongly influence the level of supply chain visibility, the ”others” dimension is included to cover these topics. The most important information types are selected and the final four dimensions are structured as can be seen in Table 9.1. The determination of included information types is evaluated with the consultants of RHDHV:

Table 9.1: Visibility dimensions of Visibility Maturity Scan.

Demand visibility	**Supply visibility**	**Internal visibility**	**Others**
POS/Sales information	Internal Inventory levels	Transport information	Trace-ability origin of materials
Demand planning	Purchase Order status	Inventory levels	Overview available data
Inventory levels	Expected arrival time	Current capacity	Interpretation of data
Promotional events	Transport Disruptions	Current productivity	
		Future State capacity	

The information types per dimension, as stated in Table 9.1, need to be assessed based on criteria. In chapter 5 is shown that Caridi et al. has developed the most comprehensive measure for inbound supply chain visibility compared to other researchers. The criteria and the corresponding scales set by Caridi et al. are used as foundation for the selected criteria and scales to assess the supply visibility and demand visibility. Criteria and scales for the other two dimensions are specified in consultation with the RHDHV experts and are also based on the overall knowledge created during literature and empirical research.

All eight information types covered by the demand and supply visibility dimensions, are assessed based on *availability*, *frequency*, *accuracy*, and *timeliness*. The scales used for these four criteria, can be found in Table 9.2, Table 9.3, Table 9.4, and Table 9.5. The criteria to judge the information flows of the other two dimensions ('internal' and 'others') are defined separately per information type. The criteria for the 'internal' and 'other' dimension can be found in C.1. Here the exact questions of the survey and possible answers can be found. Also, the precise order of the questions is shown in Appendix C.1.

Table 9.2: Scale to judge availability of information.

Score	Description
0	The company has no access to this information
1	The company has little access to this information (sent by 1% till 25% of the suppliers /customers)
2	The company has partial access to this information (sent by 25% till 50% of the suppliers / customers
3	The company has access to a very good amount of this information (sent by 25% till 50% of the suppliers / customers
4	The company has access to a large part of this information (sent by more than 75% of the suppliers / customers

Table 9.3: Scale to judge the accuracy of information.

Score	Description
1	The accuracy of the exchanged information is very low and unsatisfactory
2	The accuracy of the exchanged information is usually satisfactory, but situations in which the information is incorrect are not uncommon
3	The accuracy of the exchanged information is usually satisfactory, and the information is incorrect only in a few situations
4	The accuracy of the exchanged information is always satisfactory (very good accuracy)

Table 9.4: Scale to judge the frequency of receiving information.

Score	Description
1	This information is sometimes received when this is requested
2	This information is usually received when this is requested
3	This information is pro-actively sent by the customer/supplier (based on contractual agreements)
4	This information is real-time available

Table 9.5: Scale to judge the timeliness of information.

Score	Description
1	Always too late
2	Usually too late
3	Usually on time, and the information is only too late in a few situations
4	On time

Survey set-up

After defining the exact questions and corresponding criteria and scales, a suitable survey software is investigated. This software should meet the requirements as defined in the conceptual design phase (chapter 8). As first requirement, the possibility should be present to show a question based on the previous answer (specified follow-up structure). Also, the results should be immediately visible for the FMCG managers performing the quick scan. Preferably, the software is free or are inexpensive. Investigation towards existing tools available on the internet is performed and the three most suitable softwares found are Google Forms, Survey Monkey and ReportR. Also, a meeting with a product manager of Royal HaskoningDHV has taken place. This product manager is responsible for managing new digital propositions and product developments to standardize and automate domains and services. This product manager could inform about the existing software at RHDHV. One available software and one tool were proposed. A maturity scanning tool for all domains is available, however the possibilities turned out to be minimal. This maturity tool has no possibility to define a follow-up structure, and also the recommendations can only be presented based on one question and instead of a combination of different questions. Only one question per topic can be defined, and a recommendation per question is obliged. This makes it hard to provide the maturity of supply chain visibility based on both the availability, accuracy, frequency, and timeliness. So, no flexibility is available to create changes in the survey structure of that software and the way how results are presented. Therefore, another software was proposed by the product manager, which is a survey software that allows freedom to build your own survey and create reports based on the answer given by the user. With this software, there is a limitation is the absence of a graphical and numerical representation function. It is only possible to include text in the reports generated. The limitations of the survey investigated software are summarized in Table 9.6.

Table 9.6: Comparison survey software.

Survey Software	Strengths	Limitations
Google Forms	Flexibility to build own survey, easy, follow-up structure can be defined, free	Results are not graphically represented, results not immediately visible by client, basic layout
Survey Monkey	Flexibility to build own survey, easy, follow-up structure can be defined, the report can be made, the possibility of graphic representation, appealing layout	Expensive, not instantly downloadable reports
ReportR	Flexibility to build own survey, easy, follow-up structure can be defined, the report can be made, possibility of graphic representation, the report is instantly downloadable, appealing layout	Expensive
Maturity Scan Tool (RHDHV)	Report with clear results and graphs can be made, appealing layout, the report is instantly downloadable, free.	Little flexibility to create own survey, no follow-up structure can be defined.
Kes (RHDHV)	Flexibility to build own survey, easy, follow-up structure can be defined, the report can be made, report is instantly downloadable, appealing layout, free.	No possibility for graphical representations

Finally, the decision is made to use Kes because of the flexibility to build surveys that can satisfy all wishes and can download a report instantly. The possibility to insert graphs and calculations is a function that has currently high prioritization for the development team.

The questions and possible answers are generated in Kes. All questions per dimensions are shown in Appendix C.1 as mentioned before. To illustrate the order of the questions and how the tool looks, an illustration is provided of the first questions related to the assessment of POS/sales information. With the first the company is asked if they have access to the sales information of customers (Figure 9.1). If there is access to this information, the accuracy, frequency and timeliness related questions are asked as well. This is illustrated in Figures 9.2, 9.3, and 9.4.

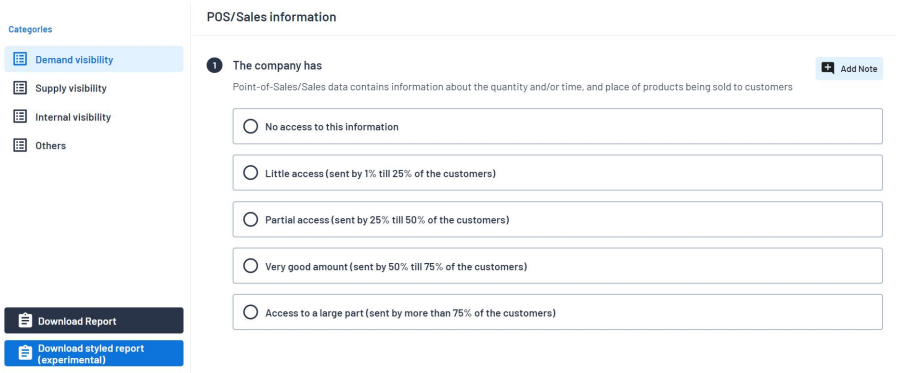


Figure 9.1: Question 1: Availability of sales information.

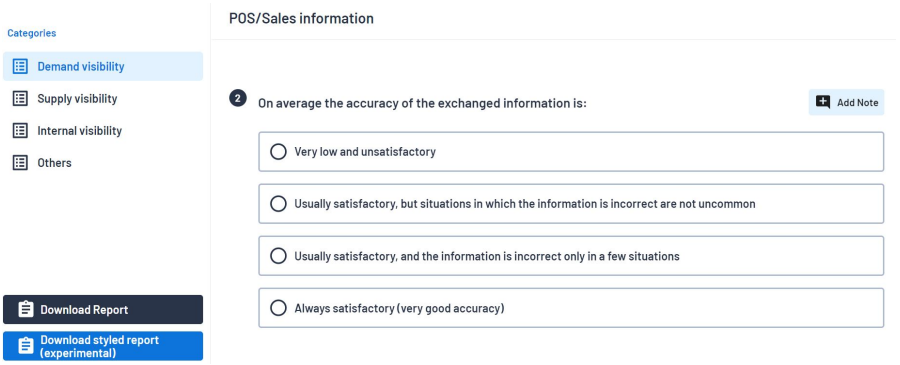


Figure 9.2: Question 2: Accuracy of sales information.

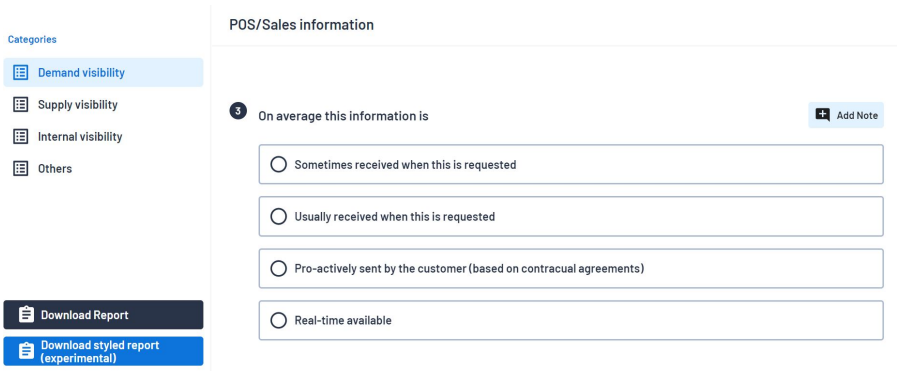


Figure 9.3: Question 3: Frequency of sales information.

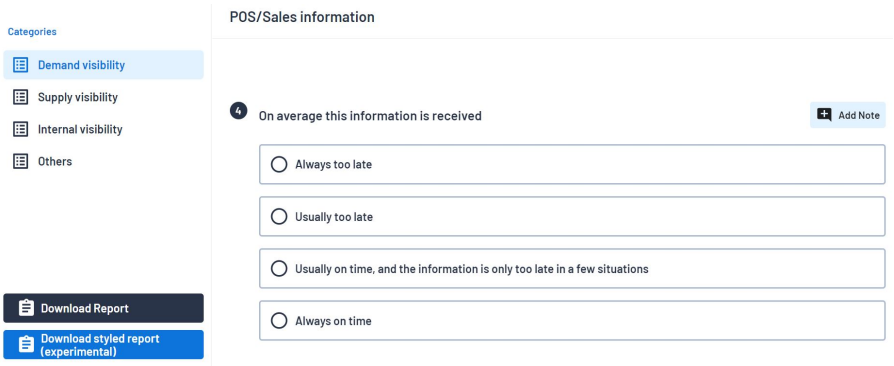


Figure 9.4: Question 4: Timeliness of sales information.

In the previous figures, four dimensions can be seen on the upper left side. A note button is added on the right side, where supply chain managers can add notes when they use the tool. In the left corner, buttons are present to download the results in a report. The 'experimental styled report' includes a cover page of Royal HaskoningDHV and the other button to download a report does not include this cover page. The user can decide when the report will be downloaded. It is not necessary to answers all questions to generate the report.

Lastly, the order of the questions is specified. The questions in categories demand visibility and supply visibility have a follow-up structure based on the first answer given that is related to the availability of an information type. If an information type is currently received, the next questions are related to the accuracy, frequency, and timeliness. Otherwise, the availability of the next information type is asked for. Also, when the user selects the option that information is real-time available, the timeliness question will not be showed anymore. If information is real-time available, it is assumed that this information is received in time. This structure is visible in Figure 9.5 and is applied in both the demand as the supply visibility category. In Kes this can be constructed using dependencies per possible answer.

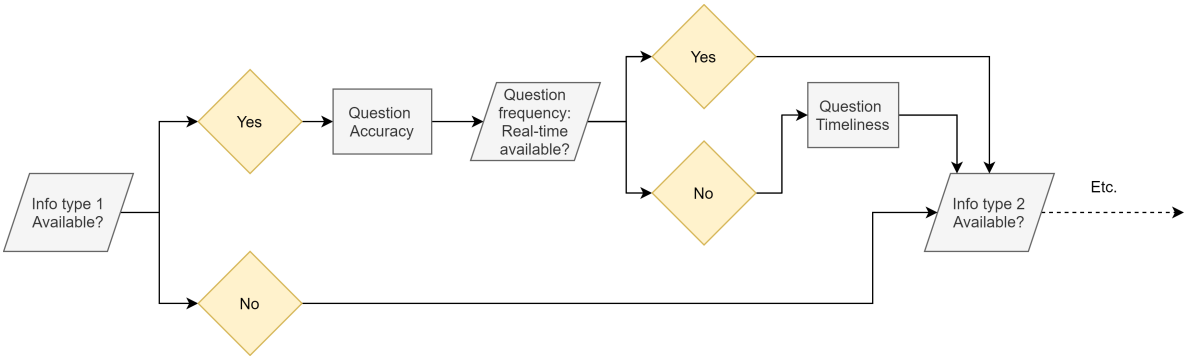


Figure 9.5: Structure questions in demand visibility and supply visibility category.

Presenting the results

Based on the answers selected during the scan, a report will be generated automatically. Therefore, a text is predefined per possible answer for every question. An overview of the report texts per possible answer can be seen in appendix C.2. An example of the full report is visible in appendix C.3. Besides the text that summarizes the answers given by the user, other graphs are computed that give an overview of the visibility maturity score of the four dimensions (Figure 9.6) and specifically for every information flow separately (Figure 9.7). Furthermore, spider graphs are included to provide results that can be interpreted quickly (Figure 9.8). These illustrations are examples of possible spider graphs that can be included in the report.

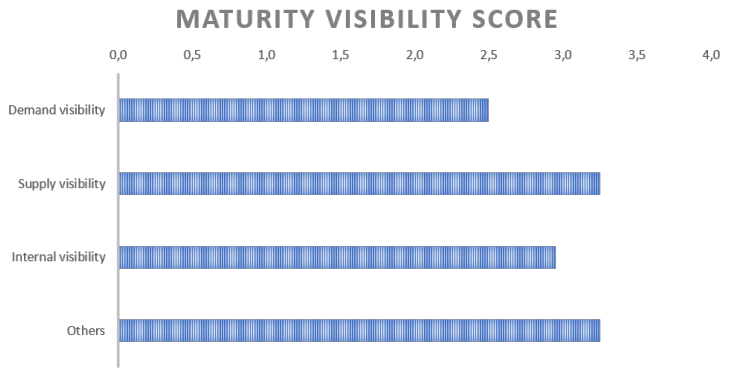


Figure 9.6: Report graph visualizing the visibility maturity score of the four dimensions.

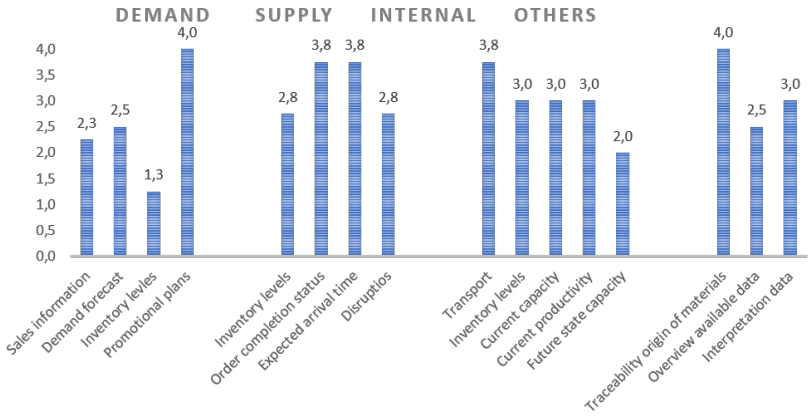


Figure 9.7: Report graph visualizing the visibility score of every information flow

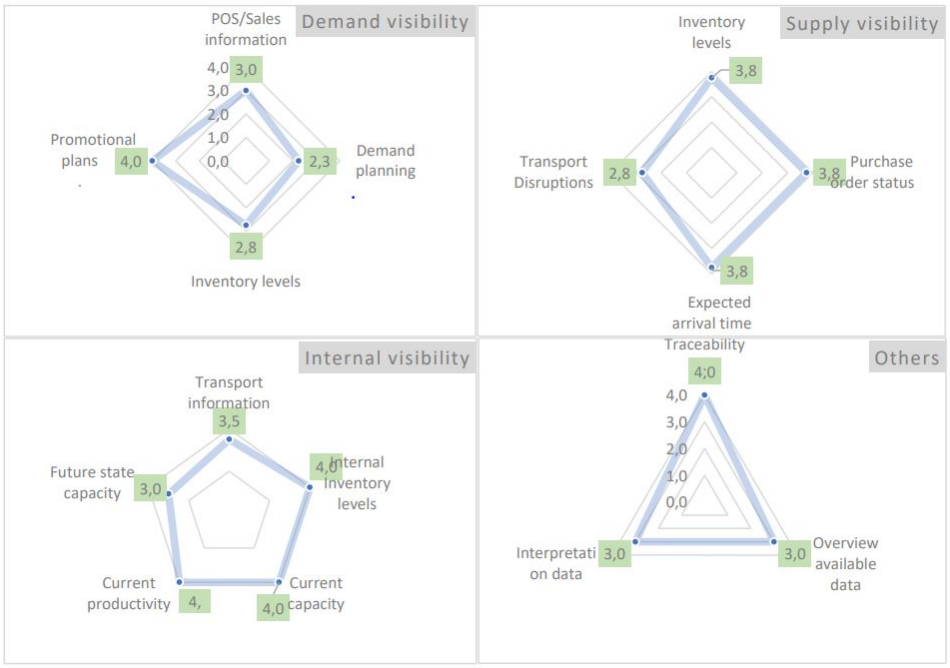


Figure 9.8: Spider graphs visualizing the four dimensions.

Formula

Based on the answer provided by the user, a visibility score should be calculated. Several techniques are considered to evaluate the performance. Common techniques are (Turchin et al. (1998)):

- *Categorical scoring system*: no different weights are assigned to attributes.
- *Weighted point average scoring system*: weights are assigned to attributes.
- *Cost-based scoring system*: weight is assigned based on costs that the attributes are responsible for.

In dialogue with the experts of RHDHV, the cost-based method is eliminated immediately. This is very complex and time consuming to express the value of certain information into revenues and costs. The weighted point average scoring system is considered but is complex. First of all, it is difficult in practice to specify the value of one performance measure relative to another and to specify the exact influence on the critical areas and priorities. Furthermore, the weights per information type and criteria will be different per FMCG enterprise, and it is not possible to predefine the weights. For the user it will most probably also be very difficult to assign these weights relatively to each other. Therefore, the categorical scoring system is used. Every attribute and criteria have the same weight. The final scores are based on the averages of the four criteria. If the inventory information is rated by a '2' for availability, '2' for accuracy, '3' for accuracy, and a '3' for the timeliness, the end score will be (2+2+3+3)/4 = 2,5. The end score of a certain dimension is based on the averages of the information types included in that dimension. Furthermore, no thresholds are specified beforehand. This needs to be determined in consolation with the client.

9.2. Detailed Design - Detailed Demand/Supply Analysis

Now, the detailed design of the Detailed Demand/Supply Analysis will be presented.

Dimensions, criteria, and scales

The included dimensions, criteria, and scales for the supply and demand analysis are similar as for the quick scan. The main difference is that the 'internal dimension' and 'other' dimension is not included and that the assessment is executed per customer or supplier separately. The dimensions included are listed below.
Demand Visibility

- POS/Sales information
- Demand planning
- Inventory levels
- Promotional plans

Supply visibility

- Inventory information
- Purchase order status
- Expected arrival time
- Transport disruptions

For this detailed analysis, the same criteria are used as for the Visibility Maturity Analysis: *availability, accuracy, frequency,* and *timeliness*. These four criteria are seen as most important as discussed with experts of RHDHV. A decision is made to not use scales, but to rank the different customers and suppliers against each others. This provides more detailed information because considerations have to be made. Since a ranking methodology is applied, the results are based less on perceptions than the Visibility Maturity Scan does.

Tool and survey set-up

Several online software packages and survey programs are investigated. However, Excell is chosen since the requirements of this tool emphasized that the analysis should provide interpretable results, insights into critical suppliers/customers, and the major opportunities. Excell has many functionalities, is flexible, and powerful to provide comprehensive and appealing overviews.

Two files are created: one related to supply visibility and the other to demand visibility. The demand visibility file is only illustrated in this report, but the principle is the same for both analyses. The current tool is designed to include ten customers or suppliers. Nonetheless, this can be extended easily.

First, The customer's name can be inserted and the annual sales of that enterprise. This is optional, but can be used to generate and apply weighted factors that specify the importance per customer. The user can indicate if the inventory information, sales information, demand planning, and promotional plans are shared by that specific customer. Automatically an overview is provided, showing which customers share certain information. This is indicated with ones and zeros (see Figure 9.9).

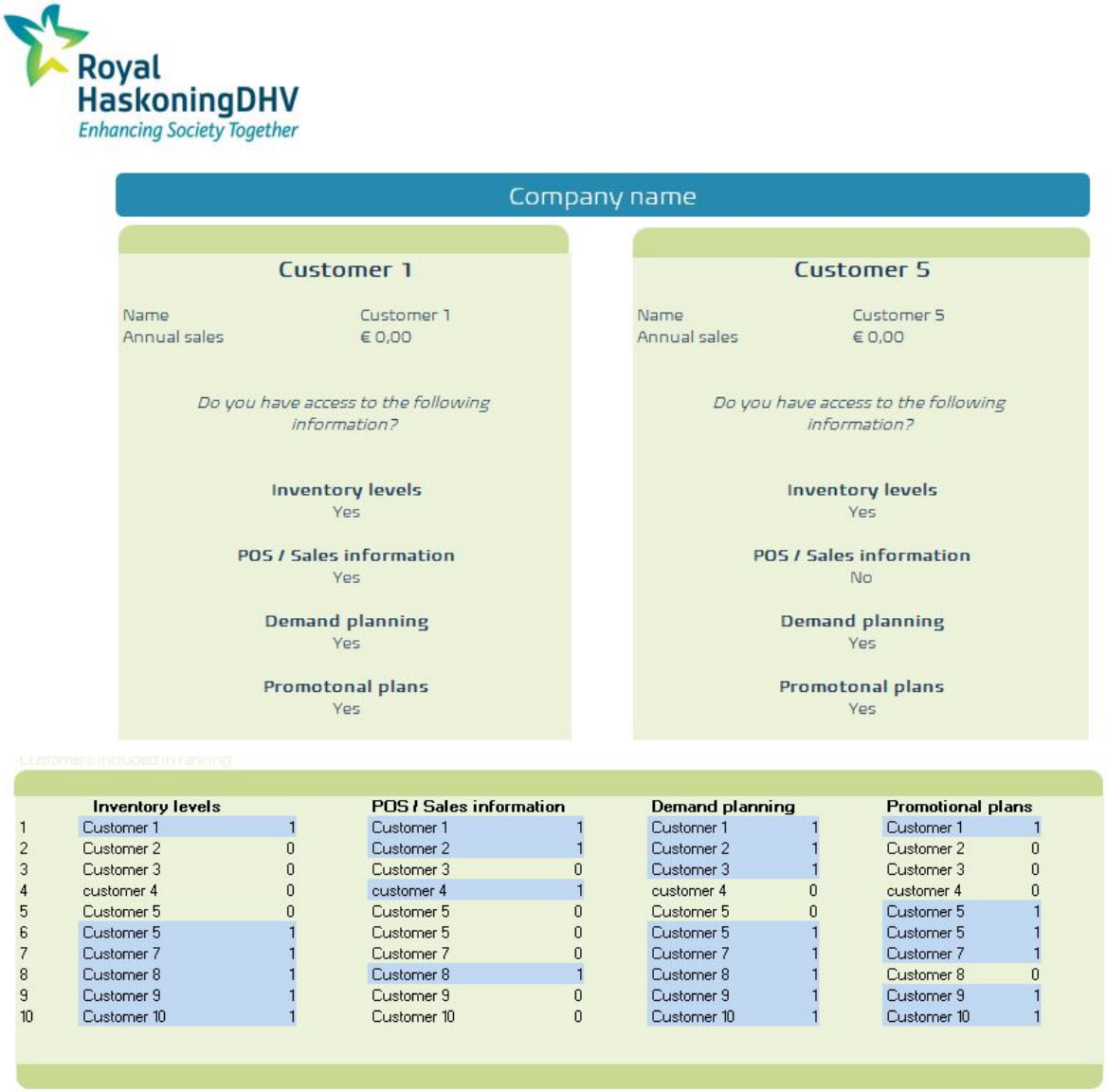


Figure 9.9: Step 1 Detailed Demand Analysis: providing customers' information.

The details about what information is shared by customers, is automatically linked to the next tab. Here, the customers that share certain information, need to be ranked. An example is visible in figure 9.10.

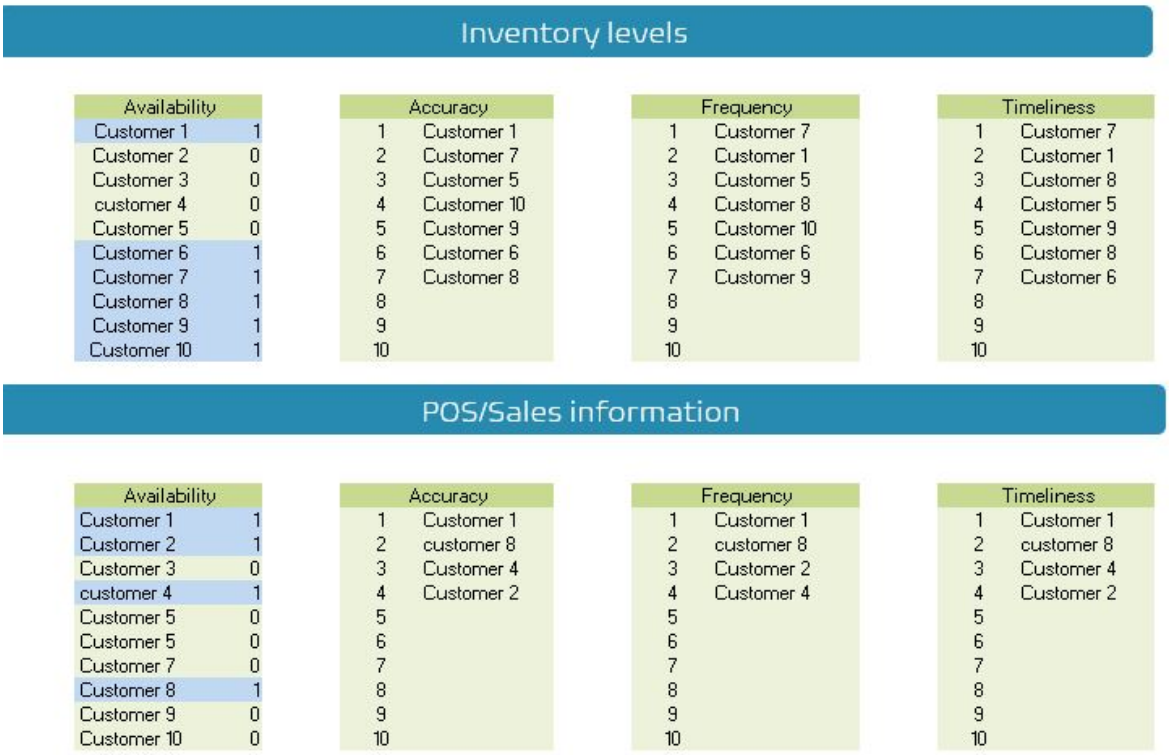


Figure 9.10: Step 2 Detailed Demand Analysis: ranking customers.

Presenting the results

After ranking the customer that share certain information, an overview can be found in the third tab in the dashboard. An example of the results can be found in the dashboard for customer 1 and customer 2 are shown in Figure 9.11.

Figure 9.11: Step 3: interpreting the results.

Figure 9.12 zooms in into the first results where the ranking position per information type can be seen. Also, the ranking position based on accuracy, frequency, or timeliness is visible. The slider at the right side makes it possible to zoom further into one of the information types.

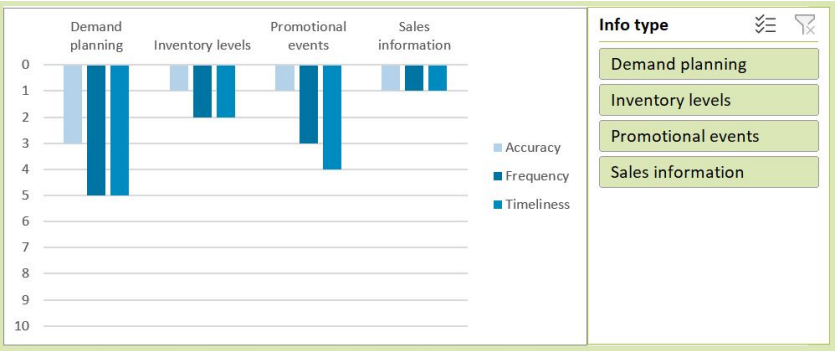


Figure 9.12: Overview of the accuracy, frequency, and timeliness of information shared by a customer.

In figure 9.13, the average score of the four information types can be found. Here, the average position is based on both the accuracy, frequency and timeliness. At the right side, the critical criteria can be seen. Since timeliness results in the lowest score, this can be seen as a focus point that and needs to be prioritized over accuracy and frequency.

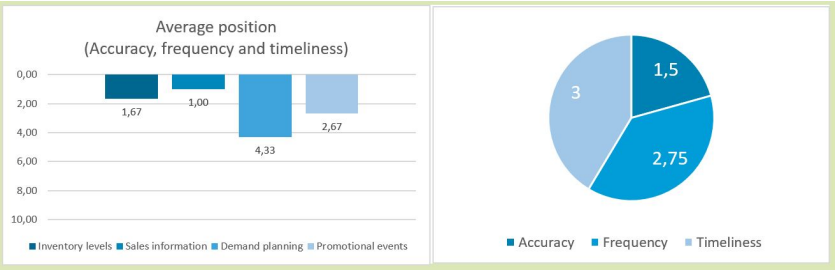


Figure 9.13: Overview average position.

Formula

For the same reasons as described in the formula paragraph of the Visibility Maturity Analysis, no weights are included in the tool. RHDHV could set priorities after an additional session to gain insights into the critical and most important areas. The ambition levels can be determined as well.

9.3. Conclusion

In this chapter the conceptual design, as established in chapter 8, is developed into a detailed design of the tool. This design is divided into the Visibility Maturity Analysis and the Detailed Demand/Supply Visibility Analysis. All the choices and considerations during this iterative process are documented. The detailed designs are developed into digital tools.

The Visibility Maturity Scan exists of four main dimensions to measure the overall maturity visibility level (supply visibility, demand visibility, internal visibility, and others). Four criteria are used to assess information types: availability, accuracy, frequency, and timeliness. This scanning tool automatically generates a report based on the answers provided and presents the maturity of supply chain visibility, bottlenecks and major improvement areas. The Detailed Demand/Supply Visibility Analysis focuses specifically on the suppliers or customers, and those are ranked based on the same criteria. Weighted factors can designate the importance of customers and suppliers, and a dashboard gives insights into opportunities. Both analyses will be used during the validation sessions with supply chain managers.

10

Verification & Validation

In this chapter, first the compliance with the predefined design requirements is verified. Secondly, findings of the validation session are presented. It total, five validation sessions are conducted with FMCG managers of leading enterprises. During these sessions, the practicability of the tool is tested, and suggestions are provided to develop the final design.

10.1. Compliance with design requirements

First it should be verified whether the design requirements, summarized in chapter 8, are met. As described in the Design Methodology (chapter 2) the requirements are verified in verification sessions with two experts of RHDHV. Table 10.1 reasons if the defined requirements are 'met', 'substantially met' or 'not met', and presents the reason why. Almost all requirements are met, but some can only be substantially met since they are related to personal interpretations as the user-friendliness and time that is needed. Since the requirements are the same for both tools, the compliance counts for the maturity scan and the detailed analysis.

Table 10.1: Verification design requirements.

#	Requirement	Reasoning	Compliance
1	Includes a comprehensive metric of visibility considering different dimensions of visibility	The experts confirmed that the maturity visibility scan includes many dimensions of supply chain visibility where no critical element is overlooked. Several validation sessions were needed to restructure the metric. Also, the detailed demand/supply analysis includes and comprehensive measure.	Met
2	Distinguishes different types of information flows	During empirical study and literature study, different information types that determine the level of visibility are researched. The information flows are assessed on various criteria included in both tools and the experts agreed that the second requirement is met.	Met
3	Assesses visibility based on different criteria	Literature study has examined existing measures for the supply chain visibility level in literature. These captured mainly the availability, frequency, and accuracy. During validation sessions with the expert RH3, the timeliness criteria are added, and after that, the experts agreed that sufficient measures are used to assess visibility.	Met
4	Provides details about scales to distinguish and judge different levels of the criteria	The experts agreed that the scales per criteria used in both analyses are self-explanatory, where no additional explanation is needed.	Met
5	Includes measurable scales	Theoretically, all scales are measurable, but can be time-consuming to actually test (expert RH1). This requirement is met since it should be possible to measure all the criteria. However, this is not actually done during the analyses.	Met
6	Expresses the maturity level of supply chain visibility quantitatively	There is a general agreement that the research is primarily exploratory and used to gain understanding of the underlying about the maturity of sc visibility. A quantitative score is assigned to the levels scale to define an end score. Therefore, the measure of both scans is quantitative.	Met
7	Limited effort in time	Based on the judgement of experts RH1 and RH2, it is expected that limited time is needed for all analysis. However, the perception of effort and time is person dependent and can not hold true for everyone. This requirement is considered as substantially met. More insights can be obtained in multiple real life validation sessions.	Substantially met
8	Finds critical areas for improvement	Experts in validation sessions agreed that critical areas are found based on criteria.	Met
9	Provides recommendations	In the validation sessions with the experts it is concluded that this requirement is met, since clear improvement areas are presented. Also, the cause of a low score is textually presented in the report. It is specified if the availability, frequency, accuracy, or timeliness is the major reason for a low visibility score.	Met
10	Provides correct information	The textual information can be judged as correct, since it is related to the answer given by the user. Also, the graphs are related to the answer given. After a demonstration and test the provided information can indeed be seen as correct. Experts RH1 and RH2 agreed that this is requirement is met.	Met
11	Provides interpretable results	Experts RH1 and RH2 agreed that the results of the both tools are clear and interpretable. The use of graphical representations enables this. It will varies per person if results are interpretable. Therefore this requirement is set as substantially met.	Substantially met
12	User friendly	After some iterations and adjustments based on feedback of RH1, explanations per question are added for the quick scanning tool to improve this requirement. The experts of RHDHV asses the tools as user friendly, but large-scale validation with end-user should prove the real user friendliness experienced. Therefore the requirement is referred to as substantially met since this will always be experienced differently by end-users.	Substantially met
13	Maturity Visibility Scan functions as starting point for further detailed analysis	This requirement is referred as substantially met since the experts of RHDHV see the potential to use the result as point for further detailed analysis. Nonetheless, this can be experienced differently by different users and is the requirement specified as substantially met.	Substantially met
14	Detailed Demand/Supply Analysis tool finds critical suppliers/customers	Experts RH1 and RH2 agreed that critical suppliers and customers are identified during a proof of concept.	Met

15	Execution of a Visibility Maturity Scan can be conducted within 15 minutes	During sessions with RH1 the duration of the visibility maturity scan is below the 15 minutes. To cover the likely extra minutes needed from other organisations than RHDHV, this needs to be tested in multiple real-life sessions. Also, the time needed can differ per person and therefore this requirement is set as substantially met.	Substantially met
16	A limited number of actions needs to be executed	The limited actions that are needed are ascertained by the experts. The user only needs to fill in a survey for both tools and the results are directly insightful afterwards.	Met
17	Measures the level of supply chain visibility from both the demand as supply side	The Visibility Maturity Scan includes both dimensions and for the detailed analysis a selection of demand and/or supply visibility can be made.	Met
18	Includes visibility of (transported) goods	The transport factor is included in both analyses and expert RH1 and RH2 agreed on this requirement.	Met
19	Considers data/ information that is sent both manually as automatically to assess supply chain visibility	Experts RH1 and RH2 assent that this requirement is met since this is included in the frequency criteria. Some of the information flows being assessed or sent manually and others automatically via IT systems.	Met
20	provides insights into the level of information exchange between with supply chain partners	Experts of RHDHV agreed that both tool focus on the availability of information exchange between parties and is therefore met.	Met
21	Measures operational/tactical and strategic supply chain visibility	Most focus is on the operational and tactical level of supply chain visibility. However, since elements as availability of data, interpretation of data, and origin of materials are covered, the strategic level can be seen as included. The outcome of the analyses can prioritize actions needed and this can also be seen as a strategic action plan.	Met
20	Functions as instrument to create awareness	This requirement is considered as substantially met since the experts of RHDHV recognized the awareness function. Nonetheless, the level of awareness created can be different per end-user and is hard to hold true for everyone	Substantially met

10.2. Validation expert sessions

In total, five validation sessions are held. Four of the session focused on the Visibility Maturity Scan, whereof two of the sessions are executed by managers of the same firm. This has been conducted to reflect if the results are comparable in the case of execution by different persons. One validation session was fully focused on the Detailed Demand/Supply Analysis. Four of the five supply chain managers also contributed to the interviews executed during the problem investigation phase. An overview of the interviewees can be found in 10.2 and the validation protocol in D. The main findings from the validation sessions are listed in this chapter.

Table 10.2: Participants validation sessions.

Name	Type of products	Validation session date	SC Experience
SCM1	Cleaning products	22-06-21	33 years
SCM2	Personal care	28-06-21	12 years
SCM3	Personal care	22-06-21	12 years
SCM4	Pet foot	06-07-21	7 years
SCM5	Personal care	30-06-21	21 years

10.2.1. Validation results of the Visibility Maturity Scan

After an introduction of the research goal and process, the supply chain managers were asked to fill in the survey and mention unclarities or provide other feedback. The results of the scan can be found in appendix D.3. In all four cases, the demand visibility obtained the lowest score. For three companies the internal visibility was the best of all four dimensions and for one company this was the supply visibility. The questions and other confusions related to the questions are listed below.

Unclarities questions

- Inaccuracies existed when the managers started with the first question of the supply dimension. Here, the question was asked: what is a supplier? Is this the supply from the manufacturer, or the

supply of raw materials? Is this related to the internal or external suppliers? [SCM2]. Also SCM 3 experienced this problem, since the supply of raw material is out of his business scope. From his Benelux perspective he can see the plants as his suppliers which was the intended scope of this tool.

- SCM3 asked if the demand planning is related to the forecast that the customers make. This can be better formulated in the explanation.
- SCM3 and SCM4 asked what is meant by future state capacity.
- SCM1 and SCM3 asked what that is referred to when there is asked if there is a clear overview of the available data.
- SCM1 asked if the sales information is the same as forecast? The explanation was not clear.
- Traceability mentioned is a very broad definition. This can be specified more precisely [SCM1]

During the validation it was easy to provide additional explanations. When the tool is used during a session, the RHDHV expert can also guide the user through the questions which was sometimes needed during the validation sessions. In case of a real session, extra explanation to clarify the unclarities can be provided easily. Nevertheless, the tool should be understandable without extra guidance as it can be placed on the website or sent by email. To prevent these problems, the explanations per question need to be sharpened. Furthermore, an introductory description is needed to clarify the aim of the analysis.

General improvement suggestions

- Extending the 'other' dimension. Add a question if the data is presented visualized well for an enterprise? Does the company has solutions like power BI to represent this? An for how many aspects are these solutions applied [SCM2]?
- Extending the 'other' dimensions. Add a question related to master data. Is the master data well organized and robust [SCM2]?
- Extending the 'other' dimension. Add a question related to KPI's. Do you have clear KPI's to manage and check the current performances [SCM2]?
- First start with a general question related to the company's size, the specific industry, and the complexity of the supply chain. Also, define clearly which specific part of the companies' supply chain is analysed In this way benchmarking can be applied effectively [SCM2, SCM4].
- Add a button: Not Applicable (NA) [SCM1, SCM3].
- When real-time available is selected, the follow-up question if information on time, is needless. Build in a structure to prevent that this question is repeated [SCM3].
- An forecast is by definition inaccurate. It could be useful to link the the scale to the size of sales forecast errors [SCM1]
- It is hard to fill in a scan for an entire company. Therefore the specific department or country should be specified beforehand to get more specific and valuable results [SCM1]
- Include questions to identify what differentiates a company and what strategic goals the company has, to determine what problem areas are more important [SCM1].
- Specify beforehand what elements are most important for a specific company. It is not always a problem if an enterprise scores low at certain dimension, but this should be indicated in the beginning [SCM1]

The suggestions to include the availability of data visualization tools, the quality of master data, and the availability of clear KPIs is a good additional elements provided by the SCM2. The other suggestions are also good to include to improve the tool. SCM1 mentioned to add additional questions to identify which elements are most important for a specific company. This is something that is considered beforehand, but hard to include with a few simple questions. However, it is important to investigate during subsequent analysis steps.

General impression and usefulness

- Since the questions are related to perceptions, it was hard to specify if information is on time or accurate. Many supply chain managers asked: What is in time? an what is accurate? [SCM2, SCM3]. SCM1 also mentioned this problem, at states that the answer given is based on the own definition of unsatisfactory, timeliness, and accuracy.
- Often doubts are visible by selecting the second or third answer [SCM1, SCM2, SCM3]
- The scan is useful for benchmarking. It is interesting to see how well a company performs against other similar enterprises [SCM1, SCM2, SCM3, SCM4].
- It would be very useful if data is collected of other companies as well, and that the score can be compared towards other enterprises having the same company characteristics. [SCM2].
- The results of the scan are in line with expectations [SCM1, SCM2, SCM3, SCM4].
- The spider diagrams are very powerful and visualizing the results. This is seen as a very positive aspect of the reports. [SCM3, SCM4].
- The report is very appealing and professional [SCM3].
- It is nice to see on what areas focus should be [SCM3, SCM4].
- The broad scan can be useful to identify the weak and strong areas of a company [SCM1]
- The measure is all-encompassing, and no critical elements are excluded [SM3].
- It would be interesting to compare different divisions within a company [SCM3].
- It is hard with this type of general questionnaires to give a specific and precise answer [SCM1]
- The tool can create awareness [SCM1, SCM3]

The critical notes provided by the supply chain managers are important to consider. Especially the danger of subjectivity is an important aspect and weakness that need to be taken into account when using the tool. It is hard to filter out this subjectivity, since the tool aims to get a general overview within limited time. Furthermore, to interpret the outcomes, the importance per attribute and criteria need to be defined, just as the priorities of a specific company. In this way, real follow-up actions can be determined. To deal with this subjectivity and use the measurements' output, a follow-up session is needed to specify these priorities.

On the other hand, the comments provided by the supply chain managers also show the practicability and usefulness of the tool. They address that the tool can be useful for benchmarking, identifying strong and weak areas, and find areas to focus on. Also, the tool can create awareness.

Benchmark results of two managers within the same company and department

Two employees [SCM3 and SCM4] from the same company executed the scan to see if the same results are provided by different persons. It should be noted that SCM4 is the supply chain manager and has knowledge about the whole supply chain of the department he is working for. SCM3 has not fully insights into the overall processes but tried to estimate the scores per information type. In Table10.3, the results are visible. The main difference can be found in the availability of POS/Sales information. SCM4 did not had insights into this information that was sent by the customers. Looking at the results, generally one point difference can be seen in the assessment by both managers. The best and worst scoring dimension, internal visibility and demand visibility respectively, were the same in both cases. The second and third position were slightly different.

This benchmark example shows the limitation related to objectivity that is already mentioned before. Since the score is based on a perception it can be assessed differently by different persons within the same company. This should be considered when the results are interpreted. As mentioned before it is important to use the results to provide grip and use it as starting point for further analysis. An additional session is needed to add more specific value to the outcomes of the scan.

Table 10.3: Benchmark of results of SCM3 and SCM4.

	SCM4				SCM3			
	Av	**Acc**	**Freq**	**Ti**	**Av**	**Acc**	**Freq**	**Ti**
Demand visibility								
POS/Sales info	0	0	0	0	3	3	3	3
Demand planning	2	2	2	2	3	2	2	2
Inventory levels	2	3	2	2	1	4	3	3
Promotional plans	2	2	2	2	2	3	2	3
Supply visibility								
Inventory levels	3	3	3	3	4	3	4	4
Purchase order status	2	4	4	4	4	4	3	4
Expected arrival time	2	2	3	3	4	4	3	4
Disruptions	2	3	3	3	3	3	2	3
Internal visibility								
Transport information	4	3	3	3	4	2	4	4
Inventory levels	3				4			
Current capacity	4				4			
Current productivity	3				4			
Future state capacity	3				3			
Others								
Traceability origin of materials	3				4			
Overview available data	3				3			
Interpretation data	3				3			

3 points difference
2 points difference
1 point difference

10.2.2. Validation results of the Detailed Demand/Supply Analysis

During a session with a supply chain manager [SCM5], the five most important customers were assessed that are responsible for 80% of the turnover. The other 20% of the turnover is represented by the other thirty-five customers. The tool created the overview as expected and the usage of the tool was simple. SCM5 agreed that this tool gave clear insights into the critical elements of the customers and can function as a health check that can be executed several times per year. Also, improvements can easily be benchmarked over the years. The enhancement of cooperation with these five customers is very important to focus on in the coming years.

A main suggestion of SCM5 was related to the other 80% of the customers that are currently not that mature in sharing information. For those customers, the quality and accuracy of the master data are very important to generate improvements in the future. Therefore this group can be ranked in the same way, but only based on the quality of master data. Another important point to also include when doing so, is the importance of each customer. It is not always worth to put much time into customers that are not even that important. In the current tool this importance is handled by indicating the turnover per customer and using the results as a weighted factor. Another idea SCM5 came up with, is to rank customers beforehand based on the importance for an enterprise. This may be easier and faster than looking into the exact turnovers per customer. SCM5 emphasized the importance of health checks for a company, and that the tool developed can contribute to an effective health check and scan. Furthermore, SCM5 highlighted the importance of enhancing supply chain visibility in general.

The analysis is only performed for the customer side, but it is assumed that this works the same for the supplier side. The tool is developed in a way that it is easy to make changes by the user regarding the

included information flows that are assessed.

10.3. Subsequent steps towards final design

Based on the suggestions and general impressions by the supply chain managers during the validation sessions, the main improvements recommended are listed below.

- First general questions should be included related to the company's size, the type of industry and the complexity of the supply chain. This allows for detailed benchmarking.
- A question should be included to identify what differentiates a company.
- Questions can be included to get an overview of the elements that are most important for that specific company. This can also be collected during a follow up sessions.
- It should be clear beforehand, that a specific part or department should be chosen for the analysis. Otherwise, it would cause results that are too general.
- Improvements can be made in the explanations to prevent unclarities. Before moving to another dimension (supply, demand, internal, and others) this can be clarified by a describing text. Furthermore the explanation of demand planning, future state capacity, and the available data can be improved since some confusions were experienced during the validation session.
- Suggestions are made to extend the 'other dimension' with the information flows related to availability of visualization solutions (like PowerBI), the quality of masterdata, and the presence of clear KPI's.
- An extra button, Not Applicaple (NA), per question should be included.

10.4. Final compliance with design requirements

A few design requirements were not fully before the validation sessions took place, but those were only substantially met 10.1. At that time the tool were not tested in practice with real end-users. After the validation sessions those requirements can be stated as met or still substantially met. A clarification per requirement is listed below.

- **Requirement 7** limited effort in time: the requirement is met since the validation sessions showed that the analysis can be executed within 15 minutes.
- **Requirement 11** - Provides interpretable results: the requirement is met since all supply chain managers confirmed this requirement.
- **Requirement 12** - User friendly: this requirement is met based on the opinion of the supply chain managers.
- **Requirement 13** - Visibility Maturity Tool functions as starting point for further detailed analysis: the requirement is also confirmed during the sessions.
- **Requirement 15** - Execution of quick scan can be conducted within 15 minutes: the requirement is met since the time needed is measured during the validation sessions.
- **Requirement 20** - Functions as an instrument to create awareness: the requirement is met as this is confirmed during the validation sessions.

10.5. Conclusion

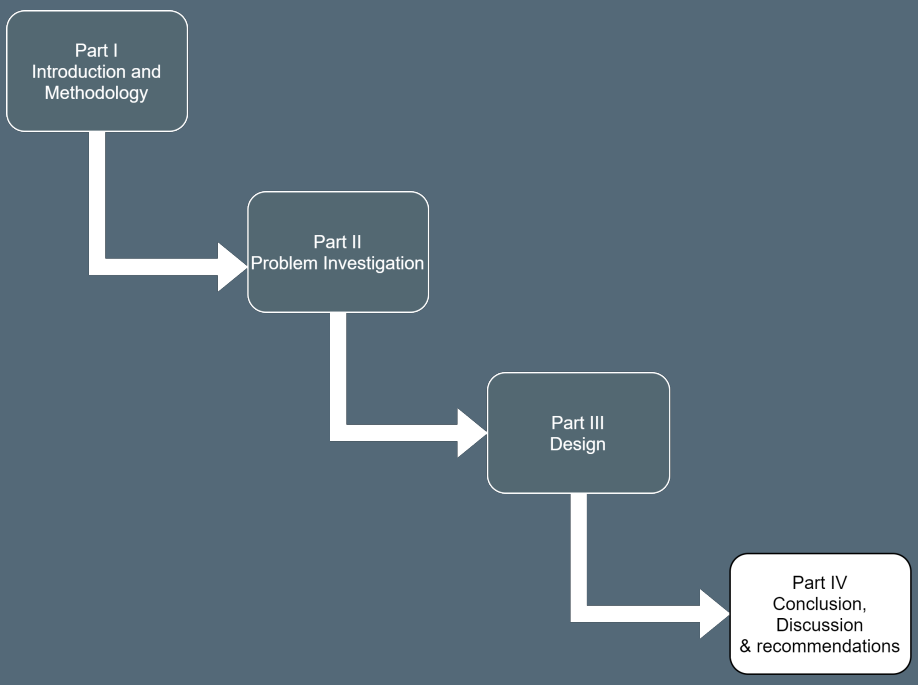
This chapter lists the approach of the validation sessions and the main suggestions and impressions of the supply chain managers that participated. A general remark that was mentioned multiple times, regarding the Visibility Maturity Scan, is that the questions are related to perceptions. Therefore it can be hard to specify if information is on time, accurate, sufficient etc. A risk is that this type of questionnaire gives a generic overview. However, the tool is developed to provide structure and grip for further analysis. The supply chain managers provide valuable suggestions for both analyses of the

tool. All supply chain managers agreed that this tool is useful for benchmarking within one organization and would be interesting to use as a benchmark towards other companies. The results of the tools were in line with expectations and the visualization results were experiences as powerful and easy interpretable. Furthermore the tools are helpful to identify strong and weak areas. Especially the Detailed Demand/Supply Visibility can be valuable and function as health check for an organisation as was concluded in the validation session. An major suggestion here is to rank customers that are less mature with regard to information sharing, based on the quality of master data.

IV

Discussion, Conclusion & Recommendations

This part discusses the applicability of this research and the added value to literature and practice. Moreover, the conclusions and main findings of the study are stated. Lastly, recommendations for future research and practical purposes are given.



11 Discussion

This chapter reflects upon the interpretation and impact of the results. The contribution to the literature and practical implications of the research are stated, followed by the study's main limitations.

11.1. Reflection on the results

This research aims to design a support tool to assess the overall maturity level of visibility and the level of visibility related to specific customers and/or suppliers. A business-to-business perspective of FMCG enterprises is set as scope. An in-depth literature study together with empirical research formed the foundation during the design and development phase of the tool.

Literature and empirical research

The literature study and empirical research obtained an understanding of the trends and complexity drivers for coordination in the FMCG industry. Additionally, critical information across the supply chain and the barriers impeding supply chain visibility were investigated. No contradictory results were found between the literature and the empirical study. However, differences were obtained in the emphasis of certain topics. When looking closely into the trends, many subjects as globalization, sustainability, and changed consumer desires came up with both data collection methods. However, during the interviews with supply chain managers, more examples of specific tendencies were appointed as the increase of direct delivery to the end-consumers, switching supply chains from global to local due to Covid-19, and the use of web crawlers. In terms of the critical information across the supply chain, most of the information types mentioned in literature and empirical research were equivalent. Nevertheless, extra attention during the empirical study was on transport-related information (ETA, OTIF) and online availability (OLA).

The most interesting results were the barriers observed that impede the supply chain visibility. In both studies, the technical and financial barriers were mentioned. However, mainly the importance of social and cultural barriers were widely discussed in literature and interviews. The main social-cultural barriers found are; lack of trust, different business cultures, resistance to change and exchange data, security and privacy concerns, and the fear of a deteriorated commercial negotiation position. Noteworthy is that, the large amount of data and the organization of master data (source data) is seen as a major barrier that is explicitly highlighted by all supply chain managers interviewed. Also, according to the supply chain experts, progress can be gained when conquering the challenge towards the transition of data into interpretable information.

These results were very valuable and functioned as foundation to design and develop the tool. Discussions and examples obtained during the empirical research created in-depth understanding of the complexity and main barriers that impede the enhancement of supply chain visibility.

The support tool
The developed support tool exists of a Visibility Maturity Scan and a Detailed Demand/Supply Analysis. The Visibility Maturity Analysis is executed by four supply chain managers and validated. In all case studies, demand visibility scored lowest and the supply visibility scored much higher. For three supply chain managers, the internal visibility obtained the best maturity score. The supply chain managers indicated that the results were in line with their expectations. Also, they designated that the tool was valuable to find critical areas and opportunities, and that it is useful to benchmark visibility within an organization and follow improvement processes. A critical notes regarding such general tools for analysis, is that subjectivity is involved.
The evaluation can be biased and opinionated, since subjective elements as timeliness, sufficiency, and accuracy need to be assessed. These factors can be interpreted differently by users. During the validation sessions, this different interpretation was also visible when two supply chain managers from the same company used the scan for the same division. Here, often one point difference in assessment of the accuracy, availability, frequency, and timeliness of information types was shown. However, the overall outcomes of the critical information types and dimensions were comparable. These two validation sessions showed the problem of subjectivity and the problem with comparison of results. To transfer these values into objective and less arbitrary outcomes, enterprise specific information should be collected as mentioned by the FMCG supply chain managers during the validation sessions. Also, including a weight to indicate the importance of the elements and criteria is considered. However, it is not straightforward to integrate weights directly in the tool. An additional session with the client is needed to determine the importance of criteria and information types and define company specific ambition levels, thresholds, and action priorities. Subjectivity is less problematic for the Detailed Demand/Supply Analysis, since customers and suppliers are ranked against each other at a detailed level. This subjectivity and lack of weighting factors, should be dealt with in a conscious way by the user or could be improved in the further development of the tool.

11.2. Implications

Theoretically, this study has contributed to the theory of enhancing supply chain visibility by measuring the current level of visibility and finding critical areas for improvement. Many authors have tried to assess supply chain visibility; a number of which focus on quantitative measures expressing the level of visibility into an index (Caridi et al. (2010a); Caridi et al. (2014)), or into a score (Williams et al. (2013); Papert et al. (2016); Brandon-Jones et al. (2014); Kim et al. (2011). Others evolved qualitative measures, expressing the perceived level of visibility into defined categories (Barratt and Oke (2007); Barratt and Barratt (2011); Bartlett et al. (2007)). The main differences become apparent when looking at the applicability of the metrics. Some metrics can be applied at supply chain level where the visibility level is measured between focal firm, customers, and suppliers (Caridi et al. (2013); Barratt and Barratt (2011); Papert et al. (2016)). Others can measure the level of visibility only at firm level (between focal firm and supplier/customer) (Caridi et al. (2010a); Brandon-Jones et al. (2014); Williams et al. (2013); Kim et al. (2011); Bartlett et al. (2007); Wei and Wang (2007)). Furthermore, in these case studies a specific industry is chosen as unit of analysis. Noteworthy are the choices made of information types included in the assessments, just as the criteria to judge. Often, only a few criteria are chosen from availability, quantity, accuracy, freshness, timeliness, and usefulness of information received. The current measures are not all-encompassing and during the research this shortcoming is tackled. The study executed contributes to the current body of literature by presenting a comprehensive and all-encompassing support tool that transforms the theoretical concept of measuring visibility, into an operational method for assessing the level of visibility in the FMCG industry.

Practically, this research resulted in a comprehensive measurement tool that can be used by FMCG enterprises and consultants of RHDHV. The Visibility Maturity Scan provides grip to identify critical areas and opportunities of FMCG firms to enhance supply chain visibility. It can be placed at the website, sent by email, or used during sessions as starting point for further project proposals. The detailed Demand/Supply Analysis provides insights into the maturity of suppliers and customers from a business-to-business perspective and can be used as part of a project or detailed analysis. The tools can create awareness of critical areas, provide support for setting action priorities, and can be used for benchmark and monitoring improvement processes within the same organization. Important

is that the output of the tool should be discussed in an additional sessions to define the importance of the supply chain visibility dimensions and criteria. In this way, ambition levels and action priorities can be set. The tool can be used for benchmarking between organizations to a limited extent since company characteristics and priorities are not included in the tool. However, when additional company information and ambition levels are obtained during sessions, this could allow for more objective benchmarks. Currently, the tool is most suitable to use as a regular health check and to benchmark the same organization over multiple years.

11.3. Limitations

Several limitations of the research should be considered and are divided into the restrictions of the methodology, obtained data, and perceptions. Also, practical limitations and restrictions regarding prioritization and differentiation are mentioned.

Limitations of research methodology

The methodology of choice is design science which includes exploratory literature and empirical research. However, due to time limitations, only a restricted number of interviews could be executed with supply chain managers. Since humans are involved in a design research, a certain level of subjectivity is introduced (Mettler et al. (2014)). Although more interviews could decrease this subjectivity, the quality of the research can be seen as appropriated by the significant involvement of experts. Furthermore, the interviewing methodology can result in interpretation bias by the researcher. However, this bias is attempted to be limited by executing multiple interviews and by validation sessions of the tool. Despite the change of bias and subjectivity when doing empirical research, this inadequacy is tried to be minimized by executing multiple interviews and validation sessions.

Limitations of obtained data

It is important to evaluate reliability and the validity of the information that is obtained during interviews, since the quality can be doubtful in case of few individual responses (Dorussen et al. (2005)). Moreover, strategic behaviour could take place influencing the reliability of the data (Ten Heuvelhof and Ten Heuvelhof (2009)). Dorussen et al. conclude that expert interviews can be used, but only if experts are willing to go along. The supply chain managers were reached without any previous connection, but still showed a willingness to contribute to an interview. Especially since all interviewees were keen to participate in validation sessions, it is assumed they were willing to provide high quality data. Also, a direct reason for strategic behaviour of the managers is unlikely. Another thread regarding the reliability of obtained data, is that of the Hawthorne effect. This effect concerns the consequences of awareness that is created when being studied and that this can impact behaviour (McCambridge et al. (2014)). During interviews, questions can be raised in certain ways, redirecting to desired answers. It could also occur that specific examples are given, and that the respondents recognises the example provided, even though this example did not dominantly come to mind initially. The aim during interviews was to minimize this Hawthorne effect by posing open questions and providing examples after thoughts were shared first by the interviewees. Lastly, social desirability may occur in the answers provided. However, sensitive topics are not emphasised in the interviews and are therefore probably limited. In conclusion, the limitations of strategic behaviour and the possibility for answers directed in a certain direction, are not likely in the empirical phase of this study. This is due to the nature of the topic and the willingness that the supply chain managers showed to participate.

Limitation regarding objectivity

A limitation of the Visibility Maturity Scan is that subjectivity is involved. The assessment of information types can be biased and opinionated since subjective elements as timeliness, sufficiency, and accuracy need to be assessed. Therefore, there is a possibility of own interpretations when questions are answered. Validation sessions also have shown the common doubt between answers when FMCG managers used the tool. The nature of the questions of the Visibility Maturity Scan and the time requirement restrictions, make it inevitable that answers are provided based on own perceptions. The Detailed Demand/Supply Analysis better deals with this problem by analysing business-to-business customers and suppliers separately at a detailed level, and by applying a ranking method. The users should take notice that perceptions influence the results and that additional sessions where relevant

information could be collected, are needed for valuable insights.

Limitations regarding prioritizing and strategical goals

Company-specific weights related to the importance of information types and criteria are not included in the Visibility Maturity Scan. It was not straightforward to integrate weights directly in the tool and therefore an additional session with the client is needed. These weights are of major importance to transfer the values of the scan into objective and less arbitrary outcomes. Enterprise specific information that should be collected during a session can include the companies' differentiation strategy, the supply chain structure, level of digitization, the ambition goals, and corresponding thresholds. In this way, the priorities and goals of a company can be included to determine critical areas and follow-up actions. This provides insights if low scoring factors from the scan are problematic and need attention. Furthermore, collecting company-specific information, weighting factors, and strategic goals, could allow for more objective bench-marking between enterprises. At the moment, the tool is more appropriate to monitor improvement processes within the same organization over time.

Practical limitations

Practically, not all features of the design can be developed with the current software used. This applies to the Visibility Maturity Scan where the Kes software is used. Currently, graphical and numerical features can not be integrated. Furthermore, the integration of the tool into the website of RHDHV is not investigated yet.

12

Conclusion & Recommendations

12.1. Conclusion

A reflection of the iterative process towards the design of the support tool is provided. Main findings from literature and interview studies that formed the foundation for the designs, are reflected upon.

Thesis objective

The aim of the thesis was defined as follows:

Design of a support tool to assess the degree of supply chain visibility in the FMCG industry and find critical areas and opportunities to enhance supply chain visibility

The tool is designed to support engineering and/or consultancy companies to create insights into the bottlenecks of FMCG enterprises and their major improvement areas within the supply chain. The tool provides a foundation for a systematic and detailed supply chain analysis. The results can be used for diagnostic purposes and monitoring improvement processes. It provides grip as a starting point for further needed expertise.

Findings exploratory research

Approach

In the problem definition phase, an in-depth literature study is executed to study the existing knowledge on the current coordination of FMCG supply chains, the added value of supply chain visibility, and barriers. Also, existing metrics to assess the level of visibility are evaluated. A gap was found between the existing measures in literature and practice. The metrics developed in literature, generally focus on supply chain visibility in specific industries, and the metrics are limited in terms of included dimensions and criteria. Also, a delimited part of the supply chain is often analysed. A link towards the usefulness and practicability is oftentimes missing. From literature, it can be concluded that there is a lack of knowledge on developing a comprehensive measurement to identify the maturity of supply chain visibility of FMCG enterprises in practice. As a result, the need for a tool has arisen, addressing complex networks. One analysis included in the tool can capture the overall maturity of supply chain visibility. The other analysis provides a detailed analysis that is specifically focused on demand and/or supply visibility of the supply chain. In order to design the tool that could support an engineering/consultancy company, a literature study is performed and complemented by findings from interviews with supply chain managers of leading FMCG enterprises and consultants of RHDHV. Together, this gave understanding into the coordination and complexity of the FMCG supply chain, just as the barriers impeding supply chain visibility. These findings formed the foundation for the design of the tool developed.

Trends and complexity drivers in the FMCG supply chain

Coordination in the FMCG supply chain is investigated to answer the first research question of the exploratory research:

RQ1: What is the state-of-the-art of coordinating the FMCG supply chain?

Coordination has become more complex with the increasing number of suppliers, customers, and other supply chain members. The diversity of products and components, geographical spread globally, and dependency between products and processes strengthen this complexity. Also, market uncertainty, the amount of data, IT systems, and technologies impact today's coordination. A main challenge can be seen in obtaining critical information, and the connection of available pieces of information across the supply chain to predict and minimize uncertainty. Current trends that are driving the industry are globalization, pressure on efficiency, information transparency, digitization, and online sales as found in both literature and in empirical research. Shifts in demographics occur, and customer desires are changing, resulting in companies trying to meet customers' sustainable, ethical, and health conscious mindsets. Furthermore, the constantly changing customer demands result in the variety of products being produced. Supply chain managers appointed the recent occurrence, Covid-19, and its impact on coordination by the resilience and vulnerability of supply chains. Enterprises are trying to react to such uncertainties by localizing supply chains. The mentioned complexity drivers and trends are having a major impact on the FMCG supply chain and its coordination. Information technologies are paving the way for better coordination by creating (end-to-end) supply chain visibility. However, achieving real-time information among and across chains that is accurate, complete, in time, and of high quality, is a challenge.

Critical information

The second research question was studied and formulated as follows:

RQ2: What information can be received and exchanged across the supply chain and what is the value of this information?

It has been shown that information is critical for responsiveness, risk management, control, operations efficiency, transparency, collaboration, and decision making. Generally, costs can be reduced and customer service levels can be increased when the right information is available. Critical information for FMCG managers to enhance visibility at the supplier side contains information about inventories, order status, expected arrival time, production schedule, and disruptions. Especially inventory level information is often absent, and the accuracy and punctuality of ETA information is insufficient. Transport disruptions are regularly communicated too late due to own interests of suppliers. Crucial outbound data contains information about sales, demand forecasts, inventory levels, and promotional plans. This information is often lacking or inaccurate leading to inefficiencies. Especially transport related information as the Estimated Time of Arrival and On-Time In-Full are mentioned as essential by supply chain managers interviewed. Also, the online-availability has become an important performance indicator and source of data.

Barriers

Barriers are found impeding supply chain visibility and information exchange in literature and practice. These barriers were researched to answer the following research question:

RQ3: What are the challenges impeding supply chain visibility

The technical and financial barriers found, relate to the lack of technical support, costs of IT investments, maintenance, and training. The unclarity of financial results and benefits strengthen this resistance, just as implementation and integration problems. The variety of hardware, software, data standards, and IT systems, are the cause for these integration difficulties. Legal barriers exists as well, but social and organizational barriers are seen as a crucial factor impacting the reluctance to share information and implementing needed IT infrastructure. The lack of trust in supply chain partners, IT systems and the sensitive nature of information exchanged, is perceived as major barrier. This lack of trust goes

hand-in-hand with risk and reliability. Furthermore, the business culture impacts the willingness and support to share information. Dominant positions of stakeholders and contractual agreements play a main role for information exchange in the supply chain. Noteworthy is that the large amount of data and the organization of master data (source data) is seen as major barrier that is explicitly highlighted by all the supply chain managers interviewed.

Measuring visibility

In the last phase of the exploratory research the extant measures for supply chain visibility were researched to answer the fourth research question:

RQ4: How can supply chain visibility be assessed?

Eleven existing assessment methods to measure the level of supply chain visibility were compared, to incorporate useful elements and criteria into the detailed design. A number of authors focus on quantitative measures expressing the level of visibility into an index or score. Other metrics found in literature evolved qualitative measures, expressing the perceived level of visibility into defined categories. Furthermore, different choices are made of information types that are included in the assessment, just as the criteria to judge. The most common criteria for supply chain visibility in literature and practice are availability, quantity, accuracy, freshness, timeliness, and usefulness of information received.

Detailed design

First a set of requirements and functionalities was established where the design should comply with. This answered the last research question of the study:

RQ5: What are the relevant requirements and functionalities for the supply chain visibility tools?

During the design phase, a conceptual design and detailed design was developed for both tools. During these stages, main dimensions and criteria were defined, just as decisions related to the visualisation and software used. Feedback was received iteratively by consultants of RHDHV and the improved detailed designs were implemented towards digital tools.

The Visibility Maturity Scan exists of four main dimensions to measure the overall visibility maturity level. Supply, demand and internal visibility factors are included. Additionally, a category is added including factors related to the traceability of materials and the availability and interpretation of data. Information is assessed based on four criteria: availability, accuracy, frequency, and timeliness. Automatically, a report is generated based on answers given, presenting the maturity of supply chain visibility, bottlenecks, and major improvement areas. This is graphically supported using spider diagrams. The Detailed Demand/Supply Analysis focuses specifically on either the demand or supply side. Customers and suppliers need to be ranked based on the same criteria. Weighting factors can designate the importance of customers and suppliers. Per supplier/customer a dashboard is created giving insights into critical suppliers and customers, and opportunities.

Validation phase

Validation sessions with FMCG supply chain managers were carried out to test the practicality, general impression, and added value of these digital tools. The Visibility Maturity Scan is executed by four managers and one supply chain manager carried out the detailed analysis. The results related to the visibility scan showed that in three of four cases, the internal visibility obtained the best maturity score. In all cases, demand visibility scored lowest and the supply visibility scored much higher. All supply chain managers indicated that the results were in line with their expectations. Also, they designated that the tool was valuable to find critical areas and opportunities. Five managers of leading FMCG companies gave suggestions. Improvement suggestions provided by the supply chain managers for the quick scan were to include elements ‘quality of master data’, ‘availability of clear KPI’s’, and ‘the availability of solutions to present performances’. The advice was provided to include company specific questions to allow for benchmarking between departments or companies. Another suggestion was to cover the company’s differentiation strategy and to include the importance of the different information

types that are assessed in relation to each other. The main suggestion for the Detailed Supply/Demand analysis was the extension of the tool by ranking the customers based on the quality of master data. This quality of the master data is essential for information sharing. The managers confirmed that the tool creates awareness for critical areas, identifies critical suppliers and customers, and provide support for setting action priorities. Also, it can be used as regular health check and benchmark for the organization over multiple years.

To conclude, the main outcome of this research is the creation on a comprehensive support tool to measure the current maturity of supply chain visibility, and finds improvement areas. By transforming the theoretical knowledge about assessment of visibility into an operational assessment method for the FMCG industry, an analysis can be made to create awareness about the current state and opportunities to improve. Based on the validation sessions with users the premise is that this study contributes to the awareness by enterprises, that it offers support for setting action priorities, and that it can be used to monitor improvement processes. It provides priorities constraints, and implications that enterprises are facing in the transition towards a visible supply chain.

12.2. Recommendations for future research

This section outlines recommendations for future research.

Investigating a larger sample covering different contexts

It is suggested that the tool developed should be tested statistically by a group that utilizes a larger sample of industries different to the FMCG sector. Also, other context of enterprises can be investigated by applying the support tool in a wider setting. It would be interesting to investigate the validity and practicability of the tool by enterprises in different context (size, different levels/positions of the supply chain, product variety, demand variability etc.).

Relevance of information

The current features of the tools can be improved by including extra properties. Further research needs to examine more closely the relevance of certain information. Insights into the relevance of specific information can be integrated as feature in the assessment of visibility for analyses included in the support tool.

Acquire insights into the impact of improved supply chain visibility

Further research should be undertaken to explore how the measure for supply chain visibility can be used to develop a model that can assess the impact and value of improved supply chain visibility. This is complex and context dependent, but very valuable scientifically and practically. Research is needed to estimate the marginal benefits and to decide in which unit this can be expressed. When improvements can be expressed, return of investments can be approximated as well.

Towards a benchmark tool

A larger amount of heterogeneous use cases could shed more light on significant benchmarks. When a larger sample is used, data can be saved allowing for comparability between companies within the same industry. This does not only include the results of the scan, but also company specific information, strategic goals, and priorities. Best-in-class illustrations can create valuable insights and enhance the supply chain visibility.

12.3. Practical recommendations

This section provide the practical suggestions.

Extending the current features of the Kes software

The current features of Kes to represent the outcome of the tool can be improved. Kes is the software used to develop the Visibility Maturity Scan. The main advantages of this software are the appealing design, and the automatic generation of the report which is directly visible after executing the questionnaire. This software is developed by a department of RHDHV, responsible for digital propositions

and product developments. Currently, main limitations of Kes are the lack of a graphical and numerical feature. Right now, only text can be generated instead of graphs and scores. Furthermore, attention should be paid to the integration into the website of RHDHV. It should be easily accessible for companies to fill in the scan on the website, and details about the company should be left mandatory for marketing purposes. Since the development of the tool is performed in-house, it is easier to raise suggestions for further improvements. The recommendation to build in numerical and graphical functions is already put on the priority list of the digital department. When this topic comes on their roadmap, the supply chain operations department will be asked to discuss the details.

Including the quality of master data in the Detailed Demand/Supply Analysis

Recommended is to pay significant attention to the assessment of master data and include this as feature in the Detailed Demand/Supply Analysis tool. For most of the stakeholders, the correctness and completeness of this data is insufficient. Nonetheless, master data creates the foundation for end-to-end visibility. When the current detailed tool is elaborated and gives insights in the critical suppliers or customers regarding this master data problem, it can be valuable to enhance supply chain visibility and easily find critical candidates where improvement is more urgent.

Appointing responsibility

It is recommended to appoint someone from the Supply Chain & Operations department in charge to further develop the tools and the implementation in current businesses. It is advised that the changes and reasons why adjustments are made, are documented.

Food for thought

While this study answered the main research question, it also gave some interesting new topics to consider.

Sustainability
Significant attention should be paid to visibility within the sustainability theme. The sustainable mindset of consumers and sustainable character of enterprises have developed strongly. Interesting is the impact of transparency and visibility on the effectiveness and the capability to create competitive and sustainable advantages.

Covid-19
Covid-19 can be used as example to reorganise the current supply chain visibility and increase its resilience. This crisis functioned as reminder of long-standing, interrelated and unresolved problems characterizing the supply chain logistics and coordination. Supply chain managers addressed that this exceptional situation also opened eyes as how to switch and adapt in such crisis and how to make fast decisions and adaptions to handle the major disruptions in demand patterns.

Trust
The research showed the importance of the role of trust in creating visibility and advantages. Simply using more data technology and IT systems is not the answer, since this collection of data rest on a foundation of trust. What is the best approach to build up this trust, and what factors and contexts influence the confidence and willingness to share information? These are complex and situation-dependent matters.

The role of IoT
IoT cannot be ignored in the transition towards enhancement of visibility in the supply chain. Technologies create possibilities for changed supply chain management and enable intelligent and connected supply chains. Understanding the role of the wide range of technical solutions on supply chain visibility and on the creation of strategic value and financial advantages, is of main importance. Especially in estimating the return of investments of IT solutions.

Cross Chain Collaboration and End-to-End visibility
Research towards supply chain visibility can contribute to cross-chain collaboration and fully end-to-end visibility as higher purpose. The roadmap towards Cross Chain Collaboration where inter- and intra collaboration exists, still has a long way to go. However, full collaboration could create efficiencies and sustainable advantages for many stakeholders.

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A

Interview Protocol

A.1. Interview invitation Supply Chain Managers

A list of 27 supply chain managers of leading FMCG companies is compiled with Nick Vermeulen (Consultant at RHDHV). These managers are selected to approach via LinkedIn. Here, the products of those FMCG companies are consumer goods that are non-electronics and non-perishables. First, a connection and a short message was sent because of the restricted number of characters that is allowed. Nine managers accepted the connection invite and a second detailed message was sent. Both messages can be found below. Eventually, five managers were willing to share information via an expert interview.

Message 1
Dear NAME,

Currently, I am doing my master's thesis of the MSc Transport, Infrastructure Logistics at the TU Delft in the research area 'supply chain visibility. I wondered if you have some time for an (expert) interview to share valuable insights based on your current role and past work experience?

Thank you in advance.

Kind regards,
Laura Guleij

Message 2
Dear NAME,

Currently, I am doing my master's thesis of the MSc Transport, Infrastructure Logistics at the TU Delft. For my research, I am exploring the challenges and opportunities to enhance supply chain visibility in the FMCG industry. Several technical solutions can create this visibility, however there are many challenges on the road to achieve such technical solutions.

Typical challenges are KPI setting, difficulties with collecting and merging data, the unwillingness to share information, etc. I wondered if I could ask some questions in an (expert) interview about your experiences to improve decision-making in your daily work. Furthermore, I am interested in the reasons behind the complexity of the collection of relevant information. The interview can be held in a Microsoft Teams meeting or at the office.

I look forward to hearing from you and I would like to thank you in advance.

Kind regards,
Laura Guleij

A.2. Interview invitation consultants RHDHV

Besides supply chain managers of FMCG enterprises, also consultants of RHDHV were approached. A selection of experts was compiled by Nick Vermeulen. An invite for an exploratory interview was sent by mail and is stated below.

Dear NAME,

I am Laura Guleij, a graduate student at RHDHV the Resources, Logistics, and Power Group. Currently, I am doing my master thesis and I am exploring the challenges and opportunities to enhance supply chain visibility in the FMCG industry. Several technical solutions can create this visibility, however, there are many challenges on the road to achieve such technical solutions (typical challenges: trust issues, KPI setting, unavailability of data, unwillingness to share information, etc.). Nick shared your contact details because he thinks you can share valuable insights based on your current role past work experience. I wondered if I could ask you some questions end of next week to understand typical supply chain visibility challenges and the reasons behind the complexity of digital implementations (including potential opportunities).

I look forward to hearing from you and I would like you in advance.

Kind regards,
Laura Guleij

A.3. Interviewees

The consultants interviewed, are listed below in the table A.1. Here, the current position and years of experience in the supply chain sector s also visible. Hereafter the supply chain managers are named in a depersonalised way.

Table A.1: Interviewed consultants RHDHV

Name	Date	Department	Function	Years of experience in SC
Expert1 RHDHV	17-3-2021	Resources Logistics & Power	Senior consultant	20 years
Expert2 RHDHV	18-3-2021	Resources Logistics & Power	Project Engineer	19 years
Expert3 RHDHV	17-3-2021	Resources Logistics & Power	Supply Chain and Operations consultant	6 years
Expert4 RHDHV	19-3-2021	Data & Digital Consultancy	Supply Chain and Operations consultant and Strategy consultant	13 years
Expert5 RHDHV	24-3-2021	Multi-Project Management & Consultancy Multinationals	Director Advisory Group Project Management & Consultancy	7 years

Table A.2: Interviewed Supply Chain Managers RHDHV

Name	Date	Function	Product type	Years of experience in SC
SCM A	31-3-2021	Logistics Supplier Manager	Personal care	20 years
SCM B	9-4-2021	Supply Chain Director Benelux	Personal care	12 years
SCM C	9-4-2021	Supply Chain Manager	Personal care	21 years
SCM D	30-3-2021	Supply Chain Director Benelux	Pet food	12 years
SCM E	30-3-2021	Vice President Strategic Supply Chain Projects	Cleaning products	33 years

A.4. Interview structure Consultants RHDHV

A semi-structured interview is prepared to discuss common problems in the FMCG industry experienced by the consultants of RHDHV. The structure and prepared questions are listed below.

Introduction
First, time is available for a personal introduction of me and the consultant. The work experiences of the consultant will be discussed and this is followed by a brief introduction to the master thesis research.

Part 1: Problem identification
In this part, typical problems that supply chain managers are often dealing with should be investigated. Examples prepared as guidance are out-of-stocks, excessive inventory levels, late delivery, inability to start production, high lead times, and inefficient information sharing. The objective is to understand the complexity behind the common problems and what information or solutions can improve these problems. Questions prepared are:

- What typical problems are supply chain managers dealing with regularly?
- What could solve these problems and what information is lacking?
- Is that information hold by other stakeholders, or can the information be collected by the company itself?
- What is tried in the past to solve the ongoing problems and what impeded attempts?

Part 2: Technologies
In the second part experiences are discussed related to technologies in the industry. These are technologies to improve business performance to collect and exchange information exchange. Also, promising future technological opportunities will be reviewed.

Prepared questions:

- What technical systems are often used to collect information and improve and coordinate operational processes?
- Where can tools/technologies support to deliver useful information (faster)?
- Where do you see unused opportunities to create supply chain visibility?

A.5. Interview structure Supply Chain Managers

A semi-structured interview is prepared, where global questions are provided to open a discussion and give examples. The objective of each interview is to obtain information based on experience about the complexity of supply chain management, common problems and the complexity of creating visibility and sharing information.

Introduction
First, some minutes are available for a personal introduction of the consultant and myself. This is followed by a brief introduction to the master thesis research and the supply chain manager's work experience and current position.

Part 1: Supply chain structure
After a personal introduction and introduction of the master thesis project, the interviewee should describe the supply structure as background for the questions. Work experiences and current responsibilities will be discussed. Topics that can be considered are the type of products, in and outsourced activities, the collaboration of third parties, and the type of suppliers and consumers.

Prepared questions:

- Can you describe the supply chain structure of the company generally?
- What is your position within this supply chain?

Part 2: Problem identification
In the second part of the interview, typical problems that supply chain managers are dealing with will be investigated. Problems can occur at different time intervals and at different levels (operational/tactical/strategic). Examples prepared as guidance are out-of-stocks, excessive inventory levels, late delivery, inability to start production and high lead times, inefficient information sharing.

- What typical problems are supply chain managers dealing with regularly at the operational/tactical/strategic level?

Part 3: Visibility related information and visibility needs
The interviewee should be asked to evaluate the current level of visibility and the lacking information that can solve inefficiencies. Examples prepared as guidance are demand forecasts, promotional events, point of sale (POS) data, on-hand inventory levels, replenishment policies, order status, supply disruptions, delivery schedules, shared planning. It is important to ask thorough questions based on the type of information being discussed. Sunken reasons why some information is hard to collect and the owner of that data should be investigated. Examples prepared for this topic that can be named are trust issues, fear for deteriorated market position, parties that are unwilling to share information, costs, company culture and technology issues. Furthermore, improvement projects and attempts to improve processes and collect data need to be discussed. The most promising areas for improvement can be evaluated.

Prepared questions:

- What information is lacking which can tackle the current problems?
- Is that information held by other stakeholders, or can the company's information be collected by the company itself?
- What is the reasons why the needed information is not available?
- What is tried in the past to solve the ongoing problems and what impeded attempts?
- What information is currently shared with other stakeholders in the supply chain and how is this information communicated (manually or ERP system etc.).

Part 4: Technologies
Lastly, the current technologies used for information exchange will be discussed just as future opportunities based on the experience of the supply chain manager. Inefficiencies that technologies can solve and reasons why realisation is hard need to be investigated.

Prepared-questions

- What technical systems are often used to collect information and improve and coordinate operational processes?
- Where can tools/technologies support to deliver useful information (faster)?
- Where do you see unused opportunities to create supply chain visibility?

Closing
In the final phase, the interviewee will be thanked for his or her time and asked if the company is willing to share information or in a further phase in the research. Also, the manager will be asked if he/she is willing to have another expert interview.

A.6. Results Interviews with SC Managers and RHDHV Experts

In this section, the most important developments, trends and challenges are listed. Also, the critical information and technologies are provided. An overview is made of what topics are raised and highlighted by which consultant or RHDHV expert. An overview of the Supply chain manager and their reference, can be found in table A.3.

A.6.1. Main developments and trends

- Amount available data
  [SCM B, D, E and RHDHV expert 1, 2, 3, 4, 5]
- More details provided about the product
  [SCM B]
- Amount of feedback provided towards customers has increased *[SCM B]*
- Direct delivery to end-consumers
  [SCM E]
- KPIs are recorded more accurately and more shared for strategic purposes
  [SCM D]
- Growth of e-commerce
  [SCM B, C]
- Use of webcrawlers
  [SCM B]
- Demand for a transparent supply chain
  [SCM B and RHDHV expert 1, 2]
- Use of Machine Learning and Artificial Intelligence *[SCM A, D]*
- Switching form global to local (due to Covid-19)
  [RHDHV expert 1, 2]
- Unmanned delivery (transport providers deliver before the shop is opened)
  [SCM A]
- Using visualization tools as PowerBI
  [SCM B, C, D and RHDHV expert 4]
- Using more sophisticated technologies
  [SCM A, B, C, D, E and consultants 1, 2, 3, 4, 5]

A.6.2. Challenges and barriers

Complexity supply chain structure

- Companies understand their level one supply but have no insight in their level two and three supply
  [RHDHV expert 1]
- Globalization
  [RHDHV expert 1, 2, 4, 5]
- Many products and supply chain partners involved
  [SCM B, E and RHDHV experts 1, 5]

Demand forecasting

- Inaccurate demand forecast
  [SCM B, C, D, E]

- Little forecasts are shared by retailers/shops and those are also often inaccurate
  [SCM B, C, D, E]
- Underestimation of forecast
  [SCM B, C, D, E]
- Overestimation of forecast
  [SCM B, C, D, E]
- Lack of sell-out/POS data
  [SCM A, B, C, E]

Production planning

- Misalignment of sales and production (underproduction or overproduction)
  [SCMB, C, D, E]
- Inability to start production
  [SCMB, E]

Manufacturing execution

- Machinery breakdowns or defects
  [SCM E]
- Contamination issues
  [SCM E]
- Quality issues
  [SCM A, E]

Inventory management

- To many Stock-outs
  [SCM A, B, C, D, E] and RHDHV expert 1, 3
- Excessive inventory levels
  [SCM A, B, C, D, E and RHDHV expert 1, 3]
- Excessive stock levels of a product that is not sold anymore
  [SCM B]
- Inventory optimization
  [SCM A, B, C, D, E]
- Creating transparency in the customers inventory level
  [SCM B, C, E]
- Receiving point of sales or sell-out data to optimize inventory management
  [SCM A, B, C, E]

Logistics

- Disruptions of the supply of raw materials
  [SCM B, E and RHDHV expert 1, 3]
- Unknown arrival times of products (tracking/tracing)
  [SCM B, C, E and RHDHV expert 1, 3]
- Late delivery to the warehouses/DCs
  [SCM A, B, C, D, E and RHDHV expert 1, 3]
- Late delivery to customers
  [SCM A, B, C, D, E and RHDHV expert 1, 3]

- Timely communication of transport disruptions
  [SCM A, C, E and RHDHV expert 1, 3]

Technological and data challenges

- Amount of data
  [SCMB, D, E] and RHDHV expert 1, 2, 3, 4, 5]
- Lack of sophisticated systems
  [SCMB, C, D, E and Expert RDHV 1, 4]
- Different softwares/hardwares/IT systems between companies *[SCM C, D, E and RHDHV expert 4]*
- Determining the responsible party to pay the costs for new information systems
  [SCM B, E]
- Automation of information exchange
  [SCM B, C, E]
- Receiving information in the same format
  [SCM B, C, D, E]
- Organization of master data
  [SCM B, C, D, E]
- Connecting and interpreting internal and external data
  [SCM B, C, D, E and RHDHV expert 1, 3, 4 , 5]

Socio-cultural challenges

- Creating trust
  [SCM B, C, E and expert RHDHV 2, 3]
- Sensitivity of information / fear to share
  [SCM A, B, C, E and expert RHDHV 2, 3]
- Fear of losing a strong commercial negotiation position
  [SCM B, C, E and RHDHV 2]
- Fear of misuse of data
  [SCM A, B, C, E]
- Fear of data being hacked
  [SCM A]
- Dealing with different business cultures
  [SCM C, E]

A.6.3. Critical information

- Inventory information
  [SCM A, B, C, D, E]
- Sales information/POS data
  [SCM A, B, C, E]
- Order information
  [SCM A, B, C, D, E]
- Forecast information
  [SCM A, B, C, D, E]
- Product information
  [SCM A, B, C, D, E]

- Transport disruption information
  [SCM B, C, D, E]
- Promotional events
  [SCM B, C]
- OTIF
  [SCM A, D, E]
- ETA
  [SCM A, B, C, D, E]
- OLA
  [SCM B]

A.6.4. Promising technologies

- Blockchain
  [SCM D and RHDHV expert 2]
- RFID tags
  [SCM A, C]
- Visualization tools as PowerBI
  [SCM B, C, D]
- Automation in processing, connecting, and analysing data
  [SCM B, C, D, E]
- Use of Machine Learning and Artificial Intelligence
  [SCM A, D]

B

Design Requirements and Functionalities

The set of included requirements is defined during an evaluation session with two experts of RHDHV and are named as RHDHV1 and RHDHV2 (see Table B.1). The functionalities followed from this final set of requirements. One, or a set of requirements are resulting in the functionalities defined. This derivation can be seen in the overview at the next page. At the vertical axis all requirements are presented. The horizontal axis shows the final functionalities that are build up based on one or several requirements. During the verification session, the same experts that are presented in Table B.1 are involved to determine if the requirements are met.

Table B.1: Experts involved during the determination of included requirements and functionalities

Name	Department	Function	Years of experience in SC
RHDHV1	Resources Logistics & Power	Supply Chain and Operations consultant	3 years
RHDHV2	Resources Logistics & Power	Supply Chain and Operations consultant	7 years

	Measurement of the maturity of supply chain visibility	Measurement of supply chain visibility considers different dimensions of visibility and is based on criteria	Provides details about scales to distinguish and judge different levels of criteria	Measurement span both upstream and downstream supply chain visibility	Measurement span both te visibility of goods as the visibility of information	Identification of critical areas and opportunities of supply chain visibility	Provides grip	Easy to use	Generates awareness	Results functions as starting point of discussion	Presents results with limited manual actions needed	Presents results with limited time	Visualizes results graphically for quick interpretation	Comprehensive measurement of the maturity of supply chain visibility per customer/supplier	Providing a benchmark of the suppliers/customers included in analysis	Results support as starting point to improve supply and demand visibility
Includes a comprehensive metric of visibility considering different dimensions of visibility	X	X											X			
Distinguishes different types of information flows		X														
Assesses visibility based on different criteria		X														
Provides details about scales to distinguish and judge different levels of the criteria			X													
Expresses the maturity level of supply chain visibility qualitatively	X												X			
Includes measurable scales			X													
Limited effort in time											X					
Finds critical areas for improvement						X	X		X	X				X	X	
Provides recommendations						X	X		X	X				X	X	
Provides correct information	X												X			
Provides interpretable results						X	X	X	X	X		X		X		
User friendly											X	X				
Maturity Visibility Scan funcitons as the starting point for further detailed analysis													X	X	X	
Detailed Demand/Supply Analysis finds critical suppliers/customers													X	X	X	
Execution of a quick scan including questionnaires can be conducted within 15 minutes											X					

	Measurement of the maturity of supply chain visibility	Measurement of supply chain visibility considers different dimensions of visibility and is based on criteria	Provides details about scales to distinguish and judge different levels of criteria	Measurement span both upstream and downstream supply chain visibility	Measurement span both te visibility of goods as the visibility of information	Identification of critical areas and opportunities of supply chain visibility	Provides grip	Easy to use	Generates awareness	Results functions as starting point of discussion	Presents results with limited manual actions needed	Presents results with limited time interpretation	Visualizes results graphically for quick interpretation	Comprehensive measurement of the maturity of supply chain visibility per customer/supplier	Providing a benchmark of the suppliers/customers included in analysis	Results support as starting point to improve supply and demand visibility
A limited number of actions needs to be executed											X					
Measures the level of supply chain visibility from both the demand and supply side				X												
Includes visibility of (transported) goods					X											
Considers data/ information that is sent both manually as automatically to assess supply		X		X												
Provides isights into the level of informtaion exchange with supply chain partners				X	X											
Measures operational/tactical and strategic supply chain visibility		X														
Functions as instrument to create awareness						X	X									

C

Visibility Maturity Scan

In this appendix the survey questions of the Visibility Maturity Scan are listed. Also, the text that will be presented in the rapport per selected answer can be seen below.

C.1. Survey Questions

The survey questions are divided into four dimensions of visibility: Demand, Supply, Internal, and Others. The questions are listed per dimension.

Demand Visibility

Information types that are assessed in the demand visibility dimension are POS/sales information, demand forecasts, inventory levels, and promotional events. For all information types four questions are asked if the information is available for the company. When the zero option is selected (no information is available), the questions regarding accuracy, frequency, and timeliness are skipped.

POS/Sales information, demand planning, inventory levels, promotional events

Availability - The company has:

0. No access to this information
1. Little access (sent by 1% till 25% of the customers)
2. Partial access sent by 25% till 75% of the customers)
3. Very good amount (sent by 50% till 75% of the customers)
4. Access to large part (sent by more than 75% of the customers

Accuracy - On average the accuracy of the exchanged information is:

1. Very low and unsatisfactory
2. Usually satisfactory, but situations in which the information is incorrect are not uncommon
3. Usually satisfactory, and the information is incorrect only in a few situations
4. Always satisfactory (very good accuracy)

Frequency - On average this information is

1. Sometimes received when this is requested

2. Usually received when this is requested
3. Pro-actively sent by the customer (based on contractual agreements)
4. Real-time available

Timeliness - On average this information is received

1. Always too late
2. Usually too late
3. Usually on time, and the information is only too late in a few situations
4. Always on time

Supply Visibility

Supply visibility is scored based on inventory level, order status, expected arrival time, disruptions and production schedule. For all information types, three questions are asked. When the zero option is selected for the availability of that information type, the questions regarding accuracy and frequency are skipped.

Inventory level, purchase order status, expected arrival time, disruptions

Availability - The company has:

0. No access to this information
1. Little access (sent by 1% till 25% of the suppliers)
2. Partial access sent by 25% till 75% of the suppliers)
3. Very good amount (sent by 50% till 75% of the suppliers)
4. Access to large part (sent by more than 75% of the suppliers

Accuracy - On average the accuracy of the exchanged information is:

1. Very low and unsatisfactory
2. Usually satisfactory, but situations in which the information is incorrect are not uncommon
3. Usually satisfactory, and the information is incorrect only in a few situations
4. Always satisfactory (very good accuracy)

Frequency - On average this information is

1. Sometimes received when this is requested
2. Usually received when this is requested
3. Pro-actively sent by the supplier (based on contractual agreements)
4. Real-time available

Timeliness - On average this information is received

1. Always too late
2. Usually too late
3. Usually on time, and the information is only too late in a few situations
4. Always on time

Internal Visibility

Internal visibility is scored based on the transport information, insights in own inventory level information, current capacities, current productivity, and the future state capacity.

Transport information
The company has:

0. No access to this information
1. Little access (1% till 25% of the orders)
2. Partial access (25% till 50% of the orders)
3. Very good amount (50% till 75% of the orders)
4. Access to a large part (more than 75% of the orders)

Transport information is also assessed based on accuracy, frequency and timeliness. Here, the same scales are used as mentioned before.

Inventory levels
The availability and accuracy of internal inventory level information are:

1. Very low and unsatisfactory
2. Usually satisfactory, but situations in which the information is incorrect are not uncommon
3. Usually satisfactory, and the information is incorrect only in a few situations
4. Always satisfactory and very accurate

Current capacity
To what extent do you know the company's current capacity of the manufacturing and site function?

1. No insight
2. Insights are unsatisfactory
3. Quite good insight
4. Very good insight in the current capabilities

Current productivity
To what extent do you know the company's current productivity of the manufacturing and site function?

1. No insight
2. Insights are unsatisfactory
3. Quite good insight
4. Very good insight in the current capabilities

Future state capacity
To what extent do you know the company's future state capacity of site and manufacturing function?

1. No insight
2. Insights are unsatisfactory
3. Quite good insight
4. Very good insight in the current capabilities

Others

Other visibility dimensions comprise the traceability origin of materials and the availability of an overview of the available data and the interpretation of the available data.

Traceability origin of materials
The company has:

1. No insight in the origin of materials and components of the products
2. Partial insight into the origin of materials and components (less than 50%)
3. Great insight into the origin of materials and components (more than 50%)
4. Insight into the origin of most materials and components

Overview of the available data
The company has:

1. No overview of the available data
2. Limited insights in the available data
3. Mostly good insights in the available data
4. A good overview of the available data

Interpretation of data
The extent to which the available data is interpreted:

1. Provides no input to proactively recognize opportunities for improvement
2. Provides limited input to proactively recognize opportunities for improvement
3. Provides mostly good input to proactively recognize opportunities for improvement
4. Provides good input to proactively recognize opportunities for improvement

C.2. Composition of the text in Report

The exact report is based on the answers provided per question. In Kes, the software that is used to develop the survey, the structure of the report can be predefined. There is a possibility to show exactly the answer given by the respondent or to define an alternative text. Also, there is an option to select no text.

In figure C.1 it is showed how the report can be structured in Kes. The header for demand visibility is defined, and the text per question can be inserted to define the structure.

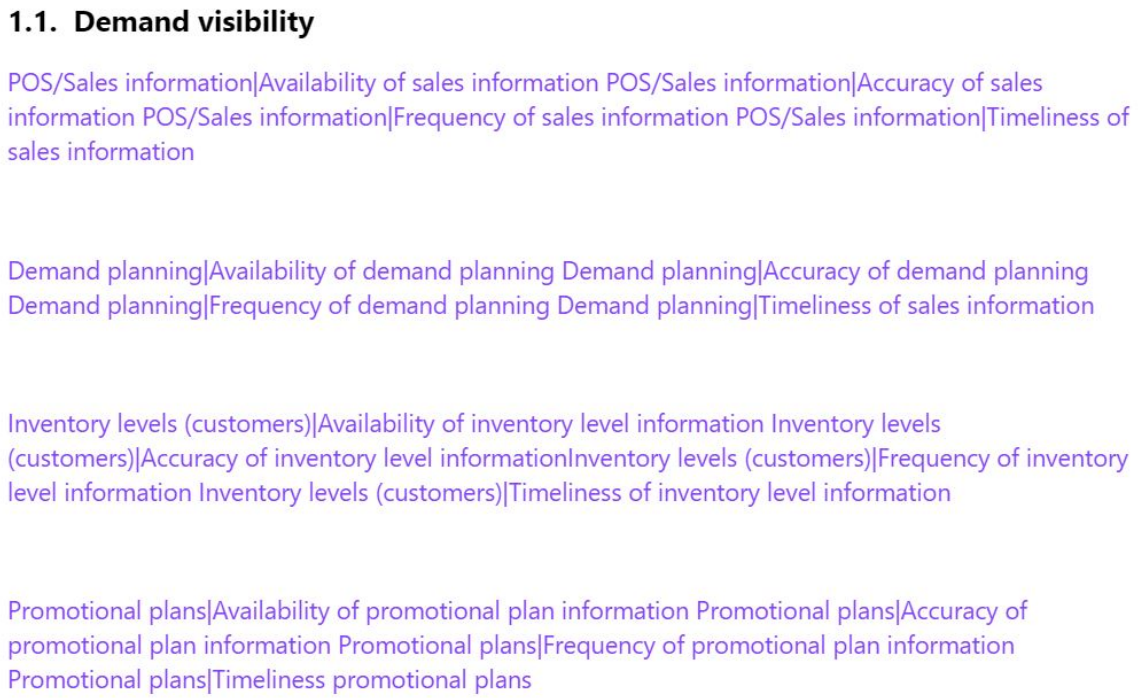


Figure C.1: Defining the report structure in KES

In Figure C.2 you can clearly see that the text predefined, exists of the four questions together. This will be presented in the first paragraph.

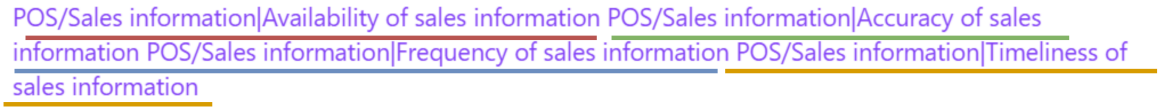


Figure C.2: Structure clarified to generate a report

All the report outputs that are possible per answer selected, is listed in the overview in this appendix. For instance, if answer 1 is chosen, the corresponding text will be inserted in the report.

Demand visibility

POS/SALES INFORMATION	
Explanation: Point-of-Sales/Sales data contains information about the quantity and/or time, and place of products being sold to customers	
Availability	
0	Currently, you don't have access to sales information. Improving the possibilities and willingness of your customers to share sales information is a major opportunity to improve your supply chain visibility. Sales information will give insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels.
1	Currently, you have access to sales information, however, only a few customers (less than 25%) is sending this information. Improving the possibilities and willingness of your customers to share sales information can have a major impact. It will give insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels when sales data is sent by a larger amount of customers.
2	Currently, you have access to sales information, however, only a few customers (between 25% and 50%) is sending this information. Improving the possibilities and willingness of your customers to share sales information can have a major impact. It will give insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels when sales data is sent by a larger amount of customers.
3	Currently, you have access to sales information of the majority of your customers (50% - 75%). Improving the possibilities and willingness to share sales information of the other customers can have a major impact. It will give a complete insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels when sales data is sent by a larger number of customers.
4	Currently, you have access to sales information of the majority of your customers (more than 75%). Improving the possibilities and willingness to share sales information of the other customers can have an impact. It will give a complete insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels.
Accuracy	
1	Unfortunately, the accuracy is very low and unsatisfactory. This can be seen as a major opportunity.
2	Unfortunately, the accuracy is very low and usually unsatisfactory. This can be seen as a major opportunity.
3	The received information is usually satisfactory and only incorrect in a few situations.
4	The received information is always satisfactory and accurate.
Frequency	
1	A possibility to improve the value of the sales information is to focus on receiving this more frequently. Now sales information is only sent sometimes when this is requested. Opportunities with customers should be investigated and IT systems can be considered.
2	A possibility to improve the value of the sales information is to focus on receiving this more frequently. Now sales information is usually received when this is requested. Opportunities with customers should be investigated and IT systems can be considered.
3	The sales information on average is pro-actively sent by the customer and makes your company very progressive and responsive.
4	The sales information on average is real-time information and makes your company very progressive and responsive.
Timeliness	
1	Nonetheless, the sales information is always received too late.
2	Nonetheless, the demand planning is usually received too late.
3	-
4	-

DEMAND PLANNING	
Explanation: The demand planning is an estimation of the future demand provided by the customers	
Availability	
0	Your company does not receive demand forecast information. Combining the demand forecasts of customers with own forecasts can improve the accuracy of predictions and decision making. This should be a focus for future improvements.
1	Your company does receive demand forecast information, but this amount is very limited (between 1% and 25%). Combining the demand forecasts of customers with own forecasts can improve the accuracy of predictions and decision making. This should be a focus for future improvements.
2	Your company does receive demand forecast information, but this amount is very limited (between 25% and 50%). Combining the demand forecasts of customers with their forecasts can improve the accuracy of predictions and decision making. This should be a focus for future improvements.
3	Your company does receive demand forecasts from many customers. Since demand forecasts are sent by 50% to 75% of the customers this is not the number one priory in the future, but still can be focused on to improve the accuracy of predictions and decision making.
4	Your company does receive demand forecasts from many customers. Since demand forecasts are sent by more than 75% of the customers this is not the number one priory in the future. However, the last 25% of the customers can improve the accuracy of predictions and decision making.
Accuracy	
1	A major issue is the accuracy of the received forecasts. Demand forecasts where the accuracy is very low and unsatisfactory can lead to information that is unusable or negatively impacts the forecasts. To improve demand visibility this needs to tackled as soon as possible.
2	A major issue is the accuracy of the received forecast. Receiving demand forecasts where the accuracy is usually satisfactory but also often incorrect and unsatisfactory, leads to unusable information or information that negatively impacts the forecasts. To improve demand visibility this needs to tackled as soon as possible.
3	The received forecasts are on average usually satisfactory, and the information is incorrect only in a few situations.
4	The received forecasts are on average always satisfactory.
Frequency	
1	The information is normally sent sometimes when this is requested. When this is received more often and proactively, the accuracy of the company's forecast can be improved.
2	The information is usually sent when requested. When this is received more often, the accuracy of the company's forecast can be improved.
3	The frequency of this information sent is normally really high.
4	The frequency of this information sent is normally really high and even accessible on a real-time basis.
Timeliness	
1	Unfortunately, the demand planning is always received too late.
2	Unfortunately, the demand planning is usually received too late.
3	-
4	-

INVENTORY LEVELS	
Explanation: Inventory level information contains information about the products available and products being out-of-stock	
Availability	
0	Information about the customer's inventory levels are lacking but are crucial to reduce the stock level and related costs. Receiving inventory information needs to be a main priority to improve demand visibility. A close collaboration needs to be enhanced in order to receive this information and in an ideal situation the company has direct insight into the inventory levels of customers to reduce lead times, risks and costs.
1	Information about the customer's inventory levels are limited (1% - 25%) but are crucial to reduce the stock level and related costs. Receiving inventory information needs to be a main priority to improve demand visibility. A close collaboration needs to be enhanced in order to receive this information and in an ideal situation your company has direct insight into the inventory levels of customers to reduce lead times, risks and costs.
2	Information about the customer's inventory levels are limited (25% - 50%) but are crucial to reduce the stock level and related costs. Receiving inventory information needs to be a main priority to improve demand visibility. A close collaboration needs to be enhanced in order to receive this information and in an ideal situation your company has direct insight into the inventory levels of customers to reduce lead times, risks and costs.
3	Information about the customer's inventory levels is received by 50% till 75% of the customers. When more customers sent inventory level information, stock levels and related costs can be reduced from both the customer side as your own company. A close collaboration needs to be enhanced in order to receive this information and in an ideal situation your company has direct insight into the inventory levels of customers to reduce lead times, risks and costs
4	Information about the customer's inventory levels is received by a large part of the customers (more than 75%). This is very pioneering compared to other FMCG companies in the industry. In the ideal situation, your company has direct insight into the inventory levels of all customers to reduce lead times, risks and costs.
Accuracy	
1	Emphasis should be on the accuracy of the received inventory level information of your customers since the accuracy is very low and unsatisfactory.
2	Emphasis should be on the accuracy of the received inventory level information of your customers. The accuracy is usually satisfactory, but situations in which the information is incorrect are not uncommon.
3	The accuracy of the received inventory level information of your customers is usually satisfactory and only incorrect in a few situations.
4	The accuracy of the received inventory level information of your customers is very good.
Frequency	
1	The frequency of the inventory level information can be improved.
2	The frequency of the inventory level information can be improved.
3	The frequency of the inventory level is quite high, but can be improved by receiving directly real-time information
4	The frequency of the received information is very high and fulfilling.
Timeliness	
1	Though, the inventory level information is always received too late.
2	Though, the inventory level information is usually received too late.
3	-
4	-

PROMOTIONAL EVENTS	
Explanation: Promotional plans indicate when promotional campaigns of your customers will take place	
Availability	
0	Lastly, the notification of promotional events is a critical area asking for improvements. Receiving this information in time can influence the production schedule and avoid stock-outs and high lead times.
1	Lastly, the notification of promotional events is a critical area asking for improvements and is only sent by 1% till 25% of the customers. Receiving this information in time can influence the production schedule and avoid stock-outs and high lead times.
2	Lastly, the notification of promotional events is a critical area asking for improvements and is only sent by 25% till 75% of the customers. Receiving this information in time can influence the production schedule and avoid stock-outs and high lead times.
3	Lastly, the notification of promotional events is sent by already 50% till 75% of the customers. Receiving this information of the other customers as well can optimize the production schedule and avoid stock-outs and high lead times.
4	Lastly, the notification of promotional events is sent by already more than 75%, which is very high.
Accuracy	
1	The information provided about these promotional plans is not accurate and should be a point of attention.
2	The information provided about these promotional plans is usually satisfactory but also often incorrect and inaccurate. This should be a point of attention.
3	-
4	-
Frequency	
1	Although this is sent, only a few promotional events are communicated which should be improved.
2	Although this is sent, only a few promotional events are communicated which should be improved.
3	-
4	-
Timeliness	
1	Nevertheless, the promotional plan information is always received too late.
2	Nevertheless, the promotional plan information is always received too late.
3	-
4	-

Supply visibility

INVENTORY LEVELS	
Explanation: Inventory information contains information about the possibility to deliver the requested purchase quantity and the lead time in case of stock-outs.	
Availability	
0	Regarding visibility of the supplier side, the missing information of inventory levels should be improved to create more value. Currently, no insights into inventory levels of suppliers are known but could improve the responsiveness towards own production processes and other supply chain activities.
1	Regarding visibility of the supplier side, the missing information of inventory levels should be improved to create more value. Currently, inventory information of 1% to 25% of the suppliers is known. Improving this proportion could improve the responsiveness towards own production processes and other supply chain activities.
2	Regarding visibility of the supplier side, the missing information of inventory levels should be improved to create more value. Currently, inventory information of 25% to 50% of the suppliers is known. Improving this proportion could improve the responsiveness towards own production processes and other supply chain activities.
3	Regarding visibility of the supplier side, the inventory level information of suppliers is convenient and between 50% and 75% of the suppliers provide this information. This proportion should be improved to create more value and improve the responsiveness towards own production processes and other supply chain activities.
4	Regarding visibility of the supplier side, the inventory level information of suppliers is convenient and more than 75% of the suppliers provide this information.
Accuracy	
1	The accuracy of the received information is very low, and should be improved to create value.
2	The accuracy of the received information is usually very low, and should be improved to create value.
3	The accuracy of inventory level information of the supplier is usually good.
4	The accuracy of inventory level information of the supplier is very good.
Frequency	
1	Gains can be generated when the frequency of this information being provided increases.
2	Gains can be generated when the frequency of this information being provided increases.
3	-
4	-
Timeliness	
1	Nonetheless, the inventory information is always received too late.
2	Nonetheless, the inventory information is always received too late.
3	-
4	-

PURCHASE ORDER STATUS	
Explanation: Order status information relates to information about orders being received, processed and transported.	
Availability	
0	Major improvements can be made when order status information is sent by customers. This contains information about orders received, processed or transported. It is critical to improve operational and logistical processes and enhance responsiveness. Ideally, the real-time location of the suppliers' goods is known.
1	Major improvements can be made when order status information is sent by customers. This contains information about orders received, processed or transported. This information is only sent by 1% to 25% of the suppliers. However, this is critical to improve operational and logistical processes and enhance responsiveness. Ideally, the real-time location of goods is known.
2	Major improvements can be made when order status information is sent by customers. This contains information about orders received, processed or transported. This information is only sent by 25% to 50% of the suppliers. However, this is critical to improve operational and logistical processes and enhance responsiveness. Ideally, the real-time location of goods is known.
3	Much order status information is received (sent by 50% to 75% of the suppliers). Improvements are possible to receive this information from all customers. Ideally, the real-time location of goods is observable.
4	Much order status information is received (sent by more than 75% of the suppliers). Improvements are possible to receive this information from all customers. Ideally, the real-time location of goods is observable.
Accuracy	
1	Problematic is the accuracy of the order status information. Incorrect data can influence your supply chain choices drastically and can be seen as a major opportunity.
2	Problematic is the accuracy of the order status information which is now usually satisfactory but often not accurate. Incorrect data can influence your supply chain choices drastically and can be seen as a major opportunity.
3	The order status information is only incorrect in a few situations, that should be limited.
4	The accuracy of order status information is very good.
Frequency	
1	The frequency of receiving this information can be improved. Ideally, it is accessible at every moment.
2	The frequency of receiving this information can be improved. Ideally, it is accessible at every moment.
3	The frequency of receiving this information is high, but ideally, this is accessible at every moment.
4	-
Timeliness	
1	Though, the purchase order information is always received too late.
2	Though, the purchase order information is always received too late.
3	-
4	-

EXPECTED ARRIVAL TIME	
Explanation: the estimated time of arrival (ETA) is the time provided by the supplier about when a product is expected to arrive.	
Availability	
0	Improving the Estimated Time of Arrival (ETA) is a major opportunity to improve current performances. When this is accurate and often provided, bottlenecks can be identified quickly. Possibilities for adjustments in activities arise, like changes in production and delivery. Also, customer service levels can be improved.
1	Improving the Estimated Time of Arrival (ETA) is a major opportunity to improve current performances (only received by 1% to 25% of the suppliers). When this is accurate and often provided, bottlenecks can be identified quickly. Possibilities for adjustments in activities arise, like changes in production and delivery. Also, customer service levels can be improved.
2	Improving the Estimated Time of Arrival (ETA) is a major opportunity to improve current performances (only received by 25% to 50% of the suppliers). When this is accurate and often provided, bottlenecks can be identified quickly. Possibilities for adjustments in activities arise, like changes in production and delivery. Also, customer service levels can be improved.
3	The availability of the Estimated Time of Arrival (ETA) data is high, but improvements can still be made. This is now sent by 50% to 75% of the suppliers. When this proportion increases, bottlenecks can be identified quickly. Also, more possibilities for adjustments in activities arise, like changes in production and delivery and the customer service levels can be improved.
4	Sufficient Estimated Time of Arrival (ETA) data is available.
Accuracy	
1	Unfortunately, the accuracy is insufficient which makes the information not usable.
2	Unfortunately, the accuracy is often insufficient which makes the information not usable.
3	Upgrades can be obtained when all information is accurate because that is not the case in a few situations.
4	The accuracy of the ETAs is in general very accurate.
Frequency	
1	The frequency of receiving this information can be improved. Ideally, it is accessible at every moment.
2	The frequency of receiving this information can be improved. Ideally, it is accessible at every moment.
3	The frequency of receiving this information is high because of the pro-active attitude of suppliers. Ideally, this is accessible at every moment.
4	-
Timeliness	
1	Nevertheless, the ETA information is always received too late.
2	Nevertheless, the ETA information is usually received too late.
3	-
4	-

DISRUPTIONS	
Explanation: Information about disruptions relates to the communication of delays and other unexpected disruptions from your suppliers.	
Availability	
0	Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now disruptions are not communicated and this is an important aspect to focus on in the future and can gain much value.
1	Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now disruptions are only communicated by 1% to 25% of the suppliers. This is an important aspect to focus on in the future and can gain much value.
2	Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now disruptions are only communicated by 25% to 50% of the suppliers. This is an important aspect to focus on in the future and can gain much value.
3	Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now disruptions are only communicated by already 50% to 75% of the suppliers. It is important to improve this communication with other suppliers to gain more value.
4	Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now disruptions are only communicated by already more than 75% of the suppliers. It is important to improve this communication with other suppliers to gain more value.
Accuracy	
1	The accuracy of the information received needs to be improved.
2	The accuracy of the information received needs to be improved.
3	-
4	-
Frequency	
1	Problematic is that the disruptions are not communicated as default, but only occasionally when requested.
2	Problematic is that the disruptions are not communicated as default, but only occasionally when requested.
3	-
4	-
Timeliness	
1	However, the disruption information is always received too late.
2	However, the disruption information is always received too late.
3	-
4	-

Internal visibility

TRANSPORT INFORMATION	
Explanation: Transport information relates to insight into the arrival time of the customer that picks up the order or insight into the departure and arrival time of orders being delivered.	
Availability	
0	No transport information is known, which includes the arrival time of the customer that picks up the order or insight into the departure and arrival time of orders being delivered. This needs to be optimized.
1	Little transport information is known (1% - 25% of the orders), which includes the arrival time of the customer that picks up the order or insight into the departure and arrival time of orders being delivered. This needs to be optimized.
2	Little transport information is known (25% - 50% of the orders), which includes the arrival time of the customer that picks up the order or insight into the departure and arrival time of orders being delivered. This needs to be optimized.
3	A very good amount of transport-related information is known.
4	A very large amount of transport-related information is known.
Accuracy	
1	Steps can be made regarding the accuracy of this transport related information.
2	Steps can be made regarding the accuracy of this transport related information.
3	-
4	-
Frequency	
1	The frequency of the information received needs to be improved and should be sent pro-actively by stakeholders.
2	The frequency of the information received needs to be improved and should be sent pro-actively by stakeholders.
3	-
4	-
Timeliness	
1	Nonetheless, the transport information is always received too late.
2	Nonetheless, the transport information is usually received too late.
3	-
4	-

INTERNAL INVENTORY LEVELS	
1	Internally, an overview of the inventory levels is missing. This should be a main focus area to improve unnecessary shortages or excesses of inventory.
2	Internally, an overview of the inventory levels is not always satisfactory. This should be a main focus area to improve unnecessary shortages or excesses of inventory.
3	Internally, an overview of the inventory levels is accurate.
4	Internally, an overview of the inventory levels is very satisfactory and accurate.

CURRENT CAPACITY	
Explanation: Capacity is related to the maximum amount your manufacturing operation can produce and the maximum storage capacity and throughput of the warehouse and/or DC.	
1	Internally, an overview of the inventory levels is missing. This should be a main focus area to improve unnecessary shortages or excesses of inventory.
2	Internally, an overview of the inventory levels is not always satisfactory. This should be a main focus area to improve unnecessary shortages or excesses of inventory.
3	Internally, an overview of the inventory levels is accurate.
4	Internally, an overview of the inventory levels is very satisfactory and accurate.

CURRENT PRODUCTIVITY	
Explanation: Productivity is related to the actual quantity being manufactured and the performance of the site function.	
1	Insights in the actual productivity and performance of site function and manufacturing are missing.
2	Insights in the actual productivity and performance of site function and manufacturing are limited.
3	Insights in the actual productivity and performance of site function and manufacturing are quite good.
4	Insights in the actual productivity and performance of site function and manufacturing are very good.

FUTURE STATE CAPACITY	
Explanation: To what extend are you aware of the future state capacity of site and manufacturing function	
1	Although it is impossible to predict the future, it is very valuable to estimate the future state capacity of site and manufacturing functions dealing with different possible scenarios. The company is not aware of this future state capacity and predictive simulation can support to create a complete estimate.
2	Although it is impossible to predict the future, it is very valuable to estimate the future state capacity of site and manufacturing functions dealing with different possible scenarios. Your company has unsatisfactory insights in the future state capacity. Predictive simulation can support to develop a complete estimate.
3	Insights into the future state capacity of site and manufacturing functions are quite good. Predictive simulation can support to develop complete estimates and create different possible scenarios.
4	Insights into the future state capacity of site and manufacturing functions are very good already. Predictive simulation can support to develop complete estimates and create different possible scenarios.

Others

TRACEABILITY ORIGIN OF MATERIALS	
1	The current mindset of customers is demanding transparency and insights into the origin of materials and components. Full insight is not available yet but is needed to meet this growing demand of transparency.
2	The current mindset of customers is demanding transparency and insights into the origin of materials and components. Partial insight is only available yet but improvements can be made to meet this growing demand of transparency.
3	The current mindset of customers is demanding transparency and insights into the origin of materials and components. You already have great insight into this information and can be shared.
4	The current mindset of customers is demanding transparency and insights into the origin of materials and components. You already have great insight into this information and can be shared.

OVERVIEW AVAILABLE DATA	
Explanation: An overview of the available data is related to internal data and external data sent by stakeholders	
1	At the moment, there is no clear overview of the data received from other stakeholders and own data that is available. This is a major opportunity to investigate. Data can be collected, interpreted and could be valuable for decision making.
2	At the moment, there is only partial insight into the data received from other stakeholders and own data that is available. This is a major opportunity to investigate in-depth. Data can be collected, combined, interpreted and could be valuable for decision making.
3	At the moment, there is a good insight into the data received from other stakeholders and own data that is available. This is important to analyze so that data can be used or combined for better decision making.
4	At the moment, there is a good insight into the data received from other stakeholders and own data that is available. This is important to analyze so that data can be used or combined for better decision making.

INTERPRETATION OF DATA	
1	Lastly, the interpretation of the available data is not sufficient. However, this interpretation is critical input to proactively recognize opportunities for improvement.
2	Lastly, the interpretation of the available data is limited. However, this interpretation is critical input to proactively recognize opportunities for improvement.
3	Lastly, the interpretation of the available data is mostly good. This interpretation is critical input to proactively recognize opportunities for improvement.
4	Lastly, the extent to which the available data is interpreted currently provides a good input to proactively recognize opportunities for improvement.

C.3. Report

An example of a report is illustrated and generated for one of the validation sessions with a company. The text is automatically generated. However, the graphs are now manually inserted, just as the major improvement opportunities. In the future, changes in the software Kes can create a geographical and numerical feature. An example is showed.

Maturity Visibility Scan

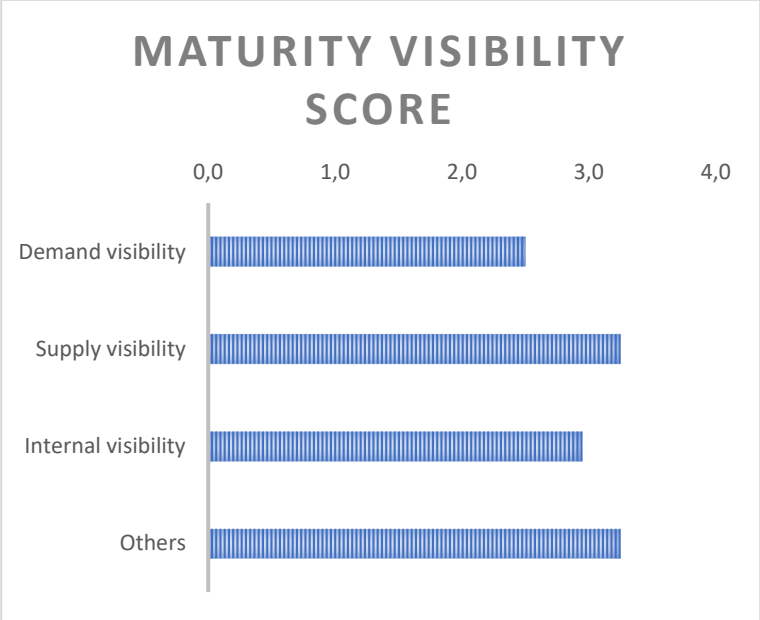
Client: [Name]

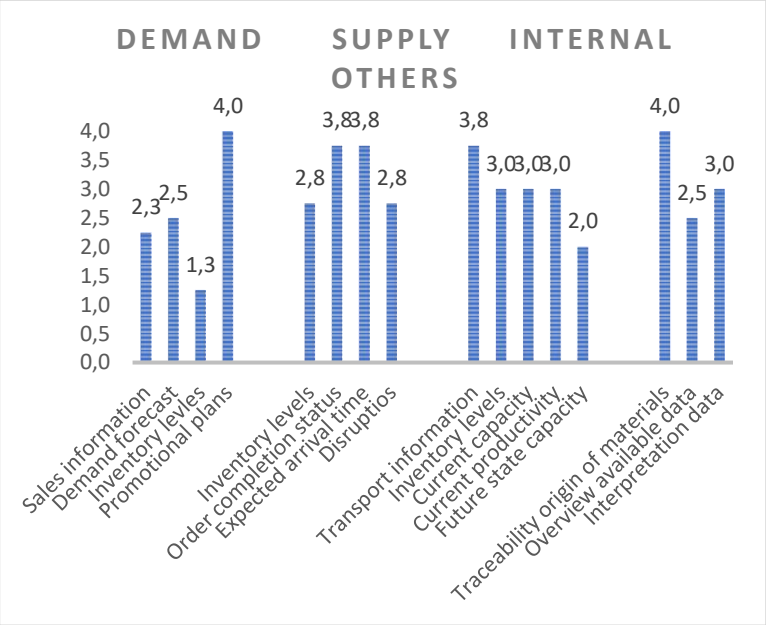
Date: [Date]

Royal HaskoningDHV
Enhancing Society Together

Dear [name], here are the results* of the maturity visibility scan for [company name] based on the demand visibility, supply visibility, internal visibility, and other factors.

1 Maturity visibility Score



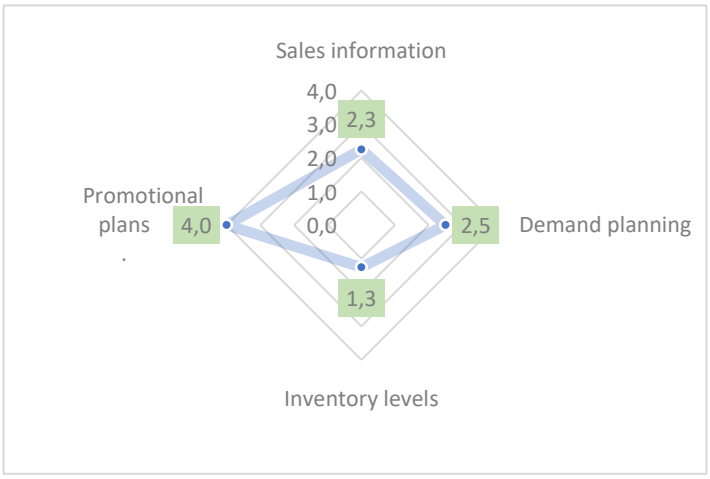


Major improvement opportunities

Demand visibility	Supply visibility	Internal visibility	Others
Sales information	Inventory levels	Future state capacity	Overview available data
Inventory levels	Disruptions		

On the next pages, your score of the four dimensions of visibility is clarified.

1.1 Demand visibility



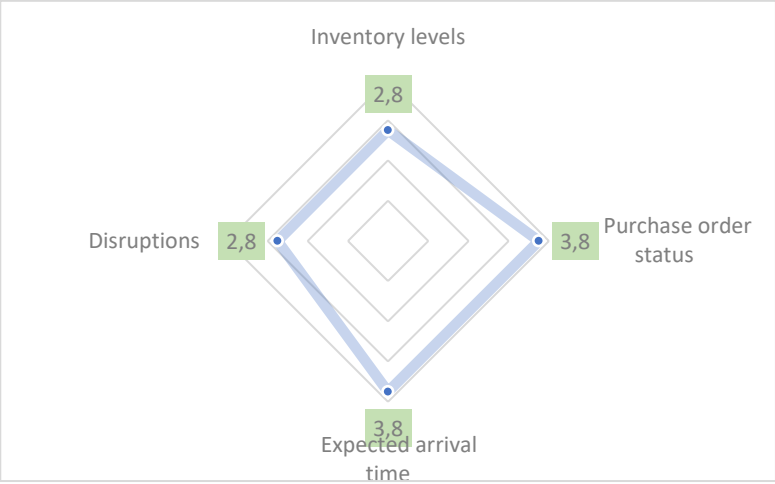
Currently, you have access to sales information, however, only a few customers (less than 25%) is sending this information. Improving the possibilities and willingness of your customers to share sales information can have a major impact. It will give insight into the total customer demand, improves production schedules, and can prevent stock-outs and excessive inventory levels when sales data is sent by a larger amount of customers. The received information is usually satisfactory and only incorrect in a few situations. The sales information on average is pro-actively sent by the customer and makes your company very progressive and responsive. Nonetheless, the demand planning is usually received too late.

Your company does receive demand planning information, but this amount is very limited (between 25% and 50%). Combining demand forecasts of customers with own estimates, can improve the accuracy of predictions and decision making. This should be a focus for future improvements. An issue is the accuracy of the received demand planning. Receiving demand planning where the accuracy is usually satisfactory but also often incorrect and unsatisfactory, leads to unusable information or information that negatively impacts the forecasts. Estimates are never fully accurate, but can definitely be improved. The frequency in which the demand planning is sent, is normally really high.

Information about the customer's inventory levels are limited (1% - 25%) but are crucial to reduce the stock level and related costs. Receiving inventory information needs to be a main priority to improve demand visibility. A close collaboration needs to be enhanced in order to receive this information and in an ideal situation your company has direct insight into the inventory levels of customers to reduce lead times, risks and costs. Emphasis should be on the accuracy of the received inventory level information of your customers since the accuracy now is very low and unsatisfactory. The frequency of the inventory level information can be improved just as the inventory level information which is usually received too late.

Lastly, the notification of promotional events is sent by already 50% till 75% of the customers. Receiving this information of the other customers as well can optimize the production schedule and avoid stock-outs and high lead times.

1.2 Supply visibility



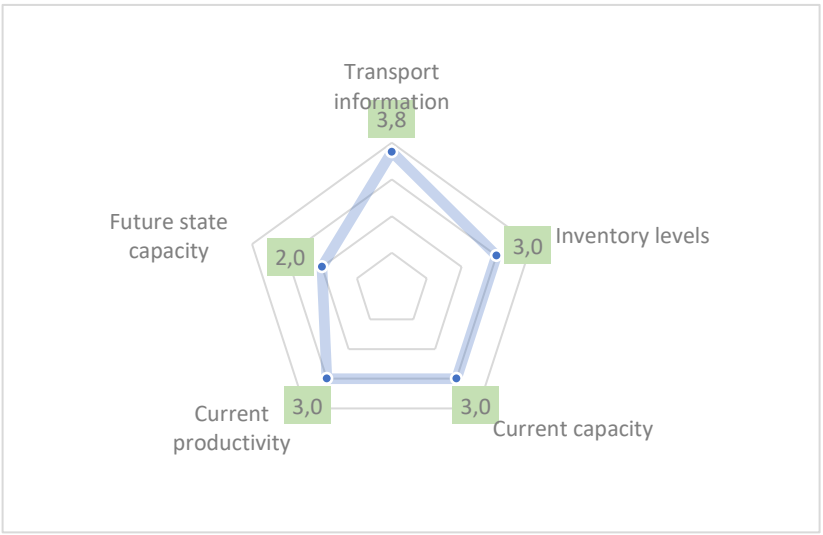
Regarding visibility of the supplier side, the missing information of inventory levels should be improved to create more value. Currently, inventory information of 25% to 50% of the suppliers is known. Improving this proportion could improve the responsiveness towards own production processes and other supply chain activities. The accuracy of inventory level information of the supplier is usually good and usually on time and only late in a few situations

Order status information is available (sent by more than 75% of the suppliers). Improvements are possible to receive this information from all customers. The order status information is only incorrect in a few situations, and that should be limited.

Sufficient Estimated Time of Arrival (ETA) data is available. Upgrades can be obtained when all information is accurate because that is currently not the case in some situations.

Direct communication of disruptions from suppliers is crucial to adapt the supply chain activities and prevent stock-outs. Right now, disruptions are communicated by already 50% to 75% of the suppliers. It is important to improve this communication with other suppliers to gain more value. Furthermore, the disruption information is usually received too late.

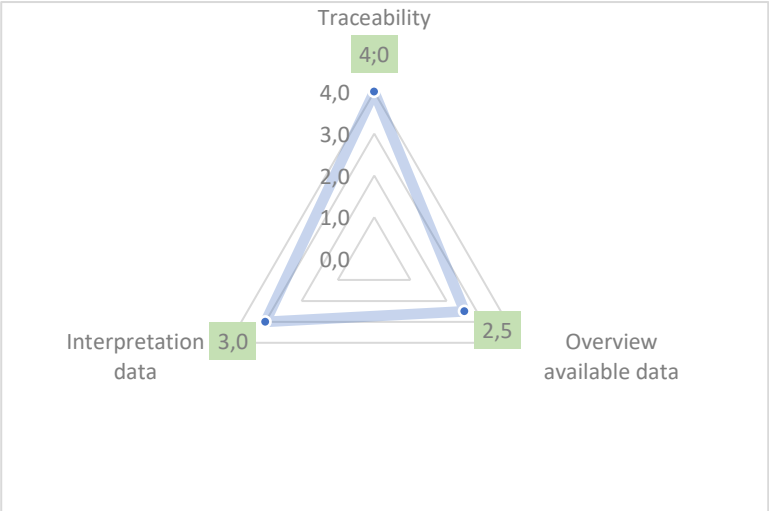
1.3 Internal visibility



A very large amount of transport-related information is known. Internally, an overview of the inventory levels is accurate. The current capacity of your company's manufacturing and site function are known quite good just as insights in the actual productivity and performance of site function and manufacturing. Although it is impossible to predict the future, it is very valuable to estimate the future state capacity of site and manufacturing functions dealing with different possible scenarios. Your company has unsatisfactory insights in this future state capacity. Predictive simulation can support to develop a complete estimate.

1.4 Others

The current mindset of customers is demanding transparency and insights into the origin of materials and components. You already have great insight into this information. At the moment, there is only partial insight into the exact data received from other stakeholders and own data that is available. This is a major opportunity to investigate in-depth. Lastly, the interpretation of the available data is mostly good. This interpretation is critical input to proactively recognize opportunities for improvement.



2 Start improving your supply chain visibility

We hope that the provided information will create awareness of critical areas of [company name] and that it will facilitate an efficient start to improve your supply chain visibility.

Our Supply Chain & Operations team is ready to help you to improve grasp new commercial opportunities, realize efficiencies and improve visibility based on specialist experience and predictive, data-powered insights. Royal HaskoningDHV provides creative, pragmatic, and proven solutions to future-proof operations. We provide tailored support for our clients in FMCG industries and offering services like a *Supply Chain & Operations Quick Scan, End-to-end supply chain visibility, and site plant and network optimization*.

Let us help you to improve

If you would like us to get in touch, please send an email to johan.pruisken@rhdhv.com and we will contact you within three working days.

Or visit our website for more information about our supply chain & operations services and project references.

* Supply chain visibility scores are based on the maturity level data from the survey. We assume that all answers are applicable to your organization

D

Validation Protocol and Results

D.1. Participants validation sessions

The supply chain managers that participated during the validations sessions are shown in Table D.1. The managers are depersonalised and referred to as SCM1, SCM2, SCM3, SCM4, and SCM5. As can be seen SCM3 and SCM4 are working for the same company.

Table D.1: Interviewed Supply Chain Managers RHDHV

Name	Date	Function	Product type	Years of experience in SC
SCM1	30-3-2021	Vice President Strategic Supply Chain Projects	Cleaning products	33 years
SCM2	30-3-2021	Supply Chain Director Benelux	Pet food	12 years
SCM3	22-06-2021	Supply Chain Director Benelux	Personal care	12 years
SCM4	06-07-2021	Demand Planner	Personal care	7 years
SCM5	9-4-2021	Supply Chain Manager	Personal care	21 years

D.2. Validation structure

A semi-structured validation session is prepared, where questions are formulated beforehand. However, the idea is that discussions arise and that feedback is given whenever that comes in mind. The structure is listed below.

Part 1: Introduction
First an introduction is made and the research aim, and the development process after the previous interview session is explained. Also, the goal of the tool is clarified.

Part 2: Using the tool
In this part the tool is used by the supply chain manager. The researcher does not provide comments or explanation during to see if the formulation of the questions is clear. Only when the supply chain manager addresses unclarities by herself/himself, the researcher will give further explanation.

Part 3: Interpreting the results
The results of the tool are shown and asked if this is in line with own expectations. Also it is checked if the results are clear and useful.

Part 4: General remarks
Furthermore, questions are asked about the overall impression and difficulties. Also, a question is

asked if there are factors missing in the measurement of supply chain visibility. Lastly, the usefulness of such tools are discussed.

Part 5: Ending
The supply chain manager will be thanked for this or her time.

D.3. Results validation session

Four supply chain managers executed the Visibility Maturity Scan and provided comments and suggestions. The results are presented in Table D.2; D.3; D.4; D.5.

Table D.2: Validation results SCM1

SCM1					
	Availability	**Accuracy**	**Timeliness**	**Timeliness**	**Average**
Demand visibility					
POS/Sales info	2	3	3	3	2.75
Demand planning	1	1	3	3	2.25
Inventory levels	2	4	3	3	3
Promotional plans	0	0	0	0	0
					1.94
Supply visibility					
Inventory levels	1	4	3	3	2.75
Purchase order status	4	3	3	4	3.5
Expected arrival time	1	1	3	3	2
Disruptions	4	3	3	3	3.25
					2.88
Internal visibility					
Transport information	2	4	3	2	2.75
Inventory levels	4				4
Current capacity	4				4
Current productivity	4				4
Future state capacity	4				4
					3.75
Others					
Traceability origin of materials	2				2
Overview available data	3				3
Interpretation data	3				3
					2.67

Table D.3: Validation results SCM2

SCM2					
	Availability	**Accuracy**	**Timeliness**	**Timeliness**	**Average**
Demand visibility					
POS/Sales info	1	3	3	2	2.25
Demand planning	2	2	3	3	2.5
Inventory levels	1	1	1	2	1.25
Promotional plans	3	3	3	3	3
					2.25
Supply visibility					
Inventory levels	2	3	3	3	2.75
Purchase order status	4	3	4	4	3.75
Expected arrival time	4	3	4	4	3.75
Disruptions	3	3	3	2	2.75
					3.25
Internal visibility					
Transport information	4	3	4	4	3.75
Inventory levels	3				3
Current capacity	3				3
Current productivity	3				3
Future state capacity	2				2
					2.95
Others					
Traceability origin of materials	4				4
Overview available data	2				2
Interpretation data	3				3
					3

Table D.4: Validation results SCM3

SCM3					
	Availability	**Accuracy**	**Timeliness**	**Timeliness**	**Average**
Demand visibility					
POS/Sales info	3	3	3	3	3
Demand planning	3	2	2	2	2.25
Inventory levels	1	4	3	3	2.75
Promotional plans	2	3	2	3	2.5
					2.63
Supply visibility					
Inventory levels	4	3	4	4	3.75
Purchase order status	4	4	3	4	3.75
Expected arrival time	4	4	3	4	3.75
Disruptions	3	3	2	3	2.75
					3.5
Internal visibility					
Transport information	4	2	4	4	3.5
Inventory levels	4				4
Current capacity	4				4
Current productivity	4				4
Future state capacity	3				3
					3.7
Others					
Traceability origin of materials	4				4
Overview available data	3				3
Interpretation data	3				3

					3.33

Table D.5: Validation results SCM4

SCM4					
	Availability	**Accuracy**	**Timeliness**	**Timeliness**	**Average**
Demand visibility					
POS/Sales info	0	0	0	0	0
Demand planning	2	2	2	2	2
Inventory levels	2	3	2	2	2.25
Promotional plans	2	2	2	2	2
					1,56
Supply visibility					
Inventory levels	3	3	3	3	3
Purchase order status	2	4	4	4	3.5
Expected arrival time	2	2	3	3	2.5
Disruptions	2	3	3	3	2.75
					2.94
Internal visibility					
Transport information	4	3	3	3	3.25
Inventory levels	3				3
Current capacity	4				4
Current productivity	3				3
Future state capacity	3				3
					3.25
Others					
Traceability origin of materials	3				3
Overview available data	3				3
Interpretation data	3				3
					3

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